9th International and 30th All India Manufacturing Technology, Design & Research Conference (AIMTDR) 2023

Souvenir

Organized by

Department of Mechanical Engineering

IIT(BHU) Varanasi-221005

8th-10th December 2023

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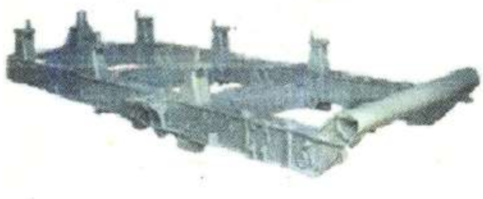
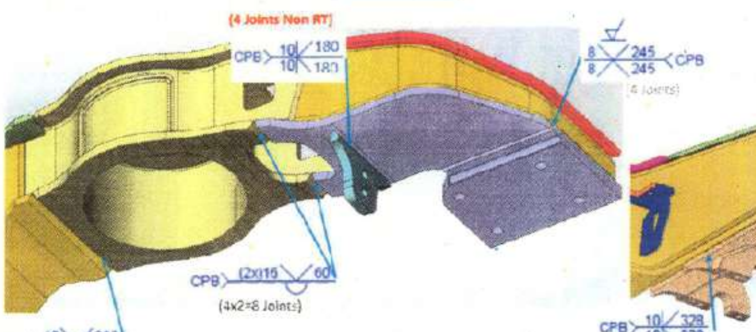


Bogie Frame for Electric Locomotive

Vande Bharat Assembled Bogie

Assembled LHB Bogie

SIDE FRAME



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9th International & 30th All India Manufacturing Technology, Design & Research Conference AIMTDR 2023

December 08-10, 2023

SOUVENIR

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Department of Mechanical Engineering
Indian Institute of Technology (BHU) Varanasi
India

First impression: Publication 2023

All India Manufacturing Technology, Design, and Research Conference (AIMTDR 2023)

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Published at:

Department of Mechanical Engineering
Indian Institute of Technology (BHU) Varanasi
(Uttar Pradesh), India

Typeset & Design by:

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Welcome to the International Conference "AIMTDR 2023", December 8-10, 2023

The 9th International and 30th All India National Conference on "AIMTDR-2023" is scheduled in the Department of Mechanical Engineering, Indian Institute of Technology, BHU, at the most appropriate time (December 8-10, 2010) close to the beginning of the new Year, to bring together the engineers technologists, entrepreneurs, researches and academicians across the country and abroad to discuss the forthcoming manufacturing and Design Research challenges in the coming decade and address frontier manufacturing and productivity enhancement issues for the global and Indian Industries.

All faculty members of the department have worked hard for the last One year for the success of this conference. More than four hundred reviewed research papers and will be presented in this conference by delegates from all corners of the country and abroad. In three days, 8 parallel sessions daily with twin mode running on parallel on different topics will be held here. Two Poster sessions are also arranged. A special inaugural and valedictory function lectures and Nine keynote addresses and Two memorial talks on state-of-the art topics will also be delivered by eminent professionals in the field of manufacturing and Design. Each session of the conference will be conducted and concluded by distinguished chairpersons for the benefit of all participants. Ten best papers awards (Nine oral presentations and one poster presentation) are also constituted for promoting best researchers in the field of manufacturing area.

We wish to express our deep gratitude to those industrial and Business and government establishments who have generously helped us financially by sponsoring/ co-sponsoring various important conference events. For an academic institution, it is really difficult to organize an international level conference without such support. The list of Sponsors/Co-sponsors is also included in the conference Souvenir. Later 10 volumes of the proceedings on different aspects of manufacturing are also planned for publications with Springer.

We are sure that participants will enjoy here a typical flavour of deliberations on manufacturing and Design challenges for the next decade and the traditional culture of this ancient city Banaras. We take this opportunity to cordially invite you all to this conference. Your participation will no doubt make this event a great success.

Lastly, we express thanks to our Director, Prof P.K. Jain for his valuable support to make this conference a memorable event in this institute.

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ABOUT AIMTDR

The All-India Manufacturing Technology, Design, and Research Conference (AIMTDR) is globally counted as one of the most prestigious conferences aiming toward a wide domain of manufacturing areas, including the conventional approach and the latest manufacturing techniques. The first AIMTDR was organized at the national level by Jadavpur University, Kolkata, in 1967. Its subsequent progress with remarkable recognition among academia and industries made it an international level conference in 2006. The 9th International and 30th AIMTDR 2023 is being organized by the Department of Mechanical Engineering, IIT (BHU) Varanasi, from 8th -10th December 2023. This conference will provide a golden opportunity for Academicians, Researchers, Engineers, Corporate Executives, and Industrial.

ABOUT IIT (BHU)

The Indian Institute of Technology (Banaras Hindu University), Varanasi, is situated in the magnificent campus of Banaras Hindu University at the southern end of the ancient city of Varanasi on the banks of the holy river Ganga. Engineering Education at Banaras Hindu University commenced in 1919, and the Institute was converted into the Indian Institute of Technology (Banaras Hindu University) Varanasi, by the Government of India on 29th June 2012.

For more information visit: https://iitbhu.ac.in

ABOUT THE DEPARTMENT

The Department of Mechanical Engineering came into existence in 1919 under the leadership of Professor Charles A. King, the first Head of the Department and Principal of the erstwhile Banaras Engineering College (BENCO). Over the last ninety-nine years, the department has grown fourfold to become the largest department in IIT (BHU), Varanasi. The post-graduate and doctoral program in the department is well-established and infrastructural facilities exist for studies and research for a range of specializations such as Machine Design, Thermal and Fluid Engineering, Production Engineering and Industrial Management.

For more information visit https://iitbhu.ac.in/dept/mec

MILESTONES OF AIMTDR MOVEMENT

YEAR	NAMED AS	HOSTING INSTITUTION
1966	Seminar on Machining and Machine Tool Technology	Indian Institute of Technology, Bombay
1967	1st All India Machine Tool Design & Research Conference	Jadavpur University, Kolkata
1968	2nd All India Machine Tool Design & Research Conference	Central Machine Tool Institute, Bangalore
1969	3rd All India Machine Tool Design & Research Conference	Indian Institute of Technology, Bombay
1970	4th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Madras
1972	5th All India Machine Tool Design & Research Conference	University of Roorkee
1973	6th All India Machine Tool Design & Research Conference	Central Machine Tool Institute, Bangalore
1976	7th All India Machine Tool Design & Research Conference	PSG College of Engineering, Coimbatore
1978	8th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Bombay
1980	9th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Kanpur
1982	10th All India Machine Tool Design & Research Conference	Central Mechanical Engineering Research Institute, Durgapur
1984	11th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Madras
1986	12th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Delhi
1988	13th All India Machine Tool Design & Research Conference	Jadavpur University, Kolkata
1990	14th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Bombay
1992	15th All India Machine Tool Design & Research Conference	PSG College of Engineering, Coimbatore
1994	16th All India Machine Tool Design & Research Conference	Central Machine Tool Institute, Bangalore
1997	17th All India Machine Tool Design & Research Conference	Regional Engineering College, Warangal
1998	18th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Kharagpur

2000	19th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Madras
2002	20th All India Machine Tool Design & Research Conference	Birla Institute of Technology, Mesra, Ranchi
2004	21th All India Machine Tool Design & Research Conference	Vellore Institute of Technology, Vellore
2006	1st International and 22nd All India Machine Tool Design & Research Conference	Indian Institute of Technology, Roorkee
2008	2nd International and 23rd All India Machine Tool Design & Research Conference	Indian Institute of Technology, Madras
2010	3rd International and 24th All India Machine Tool Design & Research Conference	Andra University, Vishakhapatnam
2012	4th International and 25th All India Machine Tool Design & Research Conference	Jadavpur University, Kolkata
2014	5th International and 26th All India Machine Tool Design & Research Conference	Indian Institute of Technology, Guwahati
2016	6th International and 27th All India Machine Tool Design & Research Conference	College of Engineering, Pune
2018	7th International and 28th All India Machine Tool Design & Research Conference	Anna University, Chennai
2021	8th International and 29th All India Machine Tool Design & Research Conference	PSG Institute of Technology and Applied Research, Coimbatore, Tamil Nadu
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23 November, 2023

Message

I am pleased to learn that the Department of Mechanical Engineering at the Indian Institute of Technology (BHU), Varanasi, is organizing the 9th International and 30th National Conference on **'All India Machine Tool Design Research (AIMTDR)-2023,'** during December 8-10, 2023.

This conference stands as a pivotal gathering, uniting experts, researchers and innovators in the field of machine tool design. It provides an invaluable forum for the exchange of groundbreaking ideas and the dissemination of cutting-edge research. May AIMTDR-2023 propel the advancement of machine tool design and contribute to the evolution of technology in this dynamic field.

I extend my heartfelt best wishes for the conference. May it be a catalyst for inspiration and collaboration, fostering new frontiers in machine tool design.

Anandi Patel

(Anandiben Patel)

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Message

I am delighted to note that the Department of Mechanical Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi is hosting the 9th International and 30th All India Manufacturing Technology, Design and Research (AIMTDR) conference from 8th to 10th December 2023.AIMTDR conference has been a well-known platform for researchers, scholars, and professionals to come together and share their views in the area of Manufacturing Technology.

The event also fulfill the dream of **'Atma Nirbhar Bharat'** and **'Make in India'**.The aim of the conference is to promote scientific excellence in various areas of modern manufacturing which includes inclusive manufacturing, Digital Manufacturing and Industry 4.0, to address the need of modern Bharat for achieving sustainable growth.

I extend warm greetings to the Chief Guest, Keynote speakers, Plenary speakers, researchers, and all the delegates from Academica and Industries. I am happy to know that more than 450 research papers are to be published in the conference proceedings and selected papers in leading international journals.

I wish for the grand success of AIMTDR 2023.

(Pramod Kumar Jain)

Date: 10th November 2023

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Message

I am delighted to know that the 9th International and 30th All India Manufacturing Technology, Design and Research (AIMTDR) conference is being organized by Indian Institute of Technology (Banaras Hindu University), Varanasi during December 8-10, 2023 at Mechanical Engineering Department, IIT(BHU) Varanasi. On this occasion, I would like to convey my warm wishes to all the researchers, academicians. organizers and industrialists for contributing towards their research work and experience in the progress of Technical knowhow and industrial inputs for growth of the country.

In the new era of Manufacturing, there are several sectors to play important roles the growth of country GDP and as the conference is based on manufacturing, I can envisage how the researchers and scientists are integrating their sincere efforts for development of our country. The scientific community certainly deserve to be applauded for their feat. As we are a part of a developing country and aiming towards a developed country, we have to put our sincere efforts all together to ensure the success of the manufacturing sector along with Design and research.

I extend my warm greetings and felicitations to the organizers and participants and send my best wishes for the great success of the International conference at IIT(BHU).

President: AIMTDR-2023

(R.N. Tripathi)
Managing Director
Ved Sassomeccanica (India) Pvt. Ltd.
Kanpur.

Regd. Office & Works :
Ved Sassomeccanica (India) Private Limited, D-18/1, Panki Industrial Area, Site-1, Kanpur - 208022 (U.P.) India
Site-II: 34 E, 34 D & 34 C (Part) Block 'A', KDA Scheme-40, Panki Industrial Area, Kanpur - 208022 (U.P.)
Tele/Fax: +91-512-2691317 • **E-mail:** ved_sasso@yahoo.com, info@vedsasso.com • **Website:** www.vedsasso.com
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Dear Esteemed Participants,

It is with great pleasure and anticipation that we extend a warm welcome to all distinguished attendees of the 9th International and 30th All India Manufacturing Technology, Design and Research Conference. We are indeed excited to have a diverse group of professionals, thought leaders, and innovators gathered here to explore the latest advancements and trends in academia and the manufacturing industry.

Also, we seize this opportunity to congratulate Prof. Santosh Kumar and his entire team from the Department of Mechanical Engineering at IIT (BHU) Varanasi, for the hard work they have put forth in organizing and hosting the 9th International and 30th AIMTDR with its much-needed colour and vigor.

As we convene for this globally significant event, we find ourselves at the intersection of creativity and industry, where innovation not only meets technology but also shapes the future of manufacturing and design on an international scale. Our collective presence at this conference reflects a commitment to pushing the boundaries of what is possible, fostering collaboration across borders, and embracing the transformative power of design in the manufacturing process. Together, we have the potential to shape the future of manufacturing, driving positive change and sustainable practices on a global magnitude.

Throughout the conference days, we encourage you to engage in dynamic discussions, share your experiences, and forge connections that transcend geographic boundaries. In our diversity lies the strength to overcome challenges, spark new ideas, and chart a course toward a more sustainable, efficient, and visionary future for our industries.

May this conference be a catalyst for breakthroughs, a platform for the exchange of ideas, and a source of inspiration that propels our collective efforts to new heights. There have been unprecedented numbers of quality papers that are to be presented in the conference. We are sure that this occasion will provide an affable environment for the researchers and academicians; and collectively let us not only envision but actively contribute to the evolution of manufacturing technology and design on the world stage.

While we extend my deepest appreciation to each one of you for your expertise, your dedication, and your role in making this conference a truly international forum for excellence, we thank you for your valuable contributions and dedication to advancing the manufacturing sector. Here's to a conference filled with discovery, collaboration, and the promise of a brighter future for our academia and industry.

Wishing each one an enriching and transformative experience.

Prof. B. B. Ahuja

Vice President - 9th International and 30th AIMTDR Conference

& Former Director, College of Engineering Pune

भारतीय प्रौद्योगिकी संस्थान

काशी हिन्दू विश्वविद्यालय

INDIAN INSTITUTE OF TECHNOLOGY

BANARAS HINDU UNIVERSITY

यांत्रिक अभियान्त्रिकी विभाग, भारतीय प्रौद्योगिकी संस्थान (का.हि.वि.वि.), वाराणसी-221005

Department of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi-221005, UP, India

Tel : 91-542-2368157 • Fax : 91-542-2368157 • e-mail : head.mec@iitbhu.ac.in

Massage from Head of Department

I have pleasure in congratulating the Department of Mechanical Engineering for the timely initiative in organizing the 9th International and 30th All India Machine Tool Design Research Conference (December 8-10, 2023) at Mechanical Engineering Department, IIT (BHU) Varanasi. As we enter in the next generation of manufacturing and Automation, it is appropriate that we take stock of the emerging technologies which can be promoted by achieving excellence in Manufacturing & Design Process Research. Our industrial products have to be competitive in the International market and must meet with stringent ISO standards.

The organizers have drawn up an ambitious programme schedules encompassing, forming & welding, Artificial Intelligence in manufacturing, Additive manufacturing, CAD/CAM, Robotics, Modelling, Reverse Engineering and Management Strategies etc. The response from Industries & Academia have been excellent, I am confident that this prestigious Conference AIMTDR-2023 will bring an opportunity not only for exchange of views amongst researches, industries and scientists but will also enable formulation of strategies for the next the year 2030 and beyond.

I extend my hearty welcome to all the delegates & colleagues, I hope they will find some time to visit the historical/ cultural places of interest in Varanasi.

I wish this International Conference AIMTDR 2023 a grand success.

Santosh Kumar
Professors & Head
Mechanical Engineering, IIT(BHU)

9th International & 30th All India Manufacturing Technology, Design and Research Conference

(AIMTDR 2023)

December 08-10, 2023

Day-1 Schedule (08.12.23)

08:00 am – 09:30 am	**Registration**							
09:30 am – 11:00 am	Inaugural Function							
11:00 am – 11:30 am	High Tea + Photo Session							
11:30 am – 12:15 pm	Keynote Talk-1 **Prof. Satyandra K. Gupta**				Keynote Talk-2 **Prof. S. Bukkapatnam**			
12:30 pm – 01:15 pm	Dr. S. M. Patil Memorial Lecture **Shri Sanjeev Rastogi**							
01:15 pm – 02:30 pm	Lunch							
02:30 pm – 04:30 pm	Session-A1	Session-B1	Session-C1	Session-D1	Session-E1	Session-F1	Session-G1	Session-H1
04:30 pm – 04:45 pm	Tea Break							
04:45 pm – 05:30 pm	Keynote Talk-3 **Dr. Debajyoti Bhaduri**				Keynote Talk-4 **Prof. Murali Sundaram**			
05:45 pm – 06:45 pm	Session-A2	Session-B2	Session-C2	Session-D2	Session-E2	Session-F2	Session-G2	Session-H2
07:00 pm Onwards	Conference Dinner							

Organized by

Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi

9th International & 30th All India Manufacturing Technology, Design and Research Conference

(AIMTDR 2023)

December 08-10, 2023

Day-2 Schedule (09.12.23)

09:00 am – 11:00 am	Session-A3	Session-B3	Session-C3	Session-D3	Session-E3	Session-F3	Session-G3	Session-H3
11:00 am – 11:45 am	Tea Break + **Poster Session**							
11:45 am – 12:30 pm	Keynote Talk-5 **Prof. N. V. Reddy**				Keynote Talk-6 **Prof. V. RadhaKrishnan**			
12:40 pm – 01:25 pm	Prof. A. Bhattacharya Memorial Lecture **Prof. U. S. Dixit**							
01:25 pm – 02:30 pm	Lunch							
02:30 pm – 03:15 pm	Keynote Talk-7 **Prof. S. S. Joshi**				Keynote Talk-8 **Prof. V. K. Jain**			
03:15 pm – 03:30 pm	Tea Break							
03:30 pm – 05:00 pm	Session-A4	Session-B4	Session-C4	Session-D4	Session-E4	Session-F4	Session-G4	Session-H4
05:15 pm – 06:00 pm	Keynote Talk-9 **Prof. N. Ramesh Babu**				Keynote Talk-10 **Prof. Amitabh Ghosh**			
06:00 pm – 07:00 pm	Meeting for NAC members							
07:00 pm Onwards	Cultural Program + Gala Dinner							

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Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi

9th International & 30th All India Manufacturing Technology, Design and Research Conference
(AIMTDR 2023)
December 08-10, 2023

Day-3 Schedule (10.12.23)

09:00 am – 11:00 am	Session-A5	Session-B5	Session-C5	Session-D5	Session-E5	Session-F5	Session-G5	Session-H5
11:00 am – 11:20 am	Tea Break							
11:30 am – 12:30 pm	Keynote Talk-11 **Dr. Neeraj Sinha**				Session on Industry Problem and Academic Solutions			
12:30 pm – 01:30 pm	Lunch							
01:30 pm – 02:30 pm	Valedictory Function							
02:30 pm Onwards	High Tea							

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Poster Session

Date: 09.12.2023 **Time:** 11:00 am - 11:45 am

Session Chairs: Prof. B. B. Ahuja, Prof. U S Dixit, Prof. V Prabhu Raja, Prof. J Ramkumar, Prof. Santosh Kumar

Location: Swatantrata Bhavan Foyer

Paper ID	Paper Title	Presenting Author
12	Effect of flow forming Processes on Microstructure and grain size of AA 6061 Aluminum Alloy	G Venkateshwarlu
72	Design and Optimization of a Heat Sink for Multi-Material Co-Extrusion in Additive Manufacturing	Mithilesh Kumar Tiwari
80	Electroformed Copper Pillar Structures on Additively Manufactured Template: Modeling and Validation	Prince Kumar Rai
84	An Experimental Investigation of micro-hole generation on Ti-6Al-4V through electrochemical micromachining.	Ganesh Damodar Kale
107	Optimisation of Machining Process Parameters of AA7475 composites	Dr. A Sreenivasulu Reddy
108	Analysis of temperature effect for FDM printed parts using ABS material in Additive Manufacturing.	Sanjay Sharma
118	Effect of High-Entropy Alloy Nanoparticles on the Microstructure and Mechanical behaviour of AA7150 Nanocomposite	Deepak Kumar
127	Influence of reduced Graphene oxide (rGO) modified CFRP composites during abrasive water jet machining	Rajesh Kumar Verma
131	Studies on different MCDM techniques in micro-electrical discharge machining of titanium alloy	R Gunasekaran
132	Microstructural Evaluation of Gd2Zr2O7 Thermal Barrier Coating Developed by EB-PVD Technique	G Bhavesh
134	IMPLEMENTATION OF JUST IN TIME MANUFACTURING USING 3D PRINTER	Rohit Chandran R

145	Implementation of Autonomation and Value Stream Mapping for Productivity Improvement	Dr. Ishwar Bhiradi
194	Design and Prototyping of a Novel LPG Valve Leakage Testing Machine	Dev Dharmesh Saglani
197	Investigation on ultrasonic welding as a post-processing approach for overcoming a material extrusion 3D printer's build volume constraint	Omkar Raj Aryan
201	Weldability Study of EN8 Medium Carbon Steel by Manual Metal Arc Welding	Soumojit Dasgupta
270	Residual Stress Analysis in an Infinite Plate with a Central Aperture under Thermal Loading	Mohit Rajput
294	A simulation based degradation study of 3D printed Ti6Al4V screw and plate implant	Dayanidhi Krishana Pathak
330	The relationship between deformation parameters and corrosion parameters of the Al-5.6Zn-2Mg powder metallurgy alloy during hot upsetting	Katika Harikrishna
350	Experimental study on the feasibility of friction stir lap welding of Polycarbonate to Al6061 sheets	Nisith Kumar Goswami
365	A Review on The Application of Magnesium Metal Ma-trix Composites in The Biomedical Field	Rawad Yaqoub Aljabr
369	Effects of Mesoporous Structure on Corrosion Behavior of Metal Fused Filament Fabricated 316L Stainless Steel	Vijaya Kumar P
386	Feasibility Analysis of aluminium alloy welding using Cold Metal Transfer (CMT) for Electric Vehicle battery tray fabrication	Rukaiya Azma
410	Machine learning based erosion response analysis of hybrid FRP composites	Sourav Kumar Mahapatra
436	Experimental Analysis and Optimization of Input Control Variables on Milling of SS316L Steel using Hybrid MCDM method (AHP-TOPSIS)	Dr. Abhishek Singh
266	Design and Analysis of Gradient Lattice Structure for Light Weighting Applications	Hemnath A K
438	Optimization of Process Parameters for Ultrasonic Welding of Al-Al Sheets	Vishwajeet Kumar

Session A1: Additive Manufacturing

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. Y Ravi Kumar & Dr. G.M. Karthik **Location:** G4 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Design and Development of a hybrid strut-based lattice structure using Fused Deposition Modelling	Prof. Y Ravi Kumar	02:30 – 03:00
13	Effect of track and layer overlapping on the residual porosity generation in the selective laser melting of AlSi10Mg	Ashish Kumar Mishra	03:00 – 03:10
37	Investigation on Kinematics in Additive Manufacturing	Yash Gopal Mittal	03:10 – 03:20
41	Energy absorption characteristics and Compressive mechanical properties of the Hybrid lattice structure	Uday Kumar Jonnala	03:20 –03:30
59	Fabrication of tri-material laminate structure using laser powder-bed fusion homemade setup	Manchu Mohan Krishna Sai	03:30 –03:40
77	Development of Novel Ti64-Fe-Co-based β-Titanium Alloy with Improved Strength and Elongation Properties Using Laser Processing Route	Ipsita Mohanty	03:40 –03:50
78	Role of Laser Fluence on the Characteristics of AlSi10Mg Track Deposited through DED-L-based Additive Manufacturing Technique	Saurav Misra	03:50 –04:00
90	Investigating Stringing Defects in 3D Printed PLA Parts: Defect Identification and Optimization Using MobileNetV2 CNN Model	Vivek V Bhandarkar	04:00 –04:10
101	Deformation behaviour and elastic energy absorption capability of additively manufactured strut-based and Voronoi lattice structures on FDM	Sankineni Rakesh	04:10 –04:20

Session B1: Advances in Machining

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Dr. Prasada Raju & Dr. Basil Kuriachen **Location:** G5 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Dimensional anisotropy of LPBF-AlSi10Mg	Dr. Basil Kuriachen	02:30 – 03:00
17	Face Centered CCD-based RSM Modelling and Optimization of parameters for Milling Electrochemical Spark Micromachining of E-Glass Fiber Composites	Kriti Sahai	03:00 – 03:10
331	Experimental Investigation on Abrasive Flow Machining of Spiral Bevel Gears	Dr Anand Petare	03:10 – 03:20
44	Investigations on the effect of hybrid cooling/lubrication strategies on machining characteristics of SS316L	Mayurkumar A Makhesana	03:20 –03:30
46	Advanced FE-based Hybrid Algorithms to Optimize Uncertain Multi response Process Parameters in Tungsten Heavy Alloy Machining	Sreejith S	03:30 –03:40
54	Wear of coated carbide tool having different microstructure and composition in wall end-milling of SS304	Ronit Kumar Shah	03:40 –03:50
67	Experimental Investigation of MHD Convection in ECDM Process for Microchannel Fabrication	Dilip Gehlot	03:50 –04:00
75	Machinability analysis of AISI 4140: A comparison between dry, flood, and vegetable oil-based EMQL machining performance	Raval Parth Niranjanbhai	04:00 –04:10
76	Fabrication of Multiple Blind Holes on Glass Using Ultrasonic-Assisted ECDM Process	Anurag Shanu	04:10 –04:20
23	Modelling of Ultrasonic-Assisted Abrasive Flow Machining using Artificial Neural Network	Dr. Gudipadu Venkatesh	04:20 – 04:30

Session C1: Processing of Advanced Materials

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. Rajesh Kumar Verma & Prof. V S Senthilkumar **Location:** G6 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Impact of Alumina ceramic reinforcement on AA6082-T6 aluminium alloy and its corrosion behavior analysis	Prof. V S Senthilkumar	02:30 – 03:00
42	Experimental study on hole quality parameters in drilling of Quartz Polymeric Composite	Dr. N Selvaraj	03:00 – 03:10
47	Experimental Investigation of Strength Properties of Aluminum Wire Reinforced Cement Concrete	Dr. Vinay Pratap Singh	03:10 – 03:20
368	Characterization of Al- 5% TiB2 functionally graded composites developed via Centrifugal Casting Method	Basudeb Rajak	03:20 –03:30
130	Numerical modelling of cure kinetics of a porous thermoset polymer	Bhishm Dewangan	03:30 –03:40
165	Fabrication of composite Material for Farm Equipment: A Review	Ekta Sharma	03:40 –03:50
207	Solid particle erosion behaviour of dolomite dust filled hemp-epoxy composites	Swaraj Maurya	03:50 –04:00
282	A comparative study of effects of multiple reinforcements incorporated with Al-Si-Mg alloy using friction stir processing	Pratap Singh	04:00 –04:10
317	Study on the mechanical and wear properties of A 319-SiC composite produced by stir casting process.	Dr. Lakkoju Sankara Rao	04:10 –04:20

Session D1: Advances in Machining

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. S. Bukkapatnam & Dr. M Vashista **Location:** G7 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Performance evaluation of ultrasonic Assisted Abrasive Flow machining	Dr. Venkatesh Gudipadu	02:30 – 03:00
83	Estimating Material Deformation Characteristics During Orthogonal Cutting Using Digital Image Correlation	Dr.Mohit Law	03:00 – 03:10
187	Analysis on Fiber Laser Micro Grooving Characteristics of Ti6Al4V	Mohit Pandey	03:10 – 03:20
85	AHP-TOPSIS Integrated Approach for Parameters Selection in WEDM of Titanium Alloy	Dr. D Devarasiddappa	03:20 –03:30
92	Predictive Modeling of Surface Roughness Parameters and MRR during Turning of Inconel 625 with Coated Inserts using Artificial Neural Network.	Muzammil Mansoor Tole	03:30 –03:40
94	The evolution of morphology and chemistry in fused silica surface after medium-pressure plasma processing	Hari Narayan Singh Yadav	03:40 –03:50
95	Performance evaluation of various tool materials and EDM parameters for fabrication of large-area micro-textured surfaces	Ranajit Mahanti	03:50 –04:00
96	Effectiveness of fixture design on cooling of viscoelastic soft polymer during cryogenic assisted micro-milling process	Partha Sarathi Mallick	04:00 –04:10
97	Modelling and Parametric analysis for WEDM during machining of heat treated AZ31 alloy	Prof. Sanjay Mishra	04:10 –04:20
98	Investigation into WECM of Nitinol SMA using ozonated NaNO3 electrolyte	Naresh Besekar	04:20 – 04:30

Session E1: Additive Manufacturing

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. N K Jain & Dr. Venkateswara Rao Komma **Location:** G2 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Solid state Additive Manufacturing	Prof. N K Jain	02:30 – 03:00
415	Fabrication Process Development of a Three Dimensionally Rotated FSS Unit Cell for Wide-Angle Microwave Absorbers	Prof. J. Ramkumar	03:00 – 03:10
106	Study on effects of additive manufacturing process conditions on part properties for engineering applications	Abhishek Raj	03:10 – 03:20
119	Mode-I Fracture Behavior of 3D Printed PEEK using Energy-partitioning Technique	Gaurav Sharma	03:20 –03:30
129	Optimization of Process parameters and Investigations of Bead Geometries of GMAW-Based Wire–Arc Additive Manufactured 316L Stainless Steels	Gaurav Kishor	03:30 –03:40
133	Statistical investigation on dispersion quantification for H13 steel particle-filled polymer composite 3D printed feature	Tadi Siva Prasad	03:40 –03:50
136	An Investigation of Threaded Insert Performance in Additively Manufactured Parts.	Dixita Yadav	03:50 –04:00
137	Effect of layer thickness on tensile properties for alumina particle reinforced polymer composite using 3D-printing	Annada Prasad Moharana	04:00 –04:10
138	A systematic review on 4-dimensional printing for the exploration of the material structures via stimulus-response	Pankaj Kumar	04:10 –04:20
144	Unravelling the processing parameters for selective positioning of multi-materials using Laser decal Transfer based µ-3D printing	Arpit Kumar Singh	04:20 – 04:30

Session F1: Advances in Machining

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. P V Rao & Dr. Joy Prakash Misra **Location:** G3 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Advances in Machining	Prof. P V Rao	02:30 – 03:00
103	Machining of Zirconia Ceramic with a USMM Process Using SiC Abrasives: An Experimental Investigation and Simulation	Debabrata Dhupal	03:00 – 03:10
115	Microstructure alteration and crystallographic texture evolution in NMQL assisted end milling of Incoloy 925	Shravan Kumar Yadav	03:10 – 03:20
120	Meso-level Surface alloying of Hastelloy C 276 using WS2 powder mixed dielectric through µ-EDM setup	Souradeep Dutta	03:20 –03:30
121	Finite Element Modal Analysis of Axisymmetric Hollow Sonotrode used in USM Machine	Pradeepti Vishwakarma	03:30 –03:40
123	Electrochemical Micromachining and Potentiodynamic Polarization Analysis of Nitinol Shape Memory Alloy in Ethylene Glycol-based Neutral Solutions	Abhijeet Sethi	03:40 –03:50
139	Experimental Investigations on Tool Wear Analysis in Dry Machining of KhN67VMTYu Super Alloy	Jayaram C Sasi	03:50 –04:00
148	Magnetorheological Ultra-Fine Finishing on the 3D Surface of K9 Optical Glass	Ajay Berry	04:00 –04:10
149	Machinability Analysis in Wire-EDM of Cryogenically Treated Ti6Al4V Alloy	Dr. Mithilesh K Dikshit	04:10 –04:20
151	Application of Machine Learning Techniques in Ecological Grinding of Inconel 718	Dr. Manoj Kumar Sinha	04:20 – 04:30

Session G1: Advances in Materials Joining

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. Kripa Shanker & Prof. Biswanath Doloi **Location:** Senate Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Effect of microstructure evolution during plastic deformation on the formability of Advanced High Strength Steels (AHSS)	Dr.Marrapu Bhargava	02:30 – 03:00
21	Numerical Study of the Effect of Tool Rotational Speeds on Material Flow and Strain Rates During Friction Stir Butt Welding of AA2219-T87 Plates	Bagadi Ramana Murthy	03:00 – 03:10
33	Effect of activated flux on SS304 under autogenous ATIG welding on weld geometry, microstructure, and hardness	Anand Baghel	03:10 – 03:20
48	Experimental Investigation of Dissimilar Laser Welding between Maraging Steel and Stainless Steel	Vishal Kumar	03:20 –03:30
55	Change in Reflectance of Silicon Wafer with Different Micro Patterned Surface Fabricated Using Fiber Laser	Tuhin Kar	03:30 –03:40
385	Comparative study on induction heating assisted hy-brid friction stir welding with friction stir welding of NiTinol in lap welding configuration	Susmita Datta	03:40 –03:50
73	The Behaviour of Dissimilar Welded Joint of Alloy 617/P92 Steel at High Temperatures	Amit Kumar	03:50 –04:00
88	Optimisation and microstructural analysis of wear characteristics on friction stir processed 2024 aluminium alloy	V S Senthil Kumar	04:00 –04:10
89	Scenario of joining various aluminium and its alloys for automobile applications by using FSW method	Sayon Dey	04:10 –04:20
91	Comparison of Mechanical Properties and Microstructural Characteristics of Conventional V-Groove and Narrow-Groove TIG-Welded Martensitic P92/304L Austenitic Stainless Steel Dissimilar Welded Joint	Gauravkumar Roshanlal Dak	04:20 – 04:30

Session H1: Trends in Materials Processing

Date: 08.12.2023 **Time:** 02:30 pm - 04:30 pm

Session Chairs: Prof. U. S. Dixit & Dr. Kaushik Bandyopadhyay **Location:** Seminar Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Recent trends in sheet metal forming	Dr. Kaushik Bandyopadhyay	02:30 – 03:00
14	Simulation of Ultra-Thin Strip Rolling using ABAQUS Explicit	Dantuluri Narendra Varma	03:00 – 03:10
30	Formability of tailor welded blanks and characterization of residual stresses-a review	Amit Kumar	03:10 – 03:20
64	Effect of Process Parameters on Surface Quality during Incremental Forming of Thin Sheets of Inconel 625	Ankit Kumar Gupta	03:20 –03:30
87	Selective area modification of Al alloy using PM green compacts of micro-nano sized powders in EDM	Bhargab Madhab Barua	03:30 –03:40
99	Investigation in the effect of texturing on indigenously developed PVD TiN coatings on cutting tool and its effect on the machining of Nimonic 90	Gaurav Kumar	03:40 –03:50
117	Characterization of TiN coating deposited by cathodic arc evaporation under various process parameter conditions	Arti Sahu	03:50 –04:00
460	Improvement of weld properties by friction stir processing	Kuldeep Singh Chauhan	04:00 –04:10
433	Design, Simulation, and Testing of 3D printed auxetic structure for Vibration Isolation	Allada Joshita, Ake Kowsik	04:10 –04:20

Session A2: Additive Manufacturing

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Prof. P M Pandey & Dr. Pawan Sharma **Location:** G4 Classroom

Paper ID	Paper Title	Presenting Author	Time
155	Mechanical strength and shrinkage investigation of fused filament fabricated H13 die steel	Subham Kumar Pandey	05:45 – 05:55
163	Structural Behaviour of Reinforced Polymer through Fused Filament Fabrication	Akash Jain	05:55 – 06:05
164	Investigating the fatigue behavior of 3D printed continuous carbon fiber reinforced polymer (CFRP) composites	Ankit Dhar Dubey	06:05 – 06:15
176	Experimental Investigation on the End Milling of Wire Arc Additive Manufactured Feature	M Shanmuka Srinivas	06:15 – 06:25
181	Experimental study on 3D printed gripper with nitinol tactile sensor for an improved gripping performance	Kashfull Orra	06:25 – 06:35
185	Porosity control in 4043 aluminium alloy fabricated through wire arc additive manufacturing process	Chanchal Chauhan	06:35 – 06:45

Session B2: Advances in Machining

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Prof. V. RadhaKrishnan & Dr. Govind Narayan Sahu **Location:** G5 Classroom

Paper ID	Paper Title	Presenting Author	Time
419	An Experimental Investigation on the Behaviour of Voltage and Current in Plasma Electrolytic Polishing	Prof. J. Ramkumar	05:45 – 05:55
160	Study of cutting performance of micro drilling of Ti-6Al-4V under different cutting parameter and MQL flowrates	Ashok Kumar	05:55 – 06:05
161	Modeling Chip Thickness Ratio and Shear Angle using Hybrid Nanofluids while Machining Inconel 718 under Minimum Quantity Lubrication	Mr. Kulkarni Paresh Vijay	06:05 – 06:15
168	Enhancing Low-Frequency Dynamic-Stiffness of Robotic Milling Machine Using Active Damping	Dr. Govind Narayan Sahu	06:15 – 06:25
171	Improvement of electrochemical micromachining by pulse amplitude modulation of step pulse waveform	Himadri Sekhar Panda	06:25 – 06:35
172	On the Electrochemical Discharge Milling of Polycarbonate using Vertically Upward Tool Feeding Technique	Sudip Santra	06:35 – 06:45

Session C2: Processing of Advanced Materials

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Dr. Tapash Kumar Nandy & Dr. Vinay Pratap Singh **Location:** G6 Classroom

Paper ID	Paper Title	Presenting Author	Time
128	Investigation on Mechanical properties of Bio-polymer nanocomposites for Artificial Bio-Bearing (ABB) applications	Prof. Rajesh Kumar Verma	05:45 – 05:55
154	Analyzing the Influence of Alloying Elements on the TribocorrosionBehavior of AZ91D Magnesium Alloy Fabricated by Stir-Ultrasonication-Squeeze Casting	Dr. A Gnanavelbabu	05:55 – 06:05
328	Effects of hBN/SiO2 Nano-sized Particles on the Performance of ZA-27 Composite	Anuj Kumar	06:05 – 06:15
354	Effect of moisture diffusion on Mode I/II fracture toughness of Banana-sisal fiber reinforced epoxy composites	Suganth V	06:15 – 06:25
425	A State-of-an-art Review of Challenges Associated with Different Drilling Methods in Carbon Fibre Reinforced Polymer and their Solution Techniques	Vaibhav Nitin Pawar	06:25 – 06:35
427	Preparation, Characterization, and Hydrothermal Performance of Carbon Quantum Dots-based Nanofluid for Coolant Application	Kartik Srivastava	06:35 – 06:45

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Session D2: Advances in Machining

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Dr. Manas Das & Dr. Manoj Kumar Sinha **Location:** G7 Classroom

Paper ID	Paper Title	Presenting Author	Time
174	Experimental Investigation into Electrochemical Discharge Turning of Cylindrical Glass	Sudip Santra	05:45 – 05:55
179	Effect of cutting parameters using uncoated and coated carbide tools on cutting force during micro milling of AZ31B magnesium alloy	Kartik Chandra Bhagat	05:55 – 06:05
183	Experimental and Numerical Investigation of Cu-Be Microchannel Heat Sink for Thermal Performance subjected to Pulsed Flow	Dr. Anup Malik	06:05 – 06:15
184	Performance analysis of different tool materials during μ-electrical-discharge milling of NiTi shape memory alloy	Satish Chaurasia	06:15 – 06:25
100	A Comparative Performance Study of Die Sink EDM and Near Dry EDM Processes in Machining of NIMONIC-90	Gangadharudu Talla	06:25 – 06:35
186	Experimental Investigations into Fiber Laser Marking on PMMA	Mohit Pandey	06:35 – 06:45

Session E2: Additive Manufacturing

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Prof. Santosh Kumar & Dr. Anubav Sinha **Location:** G2 Classroom

Paper ID	Paper Title	Presenting Author	Time
199	Investigations of impact and hardness property of the 3D printed PLA bio-composites	Neha Choudhary	05:45 – 05:55
200	Machine learning service optimization for a cloud-based additive manufacturing process in neutrosophic environment	Samriddhya Ray Chowdhury	05:55 – 06:05
210	Numerical assessment of thermo-mechanical behavior of a multi-layer additive manufacturing process	Prameet Vats	06:05 – 06:15
217	Numerical Modelling of Temperature Development in Laser Powder Bed Fusion of Stainless Steel 316L	Vishnu S	06:15 – 06:25
223	Experimental investigation on Laser Direct Energy Deposition of Inconel 625 under the Application of Ultrasonic Vibration and Inter-pass laser Remelting	Prabhat Kumar	06:25 – 06:35
229	Meniscus Guided Electrochemical Additive Manufacturing	D Sri Satya Omkar	06:35 – 06:45

Session F2: Advances in Machining

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Prof. Jose Mathew & Dr. Vivek Vajpai **Location:** G3 Classroom

Paper ID	Paper Title	Presenting Author	Time
188	Analysis on Grooving Characteristics of Al5052 Alloy Using Fiber Diode Laser	Mohit Pandey	05:45 – 05:55
189	The effect of dressing methods on the form accuracy of sintered PCD micro-grinding tools	Anang Katyayan	05:55 – 06:05
191	Effect of channel characteristics machined using μ-EDM on flow study	Aruna Kotlapati	06:05 – 06:15
195	Micro Ultrasonic Machining (Micro-USM) of Ti6Al4V Utilizing Multi Tip Micro Tools	Santosh Kumar	06:15 – 06:25
204	A Novel Approach Based on Reliability Concepts to Reduce Part Errors by Considering Thermal Errors of Machine Tools	Shashi Bhushan Gunjan	06:25 – 06:35
378	Grinding of Titanium Grade 5: A Review	Dr. Pranab Kumar Kundu	06:35 – 06:45

Session G2: Processing of Advanced Materials

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Dr. Deepak Deelip Patil & Dr. Akhilendra Pratap Singh **Location:** Senate Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
27	Effect of Unidirectional and Bidirectional cold-rolling on Magnetic properties of High entropy alloy	Rajnish Prakash Modanwal	05:45 – 05:55
62	Effects of quenching & partitioning treatment on microstructure and mechanical integrity of hot rolled microalloyed steel	Anup Kumar Maurya	05:55 – 06:05
82	Hydrogen Embrittlement and its prevention in high strength steel material	Vijay Katare	06:05 – 06:15
109	High velocity impact behavior of co-continuous ceramic composite with different volume fractions	Dr. V Krishnaraj	06:15 – 06:25
125	Experimental Studies on AA7475 Composites	Dr. A. Sreenivasulu Reddy	06:25 – 06:35
150	Influence of Retrogression and Reaging Treatments on the Electrochemical Corrosion Behavior of AA2014/Al2O3 Nanocomposites	Dr. A Gnanavelbabu	06:35 – 06:45

Session H2: Advances in Materials Joining

Date: 08.12.2023 **Time:** 05:45 pm - 06:45 pm

Session Chairs: Dr. M Z Khan & Dr. Marrapu Bhargava **Location:** Seminar Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
110	Direct bonding of Cu to Cu for high-technology applications	Dipin Kumar R	05:45 – 05:55
111	Laser Welding of Two Transparent Plastics without Any Filler Materials	Nitesh Kumar	05:55 – 06:05
113	A Numerical Analysis of Self-Piercing Riveting of Aluminium alloys using Aluminium rivets	Swaraj Pritam Swain	06:05 – 06:15
234	Analyzing Online Thermal Signature for Bead Geometry and Microstructure in Laser Material Deposition (LMD) of NiCoCrAlYHfSi for Gas-Turbine Components	Saikat Nandi	06:15 – 06:25
275	Joining of dissimilar AA6063-T6 and CRCA/IS-513 alloys by FSSW-C and conventional FSSW: A comparative study through modelling and simulations	Sukanta Das	06:25 – 06:35
444	Effect of porosity and inter-metallics on the Microstructure based finite element analysis of Al-Si alloy	Gangarapu Akhila	06:35 – 06:45

Session A3: Additive Manufacturing

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Ramesh Babu & Prof. J. Ramkumar **Location:** G4 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Revolutionizing material processing through Electrochemical Dissolution based processes	Prof. J. Ramkumar	09:00 –09:30
230	Effect of Loading Orientation on Compressive Strength of Owl Feather-Inspired Cellular Structure: Experimental Investigation	Rakesh Kumar Sharma	09:30 –09:40
243	Assessment of microwave heat treatment on mechanical and microstructural behavior of Co-Cr alloy dental parts fabricated through selective laser melting	Mohit Kumar	09:40 –09:50
246	Material Utilization Efficiency-Guided Laser-Direct Energy Deposition of Inconel 718 Alloy Powder for Aeroengine Components	Prasenjit Patra	09:50 –10:00
271	3D printed graded metamaterial for acoustic applications	Prof. J. Ramkumar	10:00 –10:10
274	Functionalization of Additively Manufactured Ti alloy using Grinding Process: Achieving Uniform Surface Roughness	Mehsana Ahmed	10:10 –10:20
281	Unleashing the Mechanical Characteristics of PLA-MWCNTs for Medical Advancements	Bobby Tyagi	10:20 –10:30
283	Evaluating the influence of infill density for impact behaviour of virgin PLA and its composites	Tapish Raj	10:30 –10:40
293	A Review on Additively Manufactured Prosthetic devices	Ajeet Manna	10:40 –10:50
297	Tensile properties of polyether ether ketone printed by fused deposition modelling	Anilbabu Puli	10:50 –11:00

Session B3: Advances in Machining

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Dr. Anant Kumar Singh & Dr. Raju Shrihari Pawade **Location:** G5 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Impactful Surface Finishing Techniques for Industry 4.0	Dr. Anant Kumar Singh	09:00 –09:30
214	Experimental Comparative Analysis of Conventional and EDM Micro-drilling Process on SLM Produced Marag-ing Steel	Jino Joshy	09:30 –09:40
220	Influence of laser annealing of Kapton polyimide substrate on non-contact-based actuation of NiTi Shape Memory Alloy bimorph based smart actuator	Kaushal Gangwar	09:40 –09:50
221	Exploring the potential of Laser-Assisted Machining on Ti6Al4V: A numerical and experimental study	Muruga Prabu U	09:50 –10:00
226	Comparative Study of Different Flank Face Textures on Coated Carbide Tool during Machining of Hardened H13 Steel	Arunabh Choudhury	10:00 –10:10
227	Fabrication of Titanium Nanotubes for Anti-fogging Application	Ratan Ahuja	10:10 –10:20
233	Stability enhancement of the boring bar by implementing a particle damping approach	Ganesan Ramu	10:20 –10:30
236	A New Mechanistic Approach for Selection of Machining Parameters in Micro Milling for Mitigating Size Effects and Chatter	Vishnu Kumar Singh	10:30 –10:40
238	Improving Grindability of Stainless-Steel Clad Surface Using SiC Wheel	Sudipta Ghosh	10:40 –10:50
157	Design and Analysis of a New Magnetorheological Worm Gear type Finishing Process for Improved Productivity	Shubham Khatri	10:50 –11:00

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Session C3: Digital Manufacturing

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Satyandra Kumar Gupta & Dr. Mohit Law **Location:** G6 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Vision-based modal analysis of machine tool systems	Dr. Mohit Law	09:00 –09:30
25	Design and In-House Development of Automatic Tube Filling Machine	Rahul Kumar	09:30 –09:40
36	Quality Assessment of Ultrasonic Welded Joints Using Image Processing Technique	Sandeep Bose	09:40 –09:50
66	Unsupervised weld defect classification through local deep image representative features	Satish Sonwane	09:50 –10:00
71	An experimental study to predict conveying velocity of a vibratory conveyor feeder using Machine Learning	Ganesh Kumar Nithyanandam	10:00 –10:10
135	Modelling of cranial implant and its prototype development using head CT scan data	Deepak Kumar	10:10 –10:20
203	RAM Analysis of the A-Pan Boiling System in the Sugar Industry	Suyash Singh	10:20 –10:30
206	The automatic classification of SS304 TIG welding defects uses visible-spectrum camera images and machine-learning technology	Aman Nohwal	10:30 –10:40
211	Ball bearing fault identification using K-nearest neighbour classifier	Samrat Mandal	10:40 –10:50

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Session D3: Advances in Machining

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. P. Hariharan & Dr. Anirban Naskar **Location:** G7 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Measurement of grinding-induced deformation-depth using grazing incidence X-ray diffraction technique	Dr. Anirban Naskar	09:00 –09:30
239	Micro-Channel Fabrication in Glass Using Nickel Coated Copper Tool in ECDM Machining and Optimization of Process Parameters	Akhilesh Kumar Tiwari	09:30 –09:40
245	Experimental investigation and hybrid metaheuristic optimization using ANN-MOJAYA on corner accuracy during WEDM for Ti-3Al-2.5V	Vivekananda Kukkala	09:40 –09:50
254	Investigation of Variant Electrodes in Electrochemical Micromachining of Stainless Steel 904L	E Rajkeerthi	09:50 –10:00
255	Temporal Feature Analysis of Audio Signal for Instabil-ity Identification in High-speed Micromilling of Thin-walled Ti6Al4V	Gururaja S	10:00 –10:10
257	Micro machinability evaluation of bottom pouring stir cast Al6061/GNPs nanocomposites	Sunil Rawal	10:10 –10:20
259	Influence of Voltage and Scanning Rate on Surface Finish in Electrochemical Jet Machining (EJM) of Ti6Al4V	Arindam Maity	10:20 –10:30
273	Inclusive application of polymer 3D printing and metal additive manufacturing for the development of modular-insert type wheels for green grinding	Sarath Babu Thekkoot Surendran	10:30 –10:40
277	A comparative study on surface roughness analysis during turning of additively manufactured and wrought Inconel-718	Dr. Kamlesh Joshi	10:40 –10:50
285	Optimization of Abrasive Jet Drilling on Alumina Plate using Silicon Carbide Abrasive	Deb Kumar Adak	10:50 –11:00

Session E3: Additive Manufacturing

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Dr. Debajyoti Bhaduri & Dr. Abhishek Das **Location:** G2 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Understanding the current and emerging joining technologies for electric vehicle battery pack manufacturing	Dr. Abhishek Das	09:00 –09:30
299	Geometrical analysis of bead in Direct Current Electrode Positive-based Submerged Arc Additive Manufacturing (SAAM)	Suraj Goala	09:30 –09:40
302	Numerical study on critical wire size for titanium melting through high-frequency induction heating for additive manufacturing process	Avadh Kishore Prasad	09:40 –09:50
307	Selective Laser Sintering of CNTs-PA12 Polymer Nanocomposites	Jairam Raigar	09:50 –10:00
310	Predictive Model for Deposition Success in Wire Laser Additive Manufacturing	Anas Ullah Khan	10:00 –10:10
313	Feasibility Study on Additive Manufacturing of Inconel 625 and Aluminum Bimetallic Parts	Manjunath Bn	10:10 –10:20
323	Development of CNN Framework for Surface Defect Analysis in WAAM of Bio-Compatible Ti6Al4V	Alok Kumar	10:20 –10:30
335	Study of Aspect Ratio of Laser Directed Energy Deposition of Inconel 718 Alloy	Ajay Kumar Maurya	10:30 –10:40
336	Analysis and Fabrication of Functionally Graded Prosthetic Socket using Fused Filament Fabrication	Mohit Teacher	10:40 –10:50
343	3D- Printed Graphene Supercapacitors for Flexible and Wearable Electronics	Sudhansu Sekhar Nath	10:50 –11:00

Session F3: Advances in Machining

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Ajay M. Sidpara & Prof. Santanu Das **Location:** G3 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Effect of Beveled Exit Edge on Burr Formation in Drilling	Prof. Santanu Das	09:00 –09:30
287	Influence of Microtool's Shape and Size on Microchannel Fabrication through Micro-EDM	Abhijeet Sethi	09:30 –09:40
290	Low-cost fabric-based wearable energy storage device	Soumili Sahoo	09:40 –09:50
298	Surface topographical characterization of ZnO nanostructured CFRP composite in high speed micro drilling	Arnab Das	09:50 –10:00
300	A Comparative Study of Die-sinking EDM and Electrical Discharge Drilling (EDD) Process for making small holes in Cemented Carbide	Prof. S K S Yadav	10:00 –10:10
305	Tool Condition Monitoring Techniques in Micromilling: A Review	Avinash Harischandra Kamble	10:10 –10:20
311	High-Infeed Grinding of Aluminium Composite by Patterned Diamond Tool	Trilochan Prasad Nanda	10:20 –10:30
312	Laser-based drilling of Granite: morphological and microstructural studies	Antash Kishore Sinha	10:30 –10:40
315	Dry and near dry grinding with patterned brazed CBN wheel	Bandana Priyadarshini	10:40 –10:50
272	A Comparative Thermal Analysis of Aluminum Welding using Friction Stir Welding (FSW), Plasma-FSW, and Tungsten Inert Gas (TIG)-FSW	Deepak Kumar Yaduwanshi	10:50 –11:00

Session G3: Advances in Materials Joining

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Jeevan Jaidi & Dr. Lakshay **Location:** Senate Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	FSW Tool-pin Profile Effects on Material Flow Mixing and Weld Geometry: A numerical study using different approaches and their limitations	Prof. Jeevan Jaidi	09:00 –09:30
278	Thermomechanical Modeling and Analysis of Friction Stir Butt Welding of Aerospace Grade Aluminium-alloy (2219-T87) Plates	Bagadi Ramana Murthy	09:30 –09:40
286	Experimental Investigations and Development of a Welding Fixture for Friction Stir Welding of Titanium Alloys	Ramprasad G	09:40 –09:50
322	Design and Development of FSW Tool for Carbon-Manganese Steel	Sanjay Raj	09:50 –10:00
341	Multipass Friction Stir Welding of Age Harden Aluminum alloy	Sunil Kumar Yadav	10:00 –10:10
351	High Strain Rate Electromagnetic Crimping on a Variation of Impact Target Geometry	Ummed Singh	10:10 –10:20
357	Influence of ALCLAD layer on the process responses during dissimilar micro-friction stir welding (μFSW) of aluminum alloy sheets	Mayank Verma	10:20 –10:30
384	Predicting weld interface profile of laser wobble welding using an analytical approach at early design stage	Indranil Manna	10:30 –10:40
70	Laser overlap welding of tab-to-terminal electrical interconnects for electric vehicle battery pack	Nikhil Kumar	10:40 –10:50
405	Quality Assessment of fabricated micro-holes on microsliced Ti-6Al-4V alloy sheet using Maglev EDM	Prof Nirmal Kumar Singh	10:50 –11:00

Session H3: Trends in Materials Processing

Date: 09.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Dr. Kishor Kumar Gajrani & Dr. Venkatesh Gudipadu **Location:** Seminar Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Hybrid Metal Additive Manufacturing	Kishor Kumar Gajrani	09:00 –09:30
142	An experimental effort implemented over CVD TiSiN thin film coating to improve mechanical and corrosion properties by annealing	Dr. Spandan Guha	09:30 –09:40
143	Cyclic oxidation behavior of free-standing plasma sprayed Al_2O_3 - Cr_2O_3 coatings at 1000 °C temperature	Setu Suman	09:40 –09:50
156	Single point incremental forming of CRCA-Tailor welded sheets	Yogesh Kumar Dewangan	09:50 –10:00
158	Prediction of Bending Angle of Ti6Al4V Alloy Sheets Formed Multiple Laser Irradiations	Sujit Murlidhar Mulay	10:00 –10:10
231	Synthesis and Characterization of Electroless Ni-P-Al_2O_3 Composite Coating on Aerospace-grade Mg Alloy for Improving Wear Resistance	Dr. Tushar Banerjee	10:10 –10:20
247	Prediction of Cup Height using Non-Associated Flow Rule during Square Deep Drawing of Anisotropic Sheets	Amit Kumar	10:20 –10:30
252	AFM Surface Morphology Investigation of Micro Holes on AISI 316 Stainless Steel by EDM Drilling	Dr. U Ashok Kumar	10:30 –10:40
258	Effect of weld zone and forming histories on crushing behaviour of stretch-formed domes of laser welded blanks	Bhupesh Singh Katiyar	10:40 –10:50

Session A4: Additive Manufacturing

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. Murali Sundaram & Dr. Kapil Kumar **Location:** G4 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Nature Inspired Optimization Algorithm	Dr. Kapil Kumar	03:30 –04:00
348	Staircase effect in Laser decal transfer based μ-3D printing for curved structure.	Anshu Sahu	04:00 –04:10
349	Printability of AlSi10Mg and Ti6Al4V in LPBF using Machine Learning	Md Tabraiz Imam	04:10 –04:20
355	A New Method for Part Consolidation and Functional Integration	Senthilkumaran K.	04:20 –04:30
356	Microstructural characterization of AZ31B deposit made by novel PBFS process	Prabhakar Kumar Singh	04:30 –04:40
360	Computational analysis of additively-manufactured tablets with hybrid infill pattern	R Durga Prasad Reddy	04:40 –04:50
370	Laser Polishing of Additive manufactured Cobalt Chrome Alloy by Continuous Wave Line Focused Beam: A Response Surface Methodology based approach for improving Surface finish	Abhishek Kumar	04:50 –05:00

Session B4: Advances in Machining

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. S. S. Joshi & Dr. Dasarath Ram Yadav **Location:** G5 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Digital Twins in the field of Prognostics and Condition monitoring	Dr. Sabareesh G Rajasekharan	03:30 –04:00
316	Artificial Neural Network-Based Prediction of Wire EDM Performance Characteristics during Machining of Ni50.3-Ti29.7-Hf20 SMA	Balaji V	04:00 –04:10
318	Electrochemical machining with identical polarity of tool and workpiece: A feasibility study	Maran R	04:10 –04:20
320	Deep Learning-based Neural Network for flank wear prediction using Acoustic Emission signals on Inconel 617 alloy	Pramod A	04:20 –04:30
321	An Experimental Analysis on Vertical Milling of Ti-6Al-4V under SQL based DBD Technique	Dr. Pranab Kumar Kundu	04:30 –04:40
325	Fabrication of Tungsten carbide tool for micro-ECDM process through ECM using different electrolytes: a comparative study	Monika Singh	04:40 –04:50
18	Neural Network Based Modelling for the comparative prediction of Material Removal Rate and Surface Roughness in fabricating channels on glass and silicon surface through the M-ECSMM process	Kriti Sahai	04:50 –05:00

Session C4: Modelling & Simulation in Manufacturing

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. G L Samuel & Prof. S.K. Panda **Location:** G6 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Modeling, Simulation and verification of femto second laser micro machining process	Prof. G L Samuel	03:30 –04:00
63	Modeling and Prediction of Thermal Properties of Formulated SMAW Coating Flux Using ANFIS Model	Aditya Kumar	04:00 –04:10
69	Influence of geometric error of a five-axis CNC milling machine on the accuracy of face gear tooth surface	Prasmit Kumar Nayak	04:10 –04:20
74	Investigating the Effect of Mesh Parameters in Finite Element Simulation of Single Point Incremental Forming Process	Kirtan Paritoshkumar Lad	04:20 –04:30
93	Investigation of Surface Roughness Parameters under Dry End Milling of Inconel 625 with Coated Tool	Dr. Ramesh Rajguru	04:30 –04:40
102	Comparative Study of Multi-response Parametric Optimization of EDM Processes using Preying Behaviour Metaheuristic Algorithms	Devendra Pendokhare	04:40 –04:50
413	Effect of Electrode Load Schedules on Nugget Size and Residual Stresses in Resistance Spot Welding of Mg-alloy/Steel Sheets: A numerical study	G Prashanth Kumar Reddy	04:50 –05:00

Session D4: Advances in Machining

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Dr. D Samuel Raj & Prof. Promod Kumar Patowari **Location:** G7 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Application of Used Cooking Oil (UCO) for MQL Machining - A Feasibility Study	Dr. D Samuel Raj	03:30 –04:00
407	Fabrication of Low Friction Al-Based Metal Matrix Composites and its Machinability Study	Prof. Promod Kumar Patowari	04:00 –04:10
334	Exploring Machining Capabilities of Al-Mg2Si-Si Rod with Coated Carbide Insert	Dipanwita Biswas	04:10 –04:20
337	Influence of surface textures and tribological process parameters on frictional characteristics of Al alloy	Vikas Kumar Sahu	04:20 –04:30
338	Influence of Grain-Size on Formability in Micro-Incremental Sheet Forming of Ultra-Thin Titanium Grade 2 Foils	Mainak Pal	04:30 –04:40
358	Pair-wise Comparison of Crucial Barriers to Circular Supply Chain Adoption towards Sustainable Manufacturing Prospects: An ISM-based Approach	Rita Nagwal	04:40 –04:50

Session E4: Additive Manufacturing

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. N V Reddy & Dr. M Duraiselvam **Location:** G2 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Additive Manufacturing in Aerospace Industries	Dr. M Duraiselvam	03:30 –04:00
374	Sustainable Manufacturing of Metal Additive Powders from Machining Scrap	Karan Baramate	04:00 –04:10
376	Investigation on Influence of Various Operating Parameters in Wire Arc Additive Manufacturing using ER4043 Aluminium Alloy	Kayyala.Venkateswarlu	04:10 –04:20
381	Microstructural and Mechanical Studies of Maraging Steel Fabricated by Laser-Powder Bed Fusion and Conventional Processes: A Comparative Study	Manoj Kumar	04:20 –04:30
382	Numerical and Experimental Investigation of Freeform Fabricated Auxetic Structure-based Planar Mechanical Metamaterial	Shubhangee Singhal	04:30 –04:40
383	Prediction of Tensile strength of Additively Manufactured Continuous Carbon Fiber Reinforced Polymer Composites through Machine Learning approach	Dr. M Duraiselvam	04:40 –04:50
392	Effect of Inter-track Offset on the Dimensional Accuracy of Thick Wall Produced by Wire Arc Additive Manufacturing Process	Soumyadip Das	04:50 –05:00

Session F4: Advances in Machining

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. B. B. Ahuja & Dr. Amit Tyagi **Location:** G3 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Post-Processing of the Additively Manufactured Biomedical Implants through Hybrid Electrochemical Magnetorheological Finishing Process	Dr. Manas Das	03:30 –04:00
372	Experimental Investigations on Plasma Cutting of Medium Carbon Steel	Dr Anand Petare	04:00 –04:10
212	Modelling of microchannel cross-sectional profile generated on Ti-6Al-4V alloy by micro-abrasive waterjet	T N Deepu Kumar	04:10 –04:20
379	A new way of estimation of feedrate in centreless grinding process using video analysis.	Amal Dev B S	04:20 –04:30
393	A comparative assessment to evaluate force and stress of Nimonic 80A for different grinding schemes	Aswani Kumar Singh	04:30 –04:40
397	Effectiveness of near-dry milling of austenitic stainless steel using HiPIMS deposited TiAlSiN nanocomposite with variable Ti and Si content	Chayan Ranjan Das	04:40 –04:50
371	Modification of surface topography of Inconel 625 by fabricating ordered micro-textures using micro milling	Surya Prakash Singh	04:50 –05:00

Session G4: Processing of Advanced Materials

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. R.K. Gautam & Dr. Spandan Guha **Location:** Senate Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Impact of post heat treatment over coating materials.	Dr. Spandan Guha	03:30 –04:00
24	Effect of Heat Treatment on the Properties and Microscopic Characteristics of Different Alloys Used in Gas Turbine Engines	Geetika Kumari Salwan	04:00 –04:10
153	The Impact of Inorganic Fillers on the Static and Dynamic Mechanical Properties of Polyester Resin composites	Prof. J. Ramkumar	04:10 –04:20
241	Effect of strain rate on high temperature deformation behavior of low carbon Steel	Praveen Gagrai	04:20 –04:30
359	CO2 Laser Surface Modification of Green Si3N4 - SiO2 Ceramic for Enhanced Texture and Quality	Rajaram Kumar Gupta	04:30 –04:40
363	Preliminary investigation of development and tribological behavior of bilayer electroless Ni – B coating with copper inclusion tin stabilized bath	Abhinandan Kumar	04:40 –04:50

Session H4: Advances in Materials Joining

Date: 09.12.23 **Time**: 03:30 pm –05:00 pm

Session Chairs: Prof. Prabu Raja & Dr. Saurabh Pratap **Location:** Seminar Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Structural integrity assessment of welded structures - a case study	Prof. Prabu Raja	03:30 –04:00
387	Quantifying energy vs time mode variations obtained from ultrasonic metal welded busbar-to-busbar joints	Vijay Sharma	04:00 –04:10
388	Numerical and Experimental Analysis of the Effect of Sheet Thickness Ratio on Clinching of AA6061-T6 Sheets	Priyabrata Nath	04:10 –04:20
389	Optimisation of process parameters to fabricate tubular components of AA5083-O alloy using friction stir welding for crashworthiness applications	Debolina Sen	04:20 –04:30
398	Influence of Selective Microwave Hybrid Heating Process Parameters on Mechanical Characteristics of Inconel 625/SS 304 Dissimilar Weldment	Devendra Laxman Kamble	04:30 –04:40
406	A State-of-the-Art Review on Laser Welding of Polymers- Recent Progress, Limitations and Research Gap	Dr. Abhishek Sen	04:40 –04:50
432	Activated Tungsten Inert Gas Welding Process: A Review	Manish Kumar Jindal	04:50 –05:00

9th International & 30th All India Manufacturing Technology, Design and Research Conference

(AIMTDR 2023)

December 08-10, 2023

Session A5: Additive Manufacturing

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Dr. Neeraj Sinha & Prof. Rajnesh Tyagi **Location:** G4 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Fruit Waste Based Polymer Composites: Processing, Characterization and Applications	Dr. Hitesh Sharma	09:00 –09:30
394	Effect of print direction on tribological behavior of DMLS manufactured Ti6Al4V alloy for knee implant application	Vipin Goyal	09:30 –09:40
411	Investigation on Mechanical and Metallurgical Properties of CMT- WAAM of Copper Coated Mn-Si Alloy Steel	Ch R Vikram Kumar	09:40 –09:50
105	Fabrication of porous Aluminum structures using Laser Powder Bed Fusion for electronic applications	Nobel Karmakar	09:50 –10:00
422	Effect of build direction planes on microstructure, corrosion and wear of selective laser melted components	Tharra Bhavani	10:00 –10:10
426	A Numerical Simulation of Ceramic Powder Particles Interaction with Laser Powder Feed Additive Manufacturing	Amit Kumar	10:10 –10:20
428	Powder layer preparation by novel gravity-based powder spreading system for additive manufacturing	Aakash Tyagi	10:20 –10:30
429	A novel 5 axis hybrid scissor-based machine tool for additive manufacturing	Kanak Jindal	10:30 –10:40
443	Additive manufacturing of Stainless steel 316L by Fused deposition modeling	Sankata Tiwari	10:40 –10:50
461	Surface topography of additively manufactured carbonfiber reinforced polymer composites	Anand Sankar M	10:50 – 11:00

Session B5: Advances in Machining

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Dr. C. Samuel & Dr. U. S. Rao **Location:** G5 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Blockchain in Manufacturing, Operations and supply chain management	Dr. C. Samuel	09:00 –09:30
409	Experimental investigation of material removal mechanism and residual stress in grinding of HVOF sprayed conventional and nano-structured WC-Co coating	Puneet Nasna	09:30 –09:40
414	Numerical Investigation of Laser Micromachining of Al-SiC Composite	Simson D	09:40 –09:50
159	The evaluation of mechanical and magnetic properties of hot die steel after sustainable grinding using Barkhausen emission technique	Dr. Akash Subhash Awale	09:50 –10:00
430	Simultaneous Electric Discharge and Electrochemical Polishing of Metal Additive Manufactured Components	Tejas Petkar	10:00 –10:10
439	Investigation on the mixing behavior in microfluidic channels with varying cross sections	Deepak Singh D	10:10 –10:20
448	Finite Element-Based Simulation of Thermal Stresses Developed during Micro-Electric Discharge Machining (μEDM) of AISI 1080 Stainless Steel	Rajiv Kumar	10:20 –10:30
450	Quality evaluation of precision-shaped film cooling holes machined on aerospace nickel-based superalloy using femtosecond laser trepan drilling technique	Sunil Kumar	10:30 –10:40
451	A Comparative Analysis of Finishing Performance of Abrasive Flow Machining (AFM) Variants	Nitin Dixit	10:40 –10:50
237	Current maturity level assessment of Indian MSMEs on the Net Zero transition journey	Gaurav Upadhyay	10:50 –11:00

Session C5: Digital Manufacturing

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. P. Bharadwaj & Dr. P.C. Mani **Location:** G6 Classroom

Paper ID	Paper Title	Presenting Author	Time
224	EEG-based Color Classification for Industry 4.0 Applications	Mayukh Mondal	09:00 –09:10
284	Integrating machine vision with machine learning for predicting surface quality of abrasive waterjet milled parts	Chinmoyee Datta	09:10 –09:20
324	An IoT-embedded smart sustainable reverse logistics system towards the circular economy	Dr. Dhirendra Prajapati	09:20 –09:30
329	Assembly Sequence Planning by a Modified Particle Swarm Optimisation Algorithm	Gobinda Chandra Behera	09:30 –09:40
339	Stacked ensemble learning based bearing fault diagnosis	Subhendu Ghorai	09:40 –09:50
342	Optimizing Machining Processes with Digital Twin Technology: A Review of Recent Developments	Rajat Jain	09:50 –10:00
352	Remaining Useful Life Prediction using Physics-Based Approach and Machine Learning Techniques	Dr. Sudha Radhika	10:00 –10:10
362	Development of tool wear monitoring system using data-driven approach	Sabareesh G Rajasekharan	10:10 –10:20
431	Non-Invasive Digital Twin for Pedagogical Purposes in Digital Manufacturing	Dr. Prakruthi Hareesh	10:20 –10:30
152	Investigation of Fabricating Stainless Steel 304L Thin Wall Structure using Laser Marking Assisted Wire Arc Additive Manufacturing Process	Krishnpal Singh Tomar	10:30 –10:40
20	Topology Optimization and Modal Analysis of Engine Bracket Arm Using Additive Manufacturing	Saurabh Srivastava	10:40 –10:50

Session D5: Modelling & Simulation in Manufacturing

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. B Bhatacharya & Dr. Debasish Khan **Location:** G7 Classroom

Paper ID	Paper Title	Presenting Author	Time
104	Prediction of Thermophysical Behaviour of Laboratory-Developed SMAW Coatings of Electrode for Marine Applications	Sudish Mishra	09:00 –09:10
418	Application of Design Thinking Attributes for Product Innovation in Manufacturing Sector: ISM based Framework	Dr. Sudeshna Roy	09:10 –09:20
421	Novel Johnson-Cook Constitutive Model for Hot Tensile Response Prediction of AZ31B alloy	Aarjoo Jaimin	09:20 –09:30
166	Metallurgical characterization of friction stir welded marine grade aluminum alloy: Experimental investigation and ALE FE approach	Rituraj Bhattacharjee	09:30 –09:40
449	Multi-objective optimization-based design of high-speed machine tool spindle considering thermo-mechanical behavior	Anirban Tudu	09:40 –09:50
452	Optimization of Die Design Parameters for Connecting Rod using FEM and Taguchi Methodology	Siddharth Yadav	09:50 –10:00
434	Quantitative Phase Analysis and Image Processing Using MATLAB	Porika Abidsinghrajput	10:00 –10:10
423	Application of Value Engineering Function Analysis on FDM 3D Printer Development	Prof. J. Ramkumar	10:10 –10:20
295	Developed a Mathematical model for Sustainable Flow Shop Scheduling Problem	Suneet Singh	10:20 –10:30
326	Simulation of Magnetic Field and Force with Varying Shapes of an Electromagnetic Forming Coil for the development of the Wheelchair Structure using FEA	Tushar Tiwari	10:30 –10:40
424	Formability analysis of an automotive sheet metal component	Ravinder Kumar	10:40 –10:50
26	Effect of SiC and B4C Addition on The Properties of Aluminium Metal Matrix Hybrid Composites	Mohammad Umair Zaki	10:50 – 11:00

Session E5: Processing of Advanced Materials

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Geeta Latkar & Prof. R Ganesh Narayanan **Location:** G2 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Fracture Modes During Quasi-Static and Shock Tube Impact Testing of Friction Stir Extrusion Joined Metallic Structures	Prof. R Ganesh Narayanan	09:00 –09:30
193	Mechanical Strength Analysis of Adhesive films for Microwave Metamaterial Absorbers	Prof. J. Ramkumar	09:30 –09:40
52	Analysis of bending angle in laser forming of thin Al 6061-T6 sheets	Dr. Vinod Yadav	09:40 –09:50
390	Laser Micromachining of PDMS-Water based Transparent Microwave Metamaterial Absorber	Prof. J. Ramkumar	09:50 –10:00
377	Characterization of Poly (Methyl Methacrylate)/ Silver-Doped Hydroxyapatite Dip Coating on Ti6Al4V	Gagan Bansal	10:00 –10:10
446	Investigation of Micromilling of Copper Oxide Nanostructured CFRP Composites	Abhipsa Kar	10:10 –10:20
447	Direct Ink Writing of Medical Grade Silicon Nitride: A review of material, method, applications and challenges	Govind Kumar Verma	10:20 –10:30
68	Analysis of temperature and microstructure evolution during laser line heating of Titanium metal sheets	Dr. Vinod Yadav	10:30 –10:40
367	Effect of Carbon-Vacancy on Microwave Heating Characteristics of 3C-SiC	T L Dora	10:40 –10:50
464	Experimental Investigation on Face Turning of IN-100 Superalloy under Environment-Friendly Vegetable Oils	D Saiteja	10:50 –11:00

Session F5: Modelling & Simulation in Manufacturing

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Soumya Gangopadhyay & Dr. Harlal Singh Mali **Location:** G3 Classroom

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Smart Manufacturing: Research and Challenges	Dr. Govind Narayan Sahu	09:00 –09:30
404	Finite element simulation of chip formation and experimental characterization during dry machining of Inconel 617	Soumya Gangopadhyay	09:30 –09:40
178	Kinematic Simulation of 6-DOF CTEV (Clubfoot) Corrective Orthosis for its Automation Feasibilities during its Integrated Manufacturing	Dr Harlal Singh Mali	09:40 –09:50
190	Influence of Welding Sequence on Residual Stresses and Distortions in AA6061-T6 Pipe-to-Plate Joints	Tapas Bajpai	09:50 –10:00
192	Experimental evaluation, modelling and sensitivity analysis of temperature in bone milling using Elastic-net regression	Jaseem Sajidh N A	10:00 –10:10
222	Optimization of the tuned mass damper cavity geometry and its location of the passive damped boring bar	Mariselvan P	10:10 –10:20
225	Multi Objective Optimization of RMS configuration with hybrid approach of NSGA II and TOPSIS	Harshita Gupta	10:20 –10:30
228	A numerical technique of analyzing temperature distribution in friction stir lap welding of Al-Mg-Si alloys under different process parameters	Ankan Das	10:30 –10:40
240	Fracture Identification during Incremental Forming Process using Calibrated Damage Models with Optimized Sample Geometries	Abdul Samad	10:40 –10:50
333	Controlled environment sintering of Si3N4-SiO2-BN system and calculations of density and porosity	Prosenjit Dutta	10:50 –11:00

Session G5: Modelling & Simulation in Manufacturing

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Dr. J V Tirkey & Dr. Srihari Dodla **Location:** Senate Hall (Swatantrata bhawan)

Paper ID	Paper Title	Presenting Author	Time
462	Effects of lamellar thickness on the deformation behavior in Cu/Ag bicrystals - An Atomic Simulation Study	Dr. Srihari Dodlaa	09:00 –09:10
253	Numerical Investigations of Cold Extrusion Parameters on AA 2024 alloy	K Anupama Francy	09:10 –09:20
260	A method to control an in-situ temperature in micro end milling of Ti6Al-4V	Syed Naveed UlMeiraj	09:20 –09:30
280	A Numerical Study on KrF Excimer Laser Ablation of Unidirectional CFRP Using Simplified Geometric Models with Two Separate Strategies	Joydeep Kundu	09:30 –09:40
292	Finite-Element Simulation Study of Electrode Configurations on Weld Quality Parameters of Resistance Spot Welding of Aluminium-alloy/Steel Sheets	G Prashanth Kumar Reddy	09:40 –09:50
347	Process modeling of additive friction stir deposition	Ram Rapaka	09:50 –10:00
391	Extrusion of Non-Symmetric shapes: Simulation and Experiment	Pratik Kumar Singh	10:00 –10:10
401	Thermal Error Compensation for CNC Turning Machine Using Regression Analysis.	Aslam Taj Pasha	10:10 –10:20
126	Experimental and computational investigation of J-integral Al-7075	Vineet Kumar	10:20 –10:30
408	Estimation of critical heat sources for high-speed motorized spindle using inverse optimization method	Amal Prasad	10:30 –10:40
251	Finite Element Analysis to Predict Post Pelvic Stability Subjected With Triangular and Circular Pattern of Bone Harvesting in Bone Autograft Surgery	Syed Naveed UlMeiraj	10:40 –10:50
296	Prediction of wettability characteristics of SMAW electrode coatings using neural network modelling for power plant welds	Vijay Kumar	10:50 – 11:00

Session H5: Trends in Materials Processing

Date: 10.12.23 **Time**: 09:00 am – 11:00 am

Session Chairs: Prof. Partha Saha & Dr. Naveen Kumar **Location:** Seminar Hall (Swatantrata bhavan)

Paper ID	Paper Title	Presenting Author	Time
Invited Talk	Erosion behavior of Nitrogen Containing Steels and bead-on-plate Welds	Dr. Naveen Kumar	09:00 –09:20
262	Deformation behaviour of friction stir welded Cu-Cr-Zr-Ti alloy sheet during single point incremental forming	Dibya Ranjan Behera	09:20 –09:30
303	Influence of Laser Texturing on Contact Separation and Sliding Mode Triboelectric Nanogenerator for Vibration Sensing	Diksha Jaurker	09:30 –09:40
380	Development of Electroless Ni-B Coating with Enhanced Hardness using ANN-GA Methodology	Subhash Kumar	09:40 –09:50
396	Evaluation of microstructural, mechanical, and tribological properties of laser-treated electroless Ni-B coatings	Vaibhav Nemane	09:50 –10:00
420	Effect of addition of CNT in mitigating dissociation of B4C and in situ formation of TiC on Ti64 substrate during Laser Cladding process to achieve hard condensed coating	Prasenjit Patra	10:00 –10:10
445	3D printing of Clay ceramics using Direct Ink Writing (DIW) technique	Pankaj Bothra	10:10 –10:20
162	Development of micro-featured anti-wetting surfaces from Al-RGO dispersed polymer composite	Purnendu Das	10:20 –10:30
399	Consequences of addition of nanoparticles on tribological behaviour of coconut oil grease	Tanmoy Medhi	10:30 –10:40
463	Enhancing Surface-Mount Technology: DefectDetection and Inclusive Visual Monitoring	Raju Prasad Mahto	10:40 –10:50
353	Process Monitoring and Numerical Analysis of Mechanism of Laser Forming in Open-Cell Aluminium Foam	Prof. Partha Saha	10:50 – 11:00

Keynote

&

Memorial Talks

KEYNOTE TALK- 01

Physics-Informed AI for Enabling Robots to Learn Autonomous Tool Manipulation

Dr. Satyandra K. Gupta
Professor of Mechanical Engineering and Computer Science
Director of Realization of Robotic Systems Lab. University of South, located in Los Angeles, California USA

Extended Abstract

Many psychologists believe that humans' ability to use complex tools effectively makes them different from animals. Power tools enable humans to overcome their inherent limitations in terms of speed and force. Humans use tools to manipulate or make value-added changes to objects of interest. Most modern manufacturing processes use tools to make objects or modify the surfaces of the objects made by another process.

Using some tools such as hammers, and screwdrivers is relatively simple. On the other hand, many surface treatment processes require complex tool manipulation. Examples of these processes include sanding, polishing, buffing, trimming, coating, spraying, and blasting. Here are four factors that lead to complexity in tool manipulation:

- Tools need to perform complex motions to work on objects with difficult-to-reach features and avoid damage to parts with unwanted collisions. For example, trimming tools need to follow a complex motion to ensure that it approaches the edges being trimmed in the right position and does not gouge the surrounding material. Humans are good at using vision and tactile sensing to build mental models of objects. This model is then used by humans to generate and utilize complex tool motions.
- Many manufacturing applications require working on large parts. For example, many of the parts used in marine vehicles can be larger than thirty feet. This means that the tool needs to travel a large distance to cover the part. Humans need their locomotion ability to complement their manipulation abilities and can naturally use tools to work on large parts. Working on large parts requires reasoning about reachability and minimizing unnecessary motions to ensure operational efficiency.
- Not using the right process parameters when operating a tool can damage the part. For example, achieving the right surface finish in polishing applications requires using the right tool rotational speed, pressure, and travel velocity. Humans learn how to use the right process parameters during the training process. A trained human operator delivers the expected process performance using the appropriate process parameters. They can

easily learn new process parameter settings by conducting experiments when they are given a different material or tool.

- Tool motion and process parameters need to be adapted based on the observed performance during execution. For example, as the sanding pad during the operation starts wearing out, the human operator will adjust the pressure and rotational speed to ensure that the tool delivers the expected performance. Humans have excellent visual, tactile, haptic, and auditory sensing abilities to adapt the tool use based on the process performance.

Manipulating certain types of tools is simple for robots. That is why several robotic screwdriving solutions are already available on the market. However, effectively using tools can be challenging for robots for many processes. Unfortunately, robots in the past were unable to perform complex tool manipulation.

Challenging manufacturing processes such as surface treatment processes presents a very large segment of manufacturing. In the past, robot use in has been limited to mass production applications that relied on humans to program the robots. Robots simply executed pre-programmed motions. High-mix manufacturing applications require the part changeover to be accomplished within a few minutes, therefore, we cannot rely on humans to program robots when a new part arrives. Unfortunately, at present, the use of robots in high-mix manufacturing applications is limited, requiring humans to perform ergonomically challenging and physically demanding tasks. Using robots in these applications requires robots to autonomously manipulate tools based on high-level task descriptions and deliver human competitive task performance. This is a challenging problem and addressing it requires leveraging the latest advances in AI.

This presentation will present an overview of physics-informed AI technologies that enable robots to learn safe and efficient autonomous tool manipulation. These new technologies serve as the foundation for realizing smart robotic cells for assembly, composite layup, additive manufacturing, inspection, and sanding applications. AI-based planning enables the automated generation of efficient robot trajectories for performing complex tool motions to meet process-specific requirements. Robotic manipulators can be mounted on gantries or mobile platforms to increase their reach and work on large parts. An increase in the robot trajectory planning complexity as a result of using robots mounted on mobile platforms can be handled by new trajectory planning approaches. Smart robotic cells utilize force and vision sensing to autonomously adapt the tool motion and control its interaction with the part to produce the desired quality. Imitation learning enables robots to learn from human experts. The use of synthetic images generated from physics-informed simulations enables the use of deep learning in defect detection. Self-supervised active learning enables the robotic cell to autonomously and safely conduct experiments to learn the process parameters in the most efficient manner. Smart robotic cells powered by physics-informed AI can increase human productivity, reduce the need for humans to perform ergonomically challenging tasks, and make manufacturing process sustainable.

KEYNOTE TALK- 02

AI-driven cybersecurity assurance in smart manufacturing

Dr. S. Bukkapatnam
Professor of Industrial and Systems Engineering, College of Engineering,
Texas A&M University, USA
satish@tamu.edu

Extended Abstract

Recent advances in sensors, artificial intelligence (AI), manufacturing processes, together with computing and communications technologies are revolutionizing manufacturing. These advances allow rethinking manufacturing as a service. Concurrently, there is a shift towards democratization of manufacturing where physical supply chains are being supplanted by cyber-enabled "smart manufacturing" networks where digital objects including the design files, process plans, measurements and control data are transmitted over computer networks (via digital communication channels and shared cloud storage) and transformed into qualified physical objects at the place of need. A recent IBM's study suggests that the emerging smart manufacturing systems are the largest target for cybersecurity attacks among all industry sectors. Cybersecurity has emerged as a major concern in modern manufacturing systems. While cybersecurity risks pervade an entire manufacturing enterprise, plant floor controllers have historically been the primary targets for cyberattacks, compromising the quality, productivity, and safety. This talk motivates the emerging manufacturing cybersecurity landscape, and discusses two cybersecurity approaches, namely, dynamic watermarking of machine tool controllers, and real-time anomaly detection in collaborative robotic cells.

The first approach focuses on securing machine tool controllers. In a manufacturing plant floor, machine tool controllers are considered most vulnerable. Digital twins of controllers are essential for cybersecurity assurance as safety and cost considerations with physical controllers, and their closed architecture prevent an effective study of the vulnerabilities, attack vectors, and their defense innovations under different scenarios. A novel active learning method is presented to reconstruct a digital twin of a controller for cybersecurity applications. The resulting digital twin is a low-dimensional base representation of the closed physical machine tool controller, and it captures the salient structure and dynamic connectivity among the various components of the controller. A case study of developing a digital twin for cybersecurity assurance of a SIEMENS controller is discussed. This talk also discusses a novel dynamic watermarking (DWM) approach that can detect cyberattacks in real-time to protect MTCs from sabotage., while offering theoretical performance guarantees. Simulation studies employing a digital twin of Siemens 828D controller as well as an initial

implementation on a stepper motor suggest that the DWM can detect attacks with a latency (ARL_1) of 0.15s.

The second approach focuses on human-centric collaborative manufacturing systems. An offshoot of smart manufacturing advances is the rapid growth of human-centric collaborative manufacturing. Organizations are adopting human-centric collaborative manufacturing practices at an estimated 41.5% annual rate to reach $10 billion by 2028. The newer class of intelligent manufacturing equipment and arrays of de-caged robots are beginning to enable a more synergistic human-machine interactions (e.g., combine human strengths of dexterity and expertise with the power of the machines to enable complex product assembly cells). However, safety and trust deficits that emerge in this close-proximity human-machine collaborative manufacturing environments are a major risk factor. Anomalous motions of robots, machine tool drives and actuators, as well as material handling equipment resulting from degradations or attributable, malicious causes can significantly compromise safety, erode the trust, and can be fatal. This talk discusses alternative anomaly pathways, including cyberattacks, that can lead to deleterious consequences in a multi-station collaborative manufacturing enterprise. It also presents mathematical formulations and a few implementations of active surveillance methods that can redress some of the human safety challenges.

Anomalous robot motions caused by cyberattacks or inherent defects can lead to task failures or harmful accidents in collaborative human-robot workplaces. Therefore, it is essential to monitor robot tool paths and detect any deviation as early as possible. In this work, we propose a framework that can accurately estimate robot trajectories and detect various types of anomalous trajectory changes using an external camera.

The proposed framework consists of three components: marker-based pose estimation, Long Short-Term Memory (LSTM), and residual control charts. Marker-based pose estimation is a technique that uses markers attached to the robot to measure its position and orientation. LSTM is a type of neural network that can learn complex dynamic patterns in time-series data. Residual control charts are statistical tools that can detect outliers or changes in the data distribution. By combining these components, the framework can enhance the camera-based measurements, learn the normal robot trajectories, and identify the anomalous ones.

The framework was evaluated in a shared human-robot assembly task, where a human and a robot work together to assemble a product. The motion deviation upon detection can be used to determine a safe working distance between the human and the robot. The framework also exhibits generalizability to previously unseen trajectory deviations and adaptability to other types of external sensors.

To conclude, this work presents two novel frameworks that can enhance the security and safety of the emerging smart manufacturing systems. The first focuses on developing digital twins for machine tool controllers, and investigating a novel DWM approach for controller security assurance. The second aims to secure collaborative human-robot workplaces by using an external camera to monitor robot trajectories and detect anomalies. The framework leverages the advantages of marker-based pose estimation, LSTM, and residual control charts to achieve high accuracy and performance. The framework has implications for both research and practice, as it can enable more efficient, reliable, and flexible human-robot collaboration.

KEYNOTE TALK- 03

From Waste to Worth: A Net Zero Route for the Circular Hybrid Manufacturing of Sustainable Additive-Subtractive Parts

Dr. Debajyoti Bhaduri
Professor of High-Value Manufacturing
School of Engineering, Cardiff University, UK

Extended Abstract

Sustainable manufacturing is gaining momentum to meet United Nations Sustainable Development Goals by minimising the environmental footprint of manufacturing processes. To achieve 'Net Zero' emissions by 2050, circular economy models in manufacturing, in contrast to the conventional linear economy, are increasingly being adopted via material recycling, reduction of energy consumption and energy recovery. For additive manufacturing (AM), despite the immense benefits offered by the technology in terms of design freedom and material waste reduction, conventional AM powder production routes involving melting and atomisation processes (such as gas, water and plasma atomisation) consume substantial energy and have high carbon footprints. For example, 16-84 kg of CO2 is released per kg of AM stainless steel powder production. To mitigate this, reuse of commercial powders as well as alternative powder generation routes via solid-state crushing/ball milling (BM) of machining chips have been sporadically explored, although the majority of published work relating to the latter topic is aimed at powder metallurgy (PM) applications. The use of BM powders for AM applications is a relatively new approach for materials' recycling. Thus far, BM powders in AM have been mainly tested when single-track melting operation, for example, Laser Engineered Net Shaping of SS304L and direct metal laser sintering of pre-placed Ti-6Al-4V powders. The holistic vision of the current research centres on the circular economy approach to produce sustainable metal AM powders by recycling production scrap and to provide solutions to 'zero waste' of materials. In particular, the research aims at developing Circular Hybrid Manufacturing (CHM) process chains to generate AM powders for powder bed fusion and metal binder jetting processes, via ball milling of machining chips, to fabricate and post-process high-value AM components. The holistic concept of the CHM process chain is shown in Fig. 1.

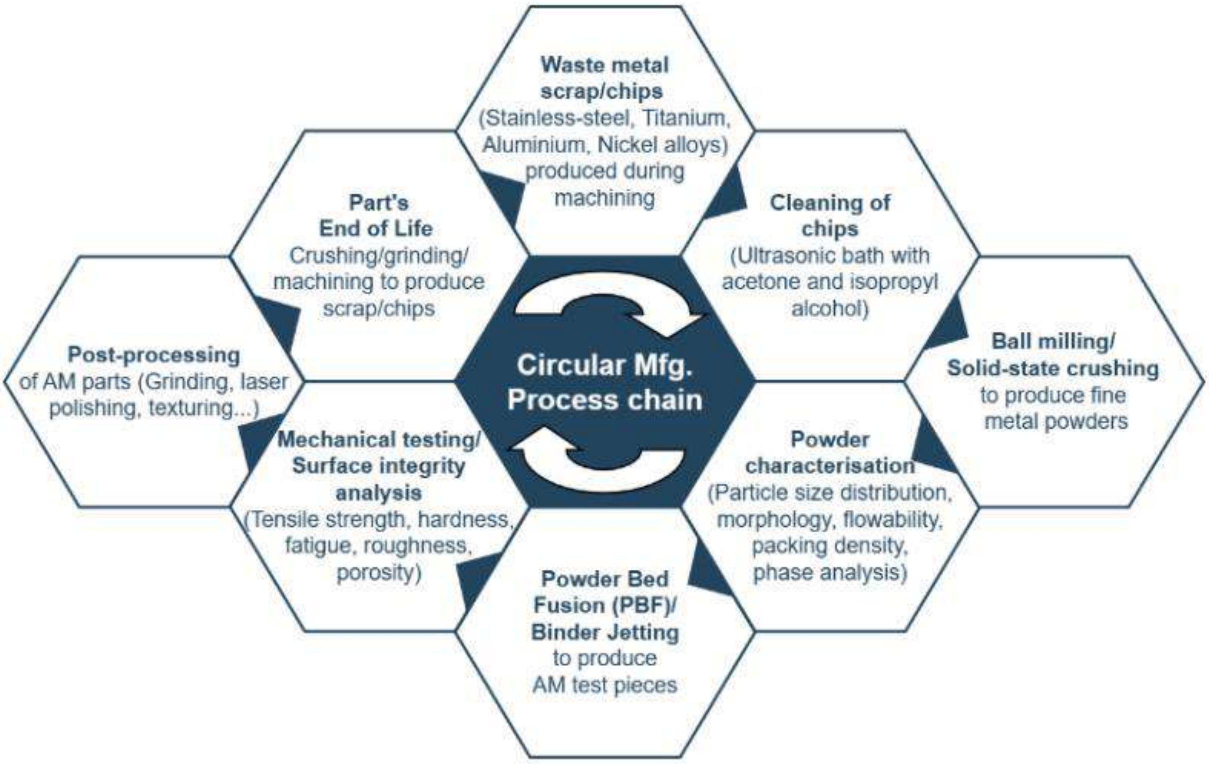


Fig. 1 Circular Hybrid Manufacturing (CHM) process chain

KEYNOTE TALK- 04

Electrochemical Additive Manufacturing: Challenges and Opportunities

Dr. Murali Sundaram

Department of Mechanical and Materials Engineering, University of Cincinnati, Cincinnati, OH, USA
sundami@ucmail.uc.edu

Extended abstract

Introduction

Electrochemical additive manufacturing (ECAM) is an emerging, nontraditional method of additive manufacturing (AM) that makes use of localized electrodeposition of metal as the material addition mechanism. Its room-temperature operation and voxel-by-voxel build nature (directly forming atom-by atom metallic bonds) enables parts to be fabricated without thermal stress, reliance on support structures. The subject of this research focuses on understanding and controlling the complexities of the ECAM process, to enable commercial adoption in the future. An overview of the ECAM simulation and experimental work performed by our research group in recent time is provided as follows.

Method

A part deposited by the ECAM process consists of volumetric units, termed voxels. Each voxel is created by localized electrochemical deposition as follows. A laterally localized anode (tool) is placed in close proximity to the cathode (substrate to be plated on), with both immersed in plating solution containing metal ions of one or more species. Upon an applied voltage, the metal ions deposit and fill the gap at a given tool position. Sequential voxels can be built corresponding to a 3D form originating from a CAD file, as illustrated in Figure 1.

Simulations

The deposition that underlies the ECAM process arises from the reduction reaction that metal ions undergo in an atom-by-atom manner at the interface in the scale of Angstroms and femtoseconds. However, these dynamics are inaccessible by experimental monitoring, which is limited to the micrometer and microsecond scales. To probe the atomic behaviors, a custom-built molecular dynamics simulation was created to simulate the ECAM process, shown in Figure 2 [1]. Captured behaviors include: electrode charging, electrolyte dynamics, interfacial reactions, and deposit growth. The governing equations derive from physical laws and electrochemical principles. This approach provides greater insight into understanding and control of the atomic-scale electrochemical behaviors driving the ECAM process.

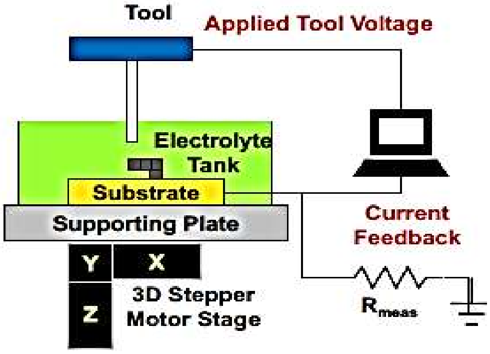


Figure 1. Schematic of ECAM process

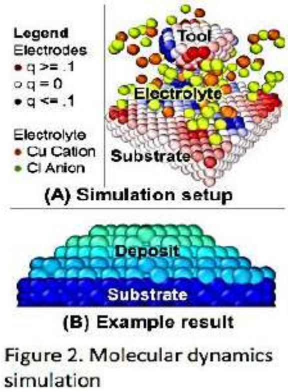


Figure 2. Molecular dynamics simulation

Experimentation

We have investigated two ways of sourcing metal ions, which corresponded to two methods of printing a compositionally-graded part. The first method to source the ions is to mix the electrolyte from metal cation-anion salts. This results in a bath with a fixed composition that was pre-determined before the deposition process. To functionally grade the part, various combinations of voltage and frequency of the applied plating signal were studied [2]. The second method to source the ions was to dissolve anodes corresponding to the source metals into the solution; this allows for dynamic control of the solution composition in-process. To functionally grade the part, the different-metal anodes were sequentially dissolved to custom concentrations at fixed intervals along the pillar build process. The results are shown in Figure 3 [3]. From all results, deposition of 4 and 5 metal alloys was achieved, including voxel-to-voxel compositional grading was achieved to different extents along the pillar parts.

Ongoing work

Upon the completion of experimental and simulation studies so far, there have been fundamental limits reached in the speed, consistency, and control of plating geometry and composition. Rigorous ongoing work is in progress to further improve these aspects of the ECAM process, which involves further advancement of the plating bath formulation and control system.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant Nos. CMMI-1400800 and CMMI-1955842.

References

1. Brant, A. and M. Sundaram, Molecular dynamics study of direct localized overpotential deposition for nanoscale electrochemical additive manufacturing process. Precision Engineering, 2019. 56: p. 412-421.
2. Brant, A. and M. Sundaram, Electrochemical additive manufacturing of graded Ni Co Fe Cu structures for electromagnetic applications. Manufacturing Letters, 2022. 31: p. 52-55.

3. Sundaram, M., A. Brant, and K. Rajurkar, Electrochemical additive manufacturing of Ni Co Fe Cu Mo high entropy alloys using a combined dissolution-deposition system. CIRP Annals, 2022. 71(1): p. 153-156.

KEYNOTE TALK- 05

Hybrid Metal Additive Manufacturing

Prof. N. Venkata Reddy

Department of Mechanical and Aerospace Engineering, IIT Hyderabad

nvr@mae.iith.ac.in

Extended Abstract

Hybrid Manufacturing (HM) broadly is a combination of two or more different processes to overcome their individual limitations and take advantage of their combined strengths to produce components resource efficiently and eco-friendly than existing processes without compromising on the quality. Hybrid technologies (metal Additive Manufacturing (AM) combined with other established processes with appropriate modifications) are gaining importance as they widen the scope of geometries, enhance process capabilities in terms of quality of component and eco-friendliness due to integration of two or more different process capabilities sequentially and/or concurrently to overcome limitations. Initial attempts on hybridization are by combining the metal deposition and removal intermittently to enhance the quality and geometric complexity by avoiding accessibility issues to removal after completely depositing the component and these systems are commercially available now. Combination of deformation processes with metal AM is gaining importance in recent years and their emphasis was on enhancing the surface quality and mechanical properties by locally deforming deposited layers and deformation of the deposited or deposition on the deformed components. This presentation is intended to emphasize details related to Hybrid concepts developed by combining Deformation and Additive Manufacturing (HyDAM) of metals either sequentially and/or concurrently including the ones being attempted at IIT Hyderabad.

KEYNOTE TALK- 06

Significance of Conceptual Changes in Manufacturing

Prof. V. Radhakrishnan

Former Professor IIT Madras and Emeritus Professor IIST Trivandrum

vpradha007@gmail.com

Extended Abstract

Manufacturing as we see it today has two major perspectives that allows it to sustain and grow. These are the technology perspectives and the business perspectives. They are basically the driving factors that has brought Manufacturing to this level of competence. Once a design is frozen its market depends on its cost and the value it gives to the customer. These are related to the design, manufacturing technologies and the business strategy. All the three have undergone dramatic changes over the years and all of them are now fully data driven.

Apart from advanced technologies and a competitive business environment, another element that has played a key role in manufacturing throughout its evolution are some of the concepts brought in over the years. Concepts are abstract ideas formed based on innovative thinking combined with the wisdom of experience. They are generic in nature allowing them to be applied in many fields.

There have been many conceptual changes that benefitted the broad field of manufacturing covering technology, systems as well as the business. Concepts often get modified or are even dumped based on the prevailing technologies, business needs, regulations as well as societal needs. As we advance in this field it is but natural to bring in new concepts and proposals that improve the efficiency, competitiveness, societal needs and environmental acceptability as well as customer satisfaction.

Moving away from manual operations to computer assisted ones created major upheavals – both socially and conceptually. As we embrace new technologies which are yet to fully unfurl, there is bound to be major challenges that may need more technological as well as conceptual solutions.

This presentation covers the significance of concepts, how they are conceived, how they evolve and change the whole area of manufacturing covering design, technology and systems with examples.

In addition to this, there are two or three new conceptual challenges in the area of manufacturing processes which are to be presented to the young researchers for their consideration.

KEYNOTE TALK- 07

Chipping of micro-tools in Milling along Complex Tools Paths: An Integrated ML-based Modeling Approach

Prof. Suhas S. Joshi

Director, Department of Mechanical Engineering, Indian Institute of Technology Indore, Indore – 452020 India

[1]Department of Mechanical Engineering, Indian Institute of Technology Bombay, Mumbai – 400 076 India

Extended Abstract

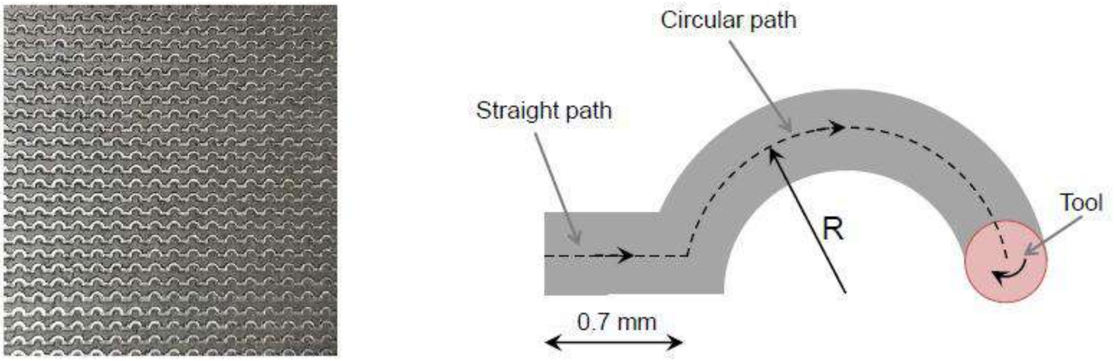
Micro-milling has extensive applications in creating complex-shaped micro dies used in jewellery making [1], medical devices [2,3], and micro-fluidic devices [4]. However, the small size of micro-milling cutters makes them susceptible to rapid wear, chipping, and unexpected breakage. Consequently, monitoring the condition of these cutters is crucial to prevent degradation in the machined surfaces and abrupt failures of the micro-cutters.

The existing research has predominantly concentrated on the impact of cutting parameters, like depth of cut, feed, and spindle speed, on tool wear, also with limited focus on abrasion wear and straight tool paths [5,6]. However, there is a notable gap in studies addressing the phenomenon of chipping in micro-milling cutters. Additionally, existing models for predicting tool conditions in micro-milling are scarce and often overlook the complexity of the tool paths involved.

Our work aims to bridge this gap by introducing an integrated approach that combines analytical and machine-learning models. This novel methodology is tailored to accurately predict tool wear, specifically focusing on chipping along with abrasion wear, thereby enhancing the understanding of overall tool condition in micro-milling. Through this approach, we aim to provide a more comprehensive tool condition monitoring framework,

crucial for the advancement of micro-machining processes, addressing the tool path complexities and chipping of the micro cutters.

To develop the integrated ML-based modeling framework, exhaustive micro-milling experiments were conducted by varying the cutting parameters like feed, depth of cut, spindle rotation speed, and tool path radius until the end of the tool life. These experiments were carried out on SS304 using several two-fluted tungsten carbide micro-end mills. The tool wear progression was captured using an in-situ camera with a microscope. Fig. 1a shows a photograph of an array of microchannels fabricated in the experiments with a radius of curvature of 750 µm. A schematic of a single slot consisting of straight and semicircular portions that form an array of microchannels is shown in Fig. 1a. The radius of the curvature is denoted by R (refer Fig.1 b.) and was varied between 250 µm to 500 µm to 750 µm, in the micro-milling experiments thereby varying the complexity in the tool path.



(a). Photograph of an array of micro-channels machined along circular tool paths

(b). Schematic of tool paths used in the experiments

Figure 1: Micro channels fabricated along circular tool paths (a) Photograph of an array of microchannels fabricated by machining along circular tool path and (b) a schematic of a single slot machined in the experiments.

Fig. 2 shows the tool wear progression with time captured using the tool boundary. The cutting tool chipping was captured and quantified using different dimensions, such as ‘C’ and ‘H’ shown in Fig. 2. The tool wear was quantified and used in analytical and ML models to capture the tool wear state.

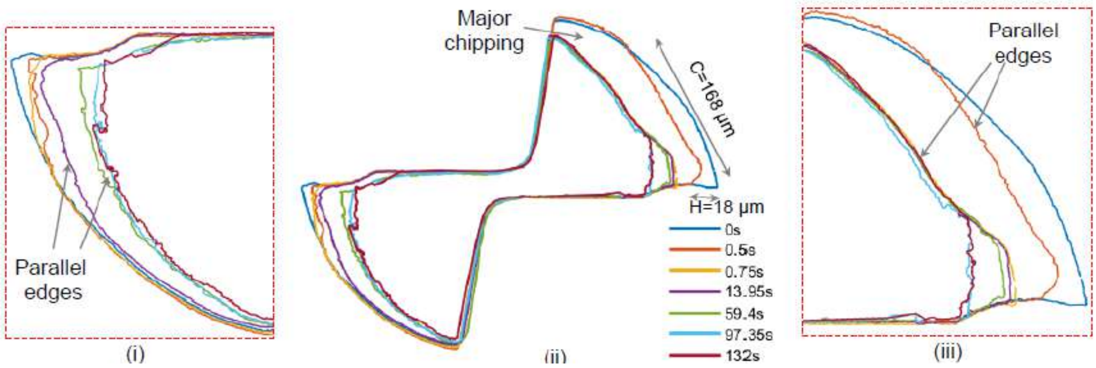


Figure 2: Tool wear progression captured using the tool boundary

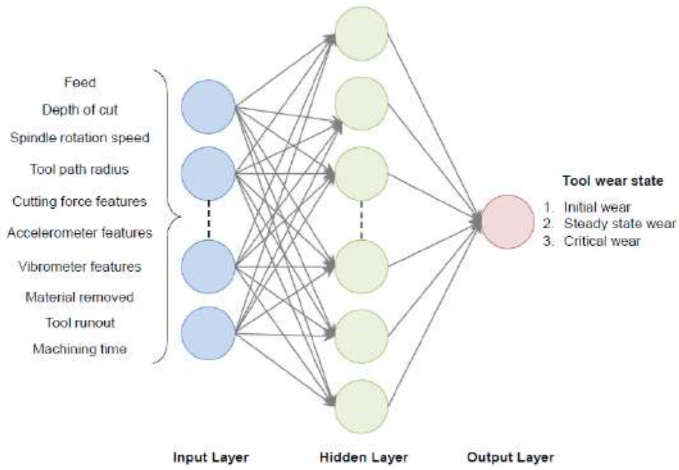


Figure 3: ANN architecture for tool wear state modeling

A total of 8,739 slots were machined using all the tools and four data points were selected from each slot. Therefore, a total of 34,956 data points were generated from the experiments. Each data point contains the input features to the model along with a labeled tool wear state. A data-based model using articial neural network (ANN) was proposed to classify the tool wear state for micro-milling along circular tool paths. The architecture of ANN model is shown in Fig. 3. The accuracy of the model is estimated as the fraction of total data points that predicted the tool wear state correctly.

The model demonstrated high accuracy, predicting tool wear states correctly in 98% of cases. Moreover, the major mode of tool wear was found to be chipping. A tool wear area up to 15,092 µm^2 was lost in a single chipping instance in the micro-milling experiments.

KEYNOTE TALK- 08

Nano-Finishing: An Overview

Prof. V. K. Jain

Former Professor IIT Kanpur

vkjain@iitk.ac.in

Extended Abstract

This talk presents an overview of nano-finishing technologies. These are basically divided in two categories: Traditional and advanced nano-finishing techniques. Traditional nano-finishing techniques are well known as grinding, lapping, honing etc. while advanced nano-finishing processes includes abrasive flow finishing, elastic emission machining, magnetic abrasive finishing, magnetorheological finishing, magnetic float polishing, chemo-mechanical polishing, electrochemical grinding, Electric Discharge Diamond Grinding, Focused Ion Beam Finishing etc. All these processes have been enhanced by adding some new features to them. This lecture also introduces such enhanced advanced nano-finishing processes such as Chemomechanical magnetorheological finishing process, Electrochemical Magnetic abrasive finishing.

The lecture also emphasizes the major applications of the different nano-finishing processes mainly, aerospace, automobile, biomedical etc. More importantly with reference to futuristic manufacturing, it has many applications in additive manufactured macro and micro parts for post processing for controlling surface finish, texture of the additive manufactured parts, radiusing etc. Apart from the applications, researchers should go into the science of the nano-finishing technologies for enhancement of the technologies in terms of efficiency and economics, both simultaneously.

KEYNOTE TALK- 09

Smart Manufacturing

Dr. N. Ramsh Babu

Professor Emeritus, Department of Mechanical Engineering
Indian Institute of Technology Madras
Email: nrbabu@iitm.ac.in

Extended Abstract

Adoption of Industry 4.0, in India, is at a nascent stage. Widespread implementation still looks to be some years away due to challenges such as the need for high investment outlay, inadequate knowhow, lack of infrastructure and lack of adequate cybersecurity norms. However, with benefits such as cost reduction, higher efficiencies, safer factories and faster speed to market, Industry 4.0 can provide the country's manufacturing sector the much-needed platform to stay competitive in the global market. Furthermore, with the government's focus on manufacturing through programmes such as 'Make in India' and policies such as the 'National Policy for Advanced Manufacturing' and the schemes such as the "Enhancing the competitiveness of Capital Goods Sector", "Skill India" and "Startup India", Industry 4.0 could play a key role in boosting the manufacturing sector's share in the country's GDP to 25 per cent soon from the current 17 per cent. That said, for the true value of Industry 4.0 to be unleashed, it has to transcend large manufacturing companies and become accessible to the 50 million plus enterprises that make up India's MSME sector, accounting for about 45 per cent of total manufacturing output and 40 per cent of total export.

After seeing the constant progress on the back of mechanisation, electrification and the advent of the assembly line over two centuries, the global manufacturing industry adopted information technology in the 1960s, when computers came into the forefront of development, simplifying human effort. From then to now, both operational technology and information technology have come a long way, unleashing a vast plethora of possibilities on the factory floor through I4.0.

Germany, the country that started looking at I4.0 adoption as early as 2010, launched 'Industry 4.0', as a national strategic initiative to establish itself as a leading provider of advanced manufacturing solutions. Countries such as the U.S., China, and Japan and European nations such as the U.K., Ireland, Sweden and Austria have all started adopting I4.0.

China developed "Made in China 2025" to fully modernize the country's manufacturing industry. The United Kingdom introduced its "Future of Manufacturing" in 2013; the European Union developed its "Factories of the future" in 2014; Singapore came out with its "RIE2020" plan; and the U.S., in 2014, launched the "Manufacturing USA" initiative that created a network of 16 member institutes. Each of the institutes focuses on a specific advanced manufacturing technology.

Industry 4.0 is not merely a matter of connecting machines and products through the Internet. It encompasses a wide range of advanced technologies, such as digital twins, artificial intelligence, high-speed wireless networks, deterministic wired networks, cloud and edge computing, and virtualization technologies like augmented reality. It is also a paradigm shift in how we organize, manage, and approach business to make the most of cyber-physical systems.

Recent upswing in market conditions post-COVID and the availability of modern technologies like IoT, Analytics, AR/VR and AI/ML, Indian manufacturing is rapidly undergoing an incredible digital transformation towards Smart Manufacturing by adopting Industry 4.0 practices. This unified platform for the next generation of smart manufacturing can unlock the hidden value from legacy manufacturing assets by contextually liberating relevant data from the shop floor equipment/devices and delivering exponential business value to the enterprise.

In this keynote, a few attempts made at Advanced Manufacturing Technology Development Centre (AMTDC), set up in IIT Madras Research Park, with the financial support from the Ministry of Heavy Industries, Government of India and the partner Industries from Machine tools, automation, and robotics sector, are presented. This Centre is a not-for-profit society, engaged in translational research and development to develop several technologies relevant to machine tools, automation & robotics, digital and smart manufacturing, are presented. This talk also covers certain aspects of smart manufacturing like (i) the conversion of the traditional manufacturing shop floor into the digital entity, (ii) the implementation of IoT system to capture the real time data from critical manufacturing processes for adaptive and real time control.

A few case studies from manufacturing process intelligence, smart machines with IoT enabled thermal error control will be used to highlight the digital transformation and smart manufacturing efforts. These efforts are essentially the capabilities built towards demonstrating the smart manufacturing in terms of monitoring, alarming, and visual display of operational aspects, supporting real-time predictive decisions.

KEYNOTE TALK- 10

Fabrionics: Futuristic Manufacturing for the Next Industrial Revolution

Prof. Amitabha Ghosh

Ex-Director IIT Kharagpur & professor of ME Dept, IIT Kanpur

amitabha@iitk.ac.in

Extended Abstract

‘Manufacturing’ plays a centre stage role in the economic growth of a country and, therefore, it is necessary to facilitate innovations leading to futuristic manufacturing engineering. However, in the coming days it will be desirable to quickly translate the research outputs into actual technologies that may help in achieving a leading role in the world of manufacturing engineering. To facilitate such ‘translational R & D’, required for innovating new and more exotic processes, it is essential to pay attention to the relevant ‘engineering science’ aspects involved. This talk starts by providing a clear understanding of the terms like ‘science’, ‘engineering’ and ‘technology’ and explains what is meant by the term ‘engineering science’ and the important role it can play in innovation leading to new and advanced manufacturing technologies. A few examples are presented. The important role played by ‘value addition’ through manufacturing is also briefly taken up for discussion. Finally, the talk discusses the new emerging areas of engineering science which need attention while framing modern and advanced curricula required to help create ‘new era’ engineers who can face the challenge of the next Industrial Revolution.

KEYNOTE TALK- 11

R&D, Technology & Innovation Management

Dr. Neeraj Sinha
Senior Advisor, Science & Technology division

NITI AAYOG, New Delhi
nprnsa@gmail.com

Extended Abstract

Promoting Entrepreneurship and Startups will ensure an unprecedented wave of long-deserved growth, prosperity and well-being that can serve the interests of the rest of the world as well as the spirit of New India. Creating a nation of job-creators and not just job-seekers is important for sustainable growth. Central to this is the need for extensive collaboration between corporate Industry, academia, and governments at the village, district, state and central levels.

India, over the centuries, has never had a shortage of great thinkers, scientists, engineers, doctors, innovators, philosophers, and artists. Indian intellectual, engineering, and artistic capabilities are second to none with some of the greatest scientists, mathematicians and engineers in the world, like former President Abdul Kalam, S. Ramanujan, Sir C.V. Raman and Dr Vikram Sarabhai, coming from various regions of India. Our philosophy, culture, fine arts, temples and sculptures also bear testimony to the same.

However, what has been lacking is a holistic innovation and entrepreneurial ecosystem that stimulates, enables and supports Inspiration, Imagination and Innovation in our schools, universities, and industries across the length and breadth of the nation. Many Indians are leading innovations in some of the largest and most innovative tech, medical, and financial companies of the world, including Google, Microso, IBM, and Adobe. Access to an innovative ecosystem in these developed countries has allowed many Indians to realise their aspirations, convert their dreams into realities, and help them blossom to their full creative potential.

With over 1.4 million schools, approximately 10500 engineering and related institutions, approximately 39000 colleges, a demographic dividend that is the envy of many a country and a fast-growing economy, the imperative in India is, therefore, to ensure that an estimated 150 million youth of India entering the workforce over the next few years can realise their

true potential through access to a world-class innovation and entrepreneurial ecosystem, leveraging rapidly advancing, accessible, affordable technologies transforming the world we live in and enabling an incredible set of opportunities for innovation and new job creation.

Revolutionary technological advancements are indeed transforming the world, giving rise to new technology and business innovations at a dizzying pace. Electronics miniaturisation has enabled a computer the size of a room to fit our pockets, aided by the convergence of computing, storage and communications at incredibly lower costs. Robotics and Artificial intelligence are driving next-generation productivity and automation. 3D printers are making real-time conceptualisation, design, prototyping and manufacturing at an SME level a reality. IoT, or the Internet of things, connects sensor technologies to mobile and satellite Technologies in every Industry, from enabling precision agriculture, healthcare, water cleansing and conservation, climate change controls, disaster prediction and management, driverless cars and space shuttles.

The S&T Vertical of NITI Aayog is the nodal division for all matters related to science and technology. This includes examination and appraisal of S&T programmes of Agencies/Departments such as the Department of Science and Technology, the Department of Biotechnology, the Department of Scientific and Industrial Research, including the Council of Scientific and Industrial Research, the Department of Space, the Ministry of Electronics and Information Technology, the Department of Telecommunications, the Department of Posts, the Ministry of Earth Sciences and the Department of Atomic Energy.

The Vertical is also involved in policy interventions for various initiatives such as methanol economy, 'Make in India' body armour, National Research Foundation, hydrogen economy and seaweed cultivation, to name a few. Besides, it is also engaged in activities like the formulation of the India Innovation Index, improving India's ranking in the Global Innovation Index, desalination of water and the standardisation of the construction, maintenance and operation of ropeways, etc., preneurial startups to succeed with possible global impact. The Vertical seeks to strengthen the science, technology and innovation ecosystem in the country in association with Central Scientific Departments/Agencies by formulating science- and technology-specific plans/programmes and policies.

Global Innovation Index

NITI Aayog has been continuously working towards improving India's ranking in the global indices, including the Global Innovation Index. The S&T Vertical is the nodal department in NITI with respect to improving India's ranking in the Global Innovation Index. NITI Aayog is also working proactively towards bringing policy interventions that could leverage India's underlying potential. Due to NITI Aayog's sustained efforts, India improved its global position from the 52nd position in 2019 to the 48th position in 2020. The S&T Vertical is constantly in touch with top-ranking countries such as Switzerland and Sweden in the Global Innovation Index to understand their best practices for improving India's ranking.

India Innovation Index

The India Innovation Index is released by NITI Aayog every year, with the Institute for Competitiveness as a knowledge partner. The Index attempts to create an extensive framework for the continuous evaluation of the innovation environment of all States and

Union Territories and rank them on the basis of their innovation index scores. NITI Aayog also handholds States and Union Territories in improving their rankings in the Index, which subsequently results in an improvement of India's ranking in the Global Innovation Index.

NITI Working Paper - "A NEW LENS FOR INNOVATION IN NEW INDIA"

The S&T Vertical published a NITI Working Paper in July 2023 under the guidance of Dr. V. K.
Saraswat, Member (S&T). The paper was conceptualised after the Member (S&T) expressed the need for a framework to measure the commercial readiness of technologies. It began with a vision of jointly assessing technological and commercial readiness, which was then refined into a structured concept, incorporating the impact of extrinsic factors like market maturity.

Advanced Ultra Supercritical Thermal Power Plant

The AUSC technology provides a means for a better utilisation of the coal reserves, coupled with a reduction in emissions. A very challenging R&D project – funded by the Government of India in a Mission Mode – has been successfully executed. Periodically reviewed by three high-level Committees. The project had been completed with ~ 60% of the sanctioned cost. The time overrun was primarily to ensure the satisfactory completion of the challenging activity of the turbine design. First-of-a-kind exercise to take up indigenous design. The R&D project has demonstrated the desired level of confidence in the design & production of wrought and cast nickel-based alloys, as well as the manufacturing of the key components on an industrial scale.

Core Advisory Group for Research and Development in the Machine Tools Sector (C-MAT)

The C-MAT was constituted in April 2006 by the Office of the Principal Scientific Adviser to the Government of India (PSA's Office). The C-MAT was a very potent initiative of the PSA's Office to promote "Make in India" – in the Machine Tools Sector – through a very vibrant interaction between the indigenous Machine Tools Industry and Indian Academia. The Indian Institute of Technology Madras (IITM), Chennai, collaborated with the Micromatic Grinding Technologies Limited (MGTL), a leading manufacturer of grinding machines in India, and the Advanced Machine Tool Testing Facility (AMTTF – a collaborative effort of the Department of Industrial Policy and Promotion, Government of India & the Machine Tool Industry, with the cost-sharing being in the ratio 70:30), in order to upgrade an existing cylindrical grinding machine tool (of the MGTL) into a high precision grinding machine tool, whose capability was targeted to be at least at par with the world's best grinding machine tools.

KEYNOTE TALK- 12

Funding opportunities for R&D of various central government agencies/ministry

Dandu Radha Prasada Raju, PhD, FNAE

(Former Scientist, Dept. of Science & Technology, Govt. of India)

R&D Adviser/Visiting Prof: IITs-Madras, Tirupati & Hyderabad,

PSG Insts.-Coimbatore, GMR Inst of Tech-Rajam, IIM-Vizag & JNTU-Anantapur

Many important initiatives and funding opportunities have been started in R&D sector like Anusandhan National Research Foundation (NRF) (serb.gov.in/serbonline.in), Dept. of Science and Technology (DST) (dst.gov.in/onlinedst.gov.in), and Dept. of Biotechnology (DBT) (dbtindia.nic.in/dbtepromis.nic.in). NRF call for proposals for funding like:

- Core Research Grant (CRG): Grants: No limit, Duration: 3 yrs., Co-PI desirable
- Startup Research Grant (SRG): Age: <42y/2y of joining, Grants: Rs 30L/2 yrs.
- Scientific and Useful Profound Res Advancement (SUPRA)
- Empowerment & Equity Opportunities for Excellence in Science (EMEQ)
- Mathematical Research Impact Centric Support (MATRICS)
- Intensification of Research in High Priority Areas (IRHPA)
- State University for Research Excellence (SURE)
- Teachers Associateship for Research Excellence (TARE)
- Fund for Industrial Research Engagement (FIRE)

Also, NRF provides fellowships and other programs like:

- National Post-Doctoral Fellowship (NPDF)
- Research Scientist Scheme(INSPIRE Faculty, Ramanujan/Ramalingaswamy Fellow)
- Abdul Kalam Tech Innovation National Fellowship
- International Research Experience
- Newton Bhabha International Fellowship (Post-PhD: UK/2 yrs.)

Dept. of Science and Technology (DST) also facilitates various grants like Scientific and Engineering Research, S&T for Socio-Economic Development, International S&T Programs, and Women Scientist Programs. Dept. of Biotechnology (DBT) call for proposals for funding in various programs like R&D Programs, Fellowships, Building Capacities and Societal Programs, International Collaboration. Lastly, a thorough discussion is presented to write an effective research proposal. A detailed discussion is enlisted like**:** Summary, review of the status, objectives, methodology, outcomes, competence, budgetary requirement, enclosures, submission of proposals, evaluation mechanism.

Memorial talk: 1

Professor Amitabha Bhattacharyya Memorial Lecture, AIMTDR 2023

Modelling and Simulation of Manufacturing Processes for Achieving Sustainable Development Goals

Prof. Uday Shanker Dixit

Department of Mechanical Engineering, Indian Institute of Technology Guwahati

Professor Bhattacharyya achieved many laurels in his life span of 61 years including prestigious Shanti Swarup Bhatnagar Prize in 1971. He has immense contribution in teaching and research in the area of machine tools at the time when Indian machine tool industry had just started growing. Although he has completed his master's degree from Bengal Engineering College in 1956, he went to pursue M.S. program at the University of Illinois for gaining expertise in machine tools. Because of his nationalistic attitude, he came back to India and decided to join Ph.D. under the supervision of Prof. Gopal Chandra Sen of Jadavpur University. Besides publishing a number of research papers in the area of machine tools and metal cutting, he has published some excellent textbooks related to machining. His book entitled “Metal Cutting: Theory and Practice” that was revised and enlarged in 1984 is still relevant. The book emphasizes a lot on the modelling of metal cutting and is full of mathematics. It uses vector algebra, coordinate geometry, trigonometry and calculus. There is a mention of fuzzy sets also in the book. Prof. Bhattacharyya was very good at mathematics and had he been in this era, he would have contributed a lot towards modelling and simulation of manufacturing processes. With his initiatives, the first All Indian Machine Tools, Design and Research (AIMTDR) conference was held in 1967 at Jadavpur University, similar to Machine Tool Design & Research (MATDOR) conference started in 1959 at UK.

With the invention of transistor in 1947 by Walter Brattain, John Bardeen and William Shockley for which got the Nobel Prize in Physics, a phenomenal progress has been made in the area of computer science and electronics. Several disruptive technologies have been developed, particularly Computer Numerical Control (CNC) in 1960s and Additive or Layer-by-Layer Manufacturing in 1980s. Meantime a lot of progress was made in the so-called non-traditional machining processes, such as laser beam machining and electrical discharge machining. Now these processes are called advanced manufacturing processes. With growing disruptive technologies as a replacement to traditional cutting processes, it was appropriate that the name of AIMTDR was changed to All India Manufacturing Technology, Design and Research in 1994, acronym remaining the same. Second decade of 21st century is known for the buzzword Industry 4.0, which emphasizes greater role of computer technology. However, with the power of computers today, virtually all aspects of manufacturing can be modelled. Execution of a model is called simulation; simulations can be called mock experiments. There are two types of models– direct and inverse. The direct model predicts the output based on input, whilst converse is done by the inverse model. With proper modelling, it is possible to make a digital twin of entire manufacturing process, which helps in optimizing the process, thus managing the resources efficiently and achieving sustainable development goals.

Finite element method (FEM) has emerged as one of the most powerful technique for modelling a process, but there are several other methods having relevance. Some classical methods are slab method, slip line method, upper bound method, lower bound method and visioplasticity. The slab method develops a simplified differential equation of the process and although highly approximate provides a good insight of the process. Method is now more than 100 years old, but is in still use, for example, recent application of slab method for modelling of asymmetric rolling. Slip line method is suitable for plane strain problems. Upper and lower bound methods provide the bounds on metal forming load. Visioplasticity is an experimental-analytical method. These methods are mainly used for load prediction. On the other hand, FEM can predict several performance parameters, such as load, temperature and various properties. With the support of FEM, even the microstructural changes in the material during processing can be predicted. However, this area is still in infancy.

Recently, meshless methods were developed to overcome the limitations of FEM, but there is hardly any significant progress in the modelling of manufacturing processes. In terms of computational efficiency, these methods could hardly surpass FEM. Moreover, engineers, in general, are not as familiar with these methods as they are with FEM. For the modelling of micromanufacturing and microstructure, crystal plasticity theory has been developed. Solution of the governing equations relies mainly on FEM. A parallel technique is molecular dynamics simulation (MDS). Theoretically, MDS can model almost any phenomenon, but practically hardly any real process is being modelled in industry. The main reason seems to be high computational time involved in these processes. Efforts have to be put by modeling experts and computer scientists to overcome this limitation.

A challenging issue in the modeling and simulation area is that it is inherently a multi-expertise activity. A good knowledge of physics as well as data analytics, numerical & and programming techniques and experimental skills, are needed to develop a robust model. This can be achieved only through collaborative efforts.

Memorial talk: 2

Dr. S. M. Patil Memorial Lecture, AIMTDR 2023

Topic: Heavy Machinery in Capital Goods Manufacturing: BHEL's Experience

Shri Sanjeev Rastogi

General Manager, Corporate Office, BHEL

New Delhi

srastogi@bhel.in

Extended Abstract

This talk on Heavy Machinery in Capital Goods Manufacturing will delve into the invaluable experiences of Bharat Heavy Electricals Limited (BHEL), a stalwart in this field. The presentation will commence with an overview of the significance of heavy machinery in capital goods manufacturing and the pivotal role they play in shaping industries, fostering economic development, and addressing evolving global demands. A focus on the dynamic nature of the sector will underscore the need for continuous innovation and adaptation.

Through real-world examples from our Manufacturing Shops, the talk will highlight BHEL's approach to developing, and delivering cutting-edge solutions for diverse industrial applications. Attention will be given to the integration of advanced technologies, sustainable practices, and the pursuit of operational excellence.

Furthermore, the discussion will extend to the challenges faced by BHEL and the industry at large. From navigating complex regulatory landscapes to addressing environmental concerns, the talk aims to provide a ***holistic view of the multifaceted nature of heavy equipment manufacturing*** and gives ***Insights into BHEL's strategies for overcoming the challenges.***

The talk concludes by offering a glimpse into the future, exploring BHEL's roadmap for continued innovation and evolution thru introduction of emerging manufacturing technologies for transforming the manufacturing landscape.

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Abstracts

Oral and Poster Presentations

Paper ID #012

Effect of flow Forming Processes on Microstructure and Grain Size of AA 6061 Aluminum Alloy

G. Venkateshwarlu[1*], K. Ramesh Kumar[2], E. Madhusudan Raju[3]
[1,3]Department of Mechanical Engineering, University College of Engineering, Osmania University, Hyderabad, India.
[2]BrahMos, Defence Research Development Organization (DRDO), Kanchan Bagh, Hyderabad, India
*gadadasu.venkatesh@gmail.com

Abstract. The point deformation method used in advanced chip-less incremental metal forming process known as flow forming is used to create long tubes with exact dimensions. AA 6061 aluminum alloy has good corrosion resistance and outstanding mechanical properties and widely used in construction of ships, aircraft and commercial vessels. In this paper, an aluminum alloy 6061 tubular preform that is fully annealed and made by cold backward flow-form using three rollers in a single pass. This paper looks at the effect of flow forming process factors viz. feed ratio, percentage of reduction, and roller axial stagger on grain size and microstructure. It was found that the microstructure had elongated precipitates in the lengthwise direction and lath precipitates in the transverse direction. Grain sizes reduced from 138±6 µm to 55±20 µm as percentage reduction increased from 30 to 60. The grain size is determined using the Image J software. Utilizing Taguchi orthogonal arrays and the Design of Experiments method, flow formed component microstructure is determined (L9 Array).
Keywords: AA6061, Flow forming, Grain size, Microstructure, Incremental flow forming.

Paper ID #013

Effect of Track and Layer Overlapping on the Residual Porosity Generation in the Selective Laser Melting of AlSi10Mg

Ashish Kumar Mishra*, Arvind Kumar
Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur 208016, India
*ashishkmishr@gmail.com

Abstract. Aluminum alloys such as AlSi10Mg are frequently used for lightweight manufacturing and using Selective Laser Melting (SLM) can further enhance their potential for use in aerospace and automotive structures. However, residual porosity becomes a major issue during SLM processing of AlSi10Mg. As SLM involves track and layer overlapping, it becomes vital to study their contribution in the porosity generation. In this study, single, double and triple layers of AlSi10Mg are built on a base plate. Metallurgical characterization showed that apart from the gas porosity, a few bigger pores, caused by improper overlapping, were present. These pores were found of larger size (> 12 µm), irregular geometry and were concentrated at the inter-track and inter-layer boundaries. The spherical pores, on the other hand, were very small in size (< 2 µm) but large in number and distributed uniformly in the deposited tracks. The large irregular pores had cracks initiated from the sharp corners. Good quality scanned tracks were seen at lower scanning speeds, while the high scanning speeds result in improper melting which further contribute to the porosity.
Keywords: Selective laser melting; Porosity; Track and layer overlapping; AlSi10Mg.

Paper ID #014

Simulation of Ultra-Thin Strip Rolling using ABAQUS Explicit

Dantuluri Narendra Varma[1*] and Ch. Srinivasa Rao[2]
[1]Research Scholar, Mechanical Engineering Department, Andhra University college of Engineering, Visakhapatnam, AP – 530003, India.
[2]Professor, Mechanical Engineering Department, Andhra University college of Engineering, Visakhapatnam, AP – 530003, India.
*nvdantuluri.rs@andhrauniversity.edu.in

Abstract. Metal forming as a manufacturing subset plays a major role in metal components manufacturing. In the present scenario, most industries focus on micro components, i.e., for microelectronic and UAV (Unmanned Ariel Vehicle) applications. The costs of manufacturing and selecting optimum process parameters is a tedious and cumbersome process. In order to overcome the difficulties, the simulation and analysis at the micro level are conducted in the present study. The NEPER is a polycrystal generation tool extensively used to generate grain structure in the workpiece i.e., 3D Voronoi Tessellations. A Python code is used to export the workpiece into the ABAQUS Explicit. The ABAQUS simulations are performed to obtain the optimum results. The experimental simulations are conducted based on the L9 Orthogonal Array. The input parameters considered are Reduction %, COF (Coefficient of Friction), and Roll speed. Output responses considered for the study are the PEEQ i.e., Equivalent plastic strain. The 7th experiment is the optimal parameter combination i.e., % Reduction 30, COF 0.02 and Roll speed 2.5 mm/s i.e., higher reduction, lower COF, and higher roll speed are desirable in the present study.
Keywords: Micro-Rolling, Ultra-thin strip rolling, NEPER, Polycrystal model, 3D Voronoi Tessellations, ABAQUS Explicit.

Paper ID #017

Face Centered CCD-based RSM Modelling and Optimization of parameters for Milling Electrochemical Spark Micromachining of E-Glass Fiber Composites

Kriti Sahai[1*], Audhesh Narayan[2]
[1,2]Motilal Nehru National Institute of Technology Allahabad, Prayagraj, Uttar Pradesh, 211003, India
*kritisahai@mnnit.ac.in

Abstract. Glass Fibers are popular over traditional materials as they have a greater strength with light weight providing better dimensional stability and flexibility in improving designs and applications. Milling-Electrochemical Spark Micromachining (M-ECSMM) is an emerging hybrid micromachining process that creates microchannels on brittle non-conducting materials. In the present work, microchannels were made on an E-glass fiber-reinforced polymer (E-GFRP) composite using M-ECSMM. Experiments are carried out using CCD-based DOE considering having voltage (V) and speed (N, rpm) as input parameters and the rate at which material is removed as MRR, tool wear rate (TWR), and average roughness (Ra) as response parameters. The multi-response optimization was carried out using Desirability Function Analysis (DFA), and the optimal solution obtained using DFA at 140 V and 14.4 rpm, the predicted value for MRR of 26.6765 mg/min, TWR as 13.7432 mg/min, and Ra as 10.5063.
Keywords: Glass Fiber Epoxy Reinforced Polymer (GFRP) Composite, Milling-Electrochemical Spark Micromachining (M-ECSMM), Material Removal Rate (MRR), Tool Wear Rate (TWR), Average Roughness (Ra), Desirability Function Analysis (DFA).

Paper ID #018

Neutral Network Based Modelling for the comparativeprediction of Material Removal Rate and Surface Roughness in fabricating channels on glass and silicon surface through M-ECSMM process

Kriti Sahai[1*], Audhesh Narayan[2]
[1,2]Department of Mechanical Engineering Motilal Nehru National Institute of Technology, Allahabad Prayagraj, Uttar Pradesh, India. 211004
*kritisahai@mnnit.ac.in

Abstract. Milling-Electrochemical Spark Micromachining (M-ECSMM) is a cutting-edge hybrid micromachining technique that produces channels, grooves, and features. The experiment performed in the current work uses the one-factorat-a-time method (OFAT) to build microchannels on glass and silicon substrates. Then the data obtained is trained using an Artificial Neural Network (ANN). Developed NN model predicts MRR and Ra using input parameters such as voltage, tool speed, electrolyte concentration, and pulse on-time (Ton), keeping pulse offtime (Toff) constant. The analysis of a comparative parametric plot of predicted values MRR and Ra for silicon and glass is done, which shows that predicted values of MRR for silicon maintain the same level with a small rise in values. Still, for glass, it shows a significant rise at 12 rpm, 95 V, Ton as 900 µs, and 4.6 M concentration. For the glass workpiece, the trained model under the same input process parameters gives MSE for training as 2.118, which is greater than the silicon workpiece, while for testing and validation, it is 8.43 and 4.00, respectively. Also, it shows the overall MSE and regression values of the NN model developed for both workpieces, and from the results, we observe that error is more in the case of glass than silicon workpieces. Thus, we can say that the model presented in this paper for process parameters best fits a Silicon workpiece compared to a Glass workpiece.
Keywords: Artificial Neural Network (ANN), Milling-Electrochemical Spark Micromachining(M-ECSMM), Back Propagation Neural Network (BPNN), MRR, Surface Roughness (R_a).

Paper ID #020

Topology Optimization and Modal Analysis of Engine Bracket Arm using Additive Manufacturing

Saurabh Srivastava[1,2], Sachin Salunkhe[2], Sarang Pande[1*], Santosh Kumar[3], Sandip Hazra[4]
[1]Department of Mechanical Engineering, Marwadi University, Rajkot, 360003, India
[2]Department of Mechanical Engineering, Vel-Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, 600062, India
[3]Department of Mechanical Engineering, Indian Institute of Technology, Banaras Hindu University, Varanasi, 221005, India
[4]Power-train Integration, Chassis Engineering, Tata Motors, Pune, 411018, India
*sarangpande@gmail.com

Abstract. One of the important components of the engines in the vehicles is the engine bracket. The bracket is designed to take up the load of the engine in static and dynamic conditions. Brackets from different sides of the vehicle support the vehicle engine. The bracket is designed according to the shape of the engine for different vehicles. The work done in the paper is about the modal analysis of the bracket arm used for different vehicles. A finite element analysis comparison of the conventional and topology-optimized bracket is made for a von Misses stress and deformation vehicle. Then, to check the engine bracket's dynamic analysis, the modal analysis is done. Second order differential equation is used for theoretical calculations, then the results are compared with the computational result. Additive manufacturing is done to check the design of the topology-optimized part.
Keywords: Topology optimization, additive manufacturing, modal analysis, finite element analysis.

Paper ID #021

Numerical Study of the Effect of Tool Rotational Speeds on Material Flow and Strain Rates During Friction Stir Butt Welding of AA2219-T87 Plates

Ramana Murthy Bagadi[1*], Jeevan Jaidi[2], Karthik G M[3], Prashanth Kumar Reddy G[4]
[1]Dept. of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
[2]Dept. of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
[3]Dept. of Mechanical Engineering, IIT BHU, Varanasi, Uttar Pradesh, 221005 India
[4]Dept. of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
*p20210053@hyderabad.bits-pilani.ac.in

Abstract. Aluminium-copper alloy AA2219-T87 material is used for the fabrication of liquid cryogenic rocket motor shells and propulsion fuel tanks owing to its superior toughness and excellent properties at cryogenic temperatures. Friction Stir Welding (FSW) process is widely used for joining AA2219-T87 because of high joint efficiency and low residual stresses in contrast to fusion-based joining techniques. In the present study, a friction stir butt welding of AA2219-T87 plates with a conical tool-pin is considered. A 3D coupled thermal-material flow model in Eulerian framework is developed in COMSOL Multiphysics software, and used to study the effect of tool rotational speed (500-1000 rpm) on thermal and material flow fields, shear strain rates, thermal histories, and size of weldment zones, keeping the tool traverse speed (600 mm/min) fixed. The plasticized workpiece material is considered a non-Newtonian fluid with apparent viscosity as a function of temperature and shear strain rate. The instantaneous net heat generation during the FSW process is due to friction between the workpiece and tool materials and the deformation energy of plasticized material flow sheared by the rotating tool. From the literature on the precipitation kinetics study of AA2219-T87 and measured peak temperatures in weldment zones, the authors proposed a temperature range for each weldment zone and found it to be more appropriate because the predicted sizes are in good agreement with the experiments. Also, proposed that a good quality weld must have a weld nugget size smaller and a heataffected zone size larger than the tool shoulder diameter.
Keywords: FSW, Eulerian framework, material flow, deformation energy, shear strain rate, weldment zones.

Paper ID #023

Modelling of Ultrasonic-Assisted Abrasive Flow Machining using Artificial Neural Network

Bhukya Shobhan[1], Kamepalli Anjaneyulu[1*], Bhargava Manikanta[1], Gudipadu Venkatesh[1]
[1]Department of Mechanical Engineering, National Institute of Technology, Warangal-506004, Telangana,
*kamepalli123@gmail.com

Abstract. Artificial intelligence is used by many researchers in an extensive variety of domains due to its technological advancements. The main aim of any machining process was to reduce processing time and improve its machining performance. Moreover, obtaining a high-level surface finish as well as improving the material removal rate was a challenging task. The newly created ultrasonic-assisted abrasive flow machining (UAAFM) procedure was utilized in this study to predict MRR and improve R_a using an artificial neural network (ANN) approach, and the effectiveness of the ANN was examined using the results of the experiments. Two optimum ANN models were created in the current work, one for surface finish improvement and the other for material removal rate. For the backpropagation approach with RMSprop optimizer, experimental data were divided into training and testing. The simulation results for the test data demonstrate that the R2 values for the experimental and ANN predicted values are both high. The projected values from the ANN and the regression values are then contrasted.
Keywords: Artificial neural network, Ultrasonic-assisted abrasive flow machining, Activation, back propagation.

Paper ID #024

Effect of Heat Treatment on the Properties and Microscopic Characteristics of Different Alloys Used in Gas Turbine Engines

Geetika K. Salwan*, Rayapati Subbarao[2], Subrata Mondal[3]
[123]NITTTR Kolkata, West Bengal, Kolkata - 700106, India
*geetikasalwan@gmail.com

Abstract. Engineering materials are mostly heat treated under controlled conditions of heating and cooling to modify their properties in order to meet the desired engineering applications. As demand of gas turbine engine is growing very fast, quest for studying the material for their applicability is increasing. In this work, properties and microstructure of different materials is analyzed in both as-received sample and after secondary processing, i.e., annealing the sample. Samples for microstructural study are prepared using standard metallographic procedures and then examined in Scanning Electron Microscope (SEM). Energy-dispersive X-ray spectroscopy (EDS) is done for analyzing elemental composition of the respective sample. Micro hardness is measured for the polished surface of the samples. Annealing has different effect on different material. For Inconel 718 only, hardness increases after annealing whereas for other elements hardness decreases. Similarly, density decreases after annealing for aluminium and Monel 400 only, whereas for other materials density increases. The effect of alloy composition and annealing, on microstructural changes is analyzed. The role of microstructure in superseding the hardness and density of the materials is observed. By EDS analysis, it is observed that there is no change in composition of the material after heat treatment. This study reveals that heat treatment can be used for modifying the property of materials and make it suitable for the gas turbine engine.

Keywords: Gas turbine engine, Micro hardness, Scanning Electron Microscope, Energy-dispersive X-ray spectroscopy.

Paper ID #025

Design and In-House Development of Automatic Tube Filling Machine

Rahul Kumar*, Venkateswara Rao Komma*, Vidit Kumar Pal
Department of Mechanical Engineering, Motilal Nehru National Institute of Technology Allahabad, Prayagraj, Uttar Pradesh, 211004 India
*rahul.2019rme54@mnnit.ac.in

Abstract. Filling is a crucial process for industries that supply fluid products such as food, cosmetics, pharmaceuticals, and beverages. While automated filling machines offer advantages in terms of efficiency and precision, the high cost of complex controllers, sensors, and actuation devices makes it challenging for micro, small, and medium enterprises (MSMEs) to afford them. As a result, many MSMEs still use manual filling processes. To address this issue, a low-cost, reliable, and easily accessible automated filling setup is needed. In this article, details of design and in-house development of an automatic tube-filling machine is presented. Proposed low-cost automatic tube filling machine has five stations, each one for a specific task. The setup can carry up to five tubes at a time, and it automates the filling, sealing, and ejection process. The proposed filling setup tries to eliminate the need for human intervention in the filling process, improving efficiency and reducing errors. While human intervention is required to insert the tubes into the tube holder at station 1, the presence of the tube is verified, while station 2 is responsible for filling the tube with a specific fluid. Station 3 checks whether the tube has been filled or not, while station 4 is responsible for sealing the tube. Finally, station 5 ejects the filled tubes using a push-out mechanism. The details of the setup provided in this paper are useful for building a reliable and affordable option for MSMEs to automate the filling process, for improving productivity and competitiveness.

Keywords: Automatic tube filling machine, Tube sealing, Productivity, Arduino, Small and medium enterprises.

Paper ID #026

Effect of SiC and B_4C Addition on the Properties of Aluminium Metal Matrix Hybrid Composites

Mohammad Umair Zaki[1*], Vikas Upadhyay[1], Faisal Hasan[2], Chaitanya Sharma[3]
[1]Department of Mechanical Engineering, National Institute of Technology, Patna, 800005, India
[2]Department of Mechanical Engineering, Aligarh Muslim University, Aligarh, 202002, India
[3]Department of Mechanical Engineering, BIT Sindri, Jharkhand, 828122, India
*mohammadz.ph21.me@nitp.ac.in

Abstract. This work studies the effect of adding silicon carbide and boron carbide on the performance of powder metallurgy-produced aluminium metal matrix hybrid composites. The weight fraction of both the reinforcements used, varied from 3 to 5 percent in a step of 1%. The fabricated composites were examined for microstructure, hardness, density, and wear properties. Microstructure was uniform and free from clustering and agglomeration owing to proper blending. Density and hardness increased as the wt. % of silicon carbide and boron carbide increased, whereas porosity and wear decreased. Higher the wt. % greater is the number of obstacles obstructing the dislocation so higher is the hardness where lower wear is due to reduced contact area on account of load bearing by these hard-reinforcing particles. Based on the finding it can be concluded that powder metallurgy is beneficial technique for producing hybrid metal matrix composites and addition of silicon carbide and boron carbide improves its hardness and wear behaviour.

Keywords: Aluminium, Boron carbide, Powder Metallurgy.

Paper ID #027

Effect of Unidirectional and Bidirectional Cold-Rolling on Magnetic properties of High entropy alloy

Rajnish P. Modanwal[1*], Jayaprakash Murugesan[2], Dan Sathiaraj[1]
[1]Advanced Forming Lab, Department of Mechanical Engineering, Indian Institute of Technology Indore, Indore 453552, India
[2]Department of Metallurgy Engineering and Materials Science, Indian Institute of Technology Indore, Indore 453552, India
*phd1901203003@iiti.ac.in

Abstract. Soft magnetic materials with high saturation magnetization and low coercivity are getting more attention in several industries, including electrical machines, magnetic shielding, and power supply production. In this study, a $FeCoNiMn_{0.25}Al_{0.25}$ based high entropyalloy was synthesized through the utilization of the vacuum arc melting technique. To examine the influence of strain path, unidirectional and bidirectional cold rolling processes are implemented on the fabricated high entropy alloy. Furthermore, we study phase evaluation, crystal structure, and chemical composition by employing X-ray diffraction, field emission scanning electron microscopy, and energy dispersive spectroscopy, respectively. Subsequently, the electrical resistivity and magnetic properties of the fabricated high entropy alloy are also investigated. It has been observed that the magnetic properties of unidirectional are superior to those of bidirectional cold rolling.
Keywords: High entropy alloy, Unidirectional cold rolling, Bidirectional cold rolling, Soft magnetic material, Electrical resistivity.

Paper ID #028

Effect of μ-EDD Parameters on Machining Responses During Drilling of Al/SiC/ZrO_2/NiTi-MMC

Saurabh Kumar Maurya[1*], Chander Kant Susheel[2], Alakesh Manna[3]
[1,2,3]Department of Mechanical Engineering, Punjab Engineering College (Deemed to be University), Chandigarh-160012 India
*skks.saurabh@gmail.com

Abtract. The use of metal matrix composites was increased day by day in numerous industrial application. As a result of increased MMCs demand in industrial application, accurate and précised machining of composites in micro domain become important. Micro-electrical discharge drilling (μ-EDD) can be effectively used for machining of micro holes in the fabricatedhybrid Al/SiC/ZrO_2/NiTi-MMC. The effect of μ-EDD process parameters such as pulse-on-time, pulse-off-time, peak current, tool rotation and electrode polarity on machining responses such as material removal rate (MRR), radial overcut (RO) and tool wear rate (TWR), a set of experiments has been carried out on fabricated MMC. Results reveals that MRR, RO and TWR increases as the peak current, pulse-on-time and tool rotation increases. Copper tool with positive polarity gives better results when compare to the other combinations. Although MRR was reduced by 11.22%, RO and TWR were improved by 14.51% and 59.52% respectively at GRA based optimal parametric setting. SEM images of the machined surface shows that hole with high circularity, less surface damage and negligible recast layer can be obtained by μ-EDD at optimal setting.
Keywords: Hybrid Al-MMC, μ-electrical discharge drilling (μ-EDD), MRR, Micro drilling, SEM analysis.

Paper ID #029

Optimization of Nozzle Parameters in Dual Nozzle CO_2 Based Vortex Tube Cooling System in Turning of Ti-6Al-4V

Banoth Srinu[1*], Khirod Mahapatro[1], P. Sai kiran[1] , P. Vamsi Krishna[1]
[1]National Institute of Technology Warangal, Warangal, Telangana, 506004, India
*banothsrinu09@gmail.com

Abstract. A dual nozzle Vortex Tube Cooling System (VTCS) that delivers cooled compressed CO_2 gas. This system aims to effectively lower the cutting temperature during the machining process of Ti-6Al-4V. Experiments were conducted in this study with a constant cutting and flow parameters during turning at different levels of nozzle diameter. From the results, it was observed that decreasing the nozzle diameter reduced the cutting temperature and surface roughness and increased the cutting force. Further, the optimization of the input parameters for better output response was done by means of the Genetic Algorithm. The experimental results were compared with the results obtained under different cooling media at the same machining conditions. There is a 37% and 66% minimizing the cutting temperature and surface roughness and a 14% increase in cutting force observed in CO_2 -VTCS compared to dry cutting.
Keywords: Ti-6Al-4V, Vortex tube, CO_2 gas, Machining performance.

Paper ID #030

Formability of Tailor Welded Blanks and Characterization of Residual Stresses-A Review

Amit Kumar[1*], D. Ravi Kumar[2], K. Hariharan[3], Debashish Gogoi[4], Manjesh Kumar[4]
[1]Department of Mechanical Engineering, BITS Pilani, Rajasthan 333031, India
[2]Department of Mechanical Engineering, Indian Institute of Technology Delhi, Delhi 110006, India
[3]Department of Mechanical Engineering, Indian Institute of Technology Madras Chennai 600036, India
[4]Department of Mechanical Engineering, SRM University-AP, Guntur 522508, India
*amit.kumar@pilani.bits-pilani.ac.in

Abstract. Making sheet metal components for automobiles using tailor-welded blanks (TWBs) have a number of advantages over conventional blanks, including greater product design flexibility, increased structural rigidity, and improved crash behavior. It is possible to get particular needed qualities in appropriate places of the produced parts by using TWBs. The use of TWBs also lowers production costs, quantity of forming processes required, weight of the vehicle (making them environmentally friendly), and it does away with post-forming welding. It is also essential to analyze the post-forming characteristics of sheet metal parts, such as micro-hardness and residual stresses, after producing sheet metal components utilizing plain sheets and tailor-welded blank (TWB). Particularly in automotive applications, residual stresses are crucial in deciding the lifetime of automotive parts. Resultant internal stresses that emerge as a result of retained elastic energy after the elimination of deformable loads or temperature variations are known as residual stresses in a part. When the component is exposed to static or dynamic loads, the tensile residual stresses are harmful and might cause an early failure. Conversely, compressive residual stresses are advantageous for parts exposed to alternating stresses. As a result, engineersdevised strategies for introducing compressive residual stresses into mechanical parts. The present study reviews forming aspects of TWBs and residual stress characterization in the welded blanks (prior to forming) and formed parts. Also, the potential methods in reducing the residual stresses in the automotive components have been outlined.

Keywords: Tailor welded blanks, Formability, Residual stresses Characterization, Automotive component and Finite element simulation.

Paper ID #033

Effect of Activated Flux on SS304 under Autogenous ATIG Weldingon Weld Geometry, Microstructure, And Hardness

Anand Baghel[1*], Chaitanya Sharma[2*], Manvandra Kumar Singh[3,] Vikas Upadhyay[4]
[1,3]Department of Mechanical Engineering, Amity University Madhya Pradesh, Gwalior, India
[2]Department of Mechanical Engineering, BIT Sindri, Sindri Dhanbad, India
[4]Department of Mechanical Engineering, National Institute of Technology Patna, Patna India
*chaitanya.sharmaji@gmail.com

Abstract. TIG welding has a limitation of low depth of penetration which is 3 mm, so improve it with the help of using Activated flux during welding of TIG welding. Activated Tungsten Inert Gas (ATIG) welding has used bead-on-plate experimentation for SS304 plates of 6 mm thick. For the experimentation, input parameter current, weld speed, gas flow rate, and arc gap are considered constant. The current research examined the microstructure properties of austenitic stainless steel SS304 compared the effects of without flux and activated flux (TiO_2, SiO_2, and Fe_2O_3) on weld bead. The results show that SiO_2-activated flux improves the depth of penetration (DoP), reduces weld width, and improves hardness at weld bead compared to without flux and with flux (TiO_2 and Fe_2O_3) on SS304 weld geometry. The microstructure grain growth at Heat affected zone (HAZ) region under Fe_2O_3 is maximum, whereas hardness is lower. The overall effect of ATIG welding gives a higher aspect ratio (DoP/Weld width) than without flux.

Keywords: TIG welding, ATIG, Flux, SS304, penetration depth, macro and microstructure, hardness.

Paper ID #034

Design and Development of Holonomic Autonomous Mobile Robot for Seamless Material Handling and Transportation

Pon Dinesh S[1*], Hariprasath D[2], Aswin Prashaad A[3], Sam Rosario F[4], Murugarajan A[5]
[1,2,3,4,5]Academic Affiliation, Coimbatore, Tamilnadu, 641022, India
*pondinesh006@gmail.com

Abstract. This project aims to design and develop an autonomous mobile robot for material handling tasks using Omni wheels. The robot will be capable of navigating in indoor environments and moving goods between different locations. The use of Omni wheels allows the robot to move in any direction, providing greater maneuverability in tight spaces. The robot will be fitted with an array of sensors, including LiDAR, and ultrasonic sensors to enable it to detect obstacles and navigate around them. It will also be designed to communicate with other robots and systems, allowing for seamless integration into existing warehouse and logistics systems. The autonomous mobile robot will be powered by a rechargeable battery and will have a range of safety features, including emergency stop buttons and obstacle detection systems. The project will involve the design and construction of the robot, as well as the development of the software necessary to enable it to perform its material handling tasks autonomously. This project could lead to a substantial enhancement in the efficiency of material handling operations in warehouses and logistics centers. By reducing the need for human labor in these tasks, the robot can increase productivity while reducing the risk of workplace injuries. Additionally, the Omni wheels used in the robot's design make it highly versatile and capable of handling a wide variety of materials and environments

Keywords: Autonomous mobile robot, material handling tasks, Omni wheels, indoor environments, goods, navigating, sensors, LiDAR, ultrasonic sensors, obstacles, communication, integration, warehouse, logistics systems, rechargeable battery, safety features, emergency stop buttons, software development, efficiency, productivity, workplace injuries, versatility.

Paper ID #035

Robot Control Using Motion Capture With IMU

Pon Dinesh S[1*], Hariharan M[2], Manikanda Prabhu M[3], Akilan M J[4], Sudhakar R[5]
[1,2,3,4,5]Academic Affiliation, Coimbatore, Tamilnadu, 641022, India
*pondinesh006@gmail.com

Abstract. This project introduces an application of gesture-based human-robot interaction utilizing an IMU sensor. The gesture recognition technique combines depth information and a traditional joint tracking algorithm, employing Gyroscope and Accelerometer to mimic dynamic gestures through skeleton angular motion. A Master/Slave structured robot control application is developed, where the master Wi-Fi on a PC is paired with the ESP32 controller acting as the slave module. The wireless setup facilitates gesture commands using the IMU sensor to control the shadow robot. During a training process, serial string array sets are stored in a local database of the application and can be subsequently transmitted to the slave module when commanded. The project presents a constructive approach to design a hand gesture-controlled robot. This system serves as a direct link between humans and the robot, relying on physical changes like tilting of the hand for control. Instead of conventional joysticks or button-based controllers, hand gestures are utilized. This technology holds significant potential for applications in surveillance, military operations, and industrial-grade robotic arms, providing valuable assistance to individuals with physical challenges.

Keywords: 2D Image, 3D Pose Estimation, Gesture Control, Esp32, IMU, ABB Robot, YARP, MOOS, Wi-Fi, Shadow Robotics, 3D CAD, Cyberglove, Socket, Robot Operating System (ROS).

Paper ID #036

Quality Assessment of Ultrasonic Welded Joints Using Image Processing Technique

Sandeep Bose[1*], Vivek Yadav[1], Rahul Kumar[1], K. Ponappa[1]
[1]PDPM Indian Institute of Information Technology, Design, and Manufacturing, Jabalpur, Madhya Pradesh, 482005, India
*1913611@iiitdmj.ac.in

Abstract. The quality assessment of ultrasonic welded joints plays a critical role in ensuring the integrity and reliability of numerous industrial applications. This paper presents a comprehensive study on utilizing image processing techniques for evaluating the quality of ultrasonic welded joints. The primary objective of this research is to gain valuable insights into weld quality and defect detection using advanced image processing methods. This study employed image processing techniques to assess the quality of ultrasonic welded joints, yielding valuable insights. The edge detection technique indicated that the overall joint quality was low, while the surface detection technique identified a high defect percentage, pointing to poor welds. These findings underscore the significance of using image processing to monitor and optimize ultrasonic welding processes for enhanced accuracy and consistency. The project demonstrates the potential of image processing and machine learning in optimizing such welding procedures.

Keywords: Ultrasonic Welding, Image Processing, Quality Assessment.

Paper ID #037

Investigation on Kinematics in Additive Manufacturing

Yash Gopal Mittal[1*], Yogesh Patil[2], Pushkar Kamble[3], Gopal Gote[1], Avinash Kumar Mehta[1], Siddhartha[1], Ganesan G[4], Shahu Karade[1], Ashik Kumar Patel[2], Neel Kamal Gupta[1], Sudhanshu Dubey[1], K. P. Karunakaran[1]
[1]Department of Mechanical Engineering, Institute Institute of Technology (IIT) Bombay, Mumbai - 400076,
[2]National Institute of Industrial Engineering (NITIE), Mumbai - 400087, India
[3]Universite de Technologie de Belfort – Montbeliard, France – 90010
[4]Department of Metallurgical Engineering and Material Science, Institute Institute of Technology (IIT) Bombay, Mumbai - 400076, India
*ymymittal1@gmail.com

Abstract: Kinematics plays a crucial role in *additive manufacturing* (AM), including the synergic movements and relative positioning of different machine components to create the final three-dimensional (3D) model. Therefore, it is essential to understand the underlying kinematics of the machine set-up in use to produce high-quality prints, including complex geometries, intricate shapes, and difficult-to-reach overhangs & underlying supports. Achieving the desired efficiency and required accuracy while printing significantly measures the machine's capabilities and kinematic limits. The overall machine kinematics includes not only the coordinated movements of the print head and the build platform but also the material feeding and curing mechanisms. Factors such as the machine type, material choice & form, and the desired resolution of the printed part also contribute to the overall kinematic requirements. The kinematic analysis of an AM machine system also includes the properties of printer components, motion control algorithms, and the software used for process control. In this research, various *state-of the-art* AM set-ups have been described with dedicated applications for metals (Multi Station Multi-Axis Hybrid Layered Manufacturing (MSMA-HLM), Electron Beam Hybrid Manufacturing (EBHM)), thermoplastics (Plastic Additive Manufacturing (PAM), Foam Additive Manufacturing (FAM)), ceramics (Sand 3D Printing (Sand-3DP)), composites (Optimal Laminated Additive Manufacturing (Opti-LAM)) and jettable liquids (Sub-zero Additive Manufacturing (SAM)). Fabricated sample parts are also described. Investigating the various kinematic set-ups can help in enhancing the capabilities and efficiency of additive manufacturing techniques, leading to advancements in the field of rapid manufacturing.

Keywords: Additive Manufacturing (AM), Kinematics, Metals, Polymers, Ice, Ceramics.

Paper ID #039

Effect of Welding Speed on Mechanical and Formability Properties of TIG Welded Al-5052 Sheets

Marrapu Bhargava[1*]
[1]Assistant Professor, Department of Mechanical Engineering, National Institute of Technology Warangal, Warangal -506004, Telangana, India
*bhargava@nitw.ac.in

Abstract. Tungsten Inert Gas (TIG) welding, which is also known as Gas Tungsten Arc Welding (GTAW), is a common welding procedure that produces the finest welding with a composition which is very much identical to that of parent metal. Al 5052 alloy is mostly used to replace steel in the marine and automotive industries. An automated TIG welding was utilized to increase the mechanical strength and microstructural properties of Aluminium 5052 alloy. The control parameters during the TIG welding are the most critical factors that have to be considered while performing the welding. The important parameters which affect TIG welding are welding speed, current and frequency. Out of the three parameters, welding speed plays a vital role in Al alloys mechanical properties and formability. The current and frequency were kept constant and the welding speed was varied. Welding is done on three different specimens using three different speeds for repeatability. Tensile tests were performed according to ASTM standards to evaluate the mechanical properties at different speeds. Mechanical tests like the Erichsen cupping test were performed to evaluate the formability of TIG welding at different speeds and microstructural studies were performed on the welded specimens to study the effect of welding speed on TIG welding.
Keywords: TIG welding, Al 5052, Formability, Microstructure.

Paper ID #041

Energy Absorption Characteristics and Compressive Mechanical Properties of the Hybrid lattice structure

Uday Kumar Jonnala[1*], Ravi Kumar Y[1]
[1]Department of Mechanical Engineering, National Institute of Technology, Warangal, Telangana-506004, India.
*uj712083@student.nitw.ac.in

Abstract. The lattice structure is made up of struts or curved beams that connect at various points. These connectors are essential for transmitting forces and preserving the overall stability of the structure. One of the main benefits of lattice structures is the exceptional strength-to-weight ratio. Lattice structures are advantageous for applications that rely on for weight reduction because of this property. The mechanical and physical characteristics of uniform lattice structures and triply periodic minimal surfaces (TPMS) have been extensively studied in the literature. These structures, whose characteristics have been thoroughly investigated, are made up of regular repetitions of a single type of lattice. However, hybrid lattice structures which combine at least two different lattice types, can give even more desirable characteristics like stiffness, compressive strength and Young's modulus. In this work, a novel method for creating a hybrid lattice has been presented. This approach will be utilized to design a complex hybrid lattice and create models using material extrusion technology. In this study, the manufacturability, the mechanical properties and energy absorption capacities of the hybrid lattice will be evaluated. The results suggest that lattice structure hybridization can enhance energy absorption.
Keywords: Triply periodic minimal surface; lattices; kelvin; schwarz primitive; Energy absorption; Material extrusion.

Paper ID #042

Experimental Study on Hole Quality Parameters in Drilling of Quartz Polymeric Composite

T. Ramalingam[1*], N. Kishore Nath[2], N. Selvaraj[3]
[1,2]Advanced Systems Laboratory, DRDO, Hyderabad, Telangana, India, 500058
[3]Department of Mechanical Engineering, National Institute of Technology- Warangal, India-506004
*t.ramling@gmail.com

Abstract. Quartz-Fibre-Reinforced cyanate ester Plastics (QFRP) has excellent electromagnetic properties which makes them the ideal choice for defence applications. The combination with cyanate ester resin makes this composite even more appealing for military applications. After composite part realization, drilling of holes is indispensable for assembly requirements. The objective of this work is to analyse the process parameters influence while machining hole on Quartz composite laminate. Various hole quality parameters are considered for the analysis and the composite laminate was made by automized process namely Vacuum Assisted Resin Transfer Moulding (VARTM). Experimental designs were performed and analysis of results showed that the maximum influence on force, torque, delamination factor is due to feed and its contributions on the respective parameters are 94.59%,66.98%, and 54.22% respectively. Similarly, the major influence on diameter and cylindricity is because of spindle speed and its respective contributions are 59.96% and 76.82%. Further, optimum solution was derived considering all hole quality parameters and experimental output for this optimized condition were validated with results of regression equations with a maximum error of 9.02%.

Keywords: Quartz polymeric composite, drilling, resin transfer moulding, hole quality, optimization.

Paper ID #043

An Experimental Investigation into the Top Burr Formation in Micro-milling using Bulk Metallic Glass

Debajyoti Ray[1*], Asit Baran Puri[2]
[1]Sanaka Educational Trust's Group of Institutions, Durgapur - 713212, India
[2]National Institute of Technology Durgapur, Durgapur - 713209, India
*debajyoti_ray2002@yahoo.co.in

Abstract. Proper functionality of micro-parts depends largely on the quality of the micro-cut features. Quality of micro-cut features includes surface roughness, micro-structural integrity, form and dimensional accuracy and machined edge quality. Formation of burrs is inevitable in almost all machining processes. As this burr formation cannot be avoided, so minimisation of burrs on the generated edges becomes essential to achieve the compliance to the required quality. Micro-cutting is an effective process to fabricate micro-features costeffectively. Micro-milling represents a flexible micro-cutting process used commonly to fabricate intricate micro-features. This paper presents an experimental study on the formation of top burrs in mechanical micro-milling of bulk metallic glass, a unique class of lightweight amorphous metallic alloy. The influence of the cutting conditions under different combinations of the cutting parameters on the formation of the top burrs is analysed and explanations for the observed trends are presented. The experimental results indicated that width of top burrs was higher at low feed rates than at higher feed rates. Experimental results also showed that increase in axial depth of cut resulted in increased burr width. However, increase in cutting speed showed a decreasing trend in the width of the burrs.

Keywords: Micro-milling, Bulk metallic glass, Cutting edge radius, Ploughing, Micro-burrs.

Paper ID #044

Investigations on the Effect of Hybrid Cooling/Lubrication Strategies on Machining Characteristics of SS316L

Mayur A. Makhesana[1*], Kaushik M. Patel[1], Navneet Khanna[2]
[1]Mechanical Engineering Department, Institute of Technology, Nirma University, Ahmedabad 382481, India
[2]Advanced Manufacturing Laboratory, Institute of Infrastructure Technology Research and Management (IITRAM), Ahmedabad 380026, India
*mayur.makhesana@nirmauni.ac.in

Abstract. The metal-cutting industries are developing further, with sustainability as the primary consideration. Cutting fluid is applied to diminish the effect of heat produced during machining. However, it poses a risk to workers' health and environmental resources. Recently, the use of minimum quantity lubrication (MQL) has been widely explored due to its environmentally friendly nature. Implementing new approaches, such as cryogenic cooling, can solve the temperature-related challenges in machining while easing disposal problems, hazardous emissions, and associated problems. In this direction, an attempt has been made in the current work to analyze the machinability of SS316L with five distinct machining environments namely dry, flood, MQL, cryogenic (LCO_2), MQL+LCO_2. Surface roughness, tool wear, power consumption, and cutting temperature are assessed using various cooling techniques. Hybrid machining significantly reduced Ra values by up to 40, 32, 10, and 17% compared to dry, flood, MQL, and LCO_2 conditions, respectively. Similarly, almost 44% reduction in cutting temperature is achieved with the improved cooling and lubrication during MQL+LCO_2 compared to dry machining. The results showed that the MQL+LCO_2 application is effective in reducing frictional forces and resulted in minimum tool wear. The outcomes demonstrated that MQL+LCO_2 is efficient in cooling and reducing friction at machining interfaces, reducing surface roughness and tool wear.
Keywords: Machining, Vegetable oil, MQL, MQL+LCO_2, Surface roughness, Tool wear, Power consumption.

Paper ID #045

Impact of Welding Processes on Microstructure and Mechanical Properties of Al-Zn-Mg Armor Aluminum Alloy Welds

Chaitanya Sharma[1*,] Vikas Upadhyay[2], Sumit Kumar Sharma[3],
[1]Mechanical Engineering Department, BIT Sindri, Sindri Dhanbad, Jharkhand, India-828123
[2]Mechanical Engineering Department, National Institute of Technology Patna, India-800005
[3]Metallurgical Engineering Department, BIT Sindri, Sindri Dhanbad, Jharkhand, India-828123
*vikas@nitp.ac.in

Abstract. Welding heat plays an important role in controlling the weld quality, microstructural and mechanical characteristics of welds which in turn depends on type of welding processes. To investigate the impact of welding methods, such as metal inert gas and friction stir welding, on the tensile characteristics of weld joints, armor grade aluminum alloy was fused using optimum parameters. The weld's hardness, strength, and ductility were assessed using hardness and tensile tests, while optical microscopy was used to study microstructural characteristics of as received base metal and fabricated welds. The choice of welding process has significant impact on weld thermal cycles, processing-structure-property relationship so as on weld tensile properties. Weld strength/hardness degradation is shown to be inversely related to heat input and vice versa. The improved tensile strength (~2.2 times) and elongation at fracture (~3.3 times) of friction stir welds was owing to recrystallized grains and lesser degree of dissolution/coarsening than metal inert gas welds. Mode of fracture was found to be dependent of welding process and was ductile and brittle for friction stir welding and metal inert welding process, respectively.
Keywords: Welding techniques, Friction stir welding, Metal inert gas welding, Aluminum alloy, Microstructure, Tensile Properties, Hardness, Fracture.

Paper ID #046

Advanced FE-based Hybrid Algorithms to Optimize Uncertain Multi Response Process Parameters in Tungsten Heavy Alloy Machining

Chithajalu Kiran Sagar[1], Sreejith S[2], Amrita Priyadarshini[2], Manmohan Das[2], Abhideep Tripathy[2]
[1]Training Department, MSME, Tool Room, CITD, Balanagar, Hyderabad, Telangana-500037
[2]Mechanical EngineeringDepartment, BITS-Pilani, Hyderabad Campus, Hyderabad, Telangana-500078

Abstract: Tungsten heavy alloys (WHAs) are gaining popularity in defence applications for the development of Kinetic energy penetrators owing to their high density, strength, and ductility. In order to improve the quality and reduce the production cost there is a need to use machining as secondary operation. WHAs, however are difficult to machine. Therefore, a solution that establishes the best cutting parameters to obtain the desired output with the fewest number of experimental trials while maintaining the accuracy of forecasted outcomes is required. In present study, a unique approach has been proposed that combines the numerical and analytical approaches with the evolutionary algorithms in order to develop multi-objective optimization models based on full factorial design data with a minimum amount of experimental tests. Three different evolutionary algorithms, namely, Non-dominated sorting genetic algorithm II (NSGA II), Hybrid Artificial bee colony algorithm (HABC) and Hybrid Cuckoo search algorithm (HCS) were used to predict the optimum cutting parameters. NSGA II was used as a benchmark among the three algorithms, while the other two were newly proposed. The best optimization strategy was proposed after the optimum cutting parameters predicted by three algorithms were validated with confirmation experiments. The proposed algorithm HCS was found to perform well for all output responses with an error variation of 3 to 15%.
Keywords: Tungsten heavy alloy, multi-objective optimization, Artificial bee colony algorithm, Cuckoo search algorithm.

Paper ID #047

Experimental Investigation of Strength Properties of Aluminum Wire Reinforced Cement Concrete

Vinay PratapSingh[1*], Anand Kumar[2], S.K.S. Yadav[2], Abhishek Kumar Gupta[2]
[1,2]HarcourtButler Technical University, Kanpur-208002, Uttar Pradesh, India
*vinayforus@gmail.com

Abstract: A large amount of aluminum wire scrap is generated every year after its useful life in electrical uses is over. Most of the scrap aluminum wire is reclaimed by recycling it for different uses. In this work, effort has been made to utilize it for reinforcing cement concrete to improve tensile and flexure properties without compromising the acceptable standard properties of cement concrete of stipulated grade. Compression, tensile and flexure strength of neat cement concrete of M30 grade as per Indian Standard Code 10262-2009 are compared with scrap aluminum wire reinforced cement concrete samples with 1, 2 and 3 per cent scrap aluminum wire by weight replacing sand.Samples of different configurations - random and aligned orientation are fabricated for bare scrap aluminum wire and PVC laminated aluminum wire reinforced cement concrete.Test has also been conducted by scratching the PVC lamination to make it rough with the aim to improve adhesion of matrix to it. Flexure strength of woven wire mesh and aligned configuration is also studied. Slump test has been conducted to determine the workability of cement concrete. Experimental investigations suggest that addition of 2 per cent scrap aluminum wire gives best results. Very little reduction in slump value in scrap aluminum wire reinforcement cement concrete samples suggest reasonably good workability which is a measure of strength and durability cement concrete samples.
Keywords: Cement concrete, scrapaluminum, compressive strength, tensile strength, slump test.

Paper ID #048

Experimental Investigation of Dissimilar Laser Welding between Maraging Steel and Stainless Steel

Vishal Kumar[1*], Vishal Kumar[1], Manchu Mohan Krishna Sai[1], Amitava Mandal[1*]
[1]Indian Institute of Technology (ISM), Dhanbad-826004, India
*amitava03@gmail.com

Abstract. The present study aims for dissimilar laser welding of Maraging Steel 250 and AISI 316 Stainless steel thin sheets and investigates the mechanical properties and microstructure of the welded bead. The process parameters such as laser power, welding speed, and focal length were varied between 250-350 W, 100-300 mm/min, and 159-179 mm respectively according to the Box-Behnken design (BBD) based on Response surface methodology (RSM). Tensile tests were performed and it showed that high UTS and percentage elongation can be achieved in a high-power and low-speed configuration. The hardness test showed non-uniformity in the micro-hardness of most of the welded joint samples. Laser power and welding speed were found to have a greater effect on tensile strength while laser power, welding speed, and focal length were showing a greater influence on percentage elongation. The optimization of the percentage elongation (EL) was found to be more desirable. The weld bead microstructure confirms the presence of epitaxial growth from the partially melted grains along both the fusion line. The columnar-dendritic structure was formed at the edge of the weld metal while both cellular dendritic structure and coarse equiaxed structure were formed near the center of the weld metal. The presence of iron and chromium along the stainless steel fusion line was confirmed by the formation of more elongated dendritic structures and micro-structural changes from cellular to columnar dendrites.
Keywords: Maraging Steel 250, AISI 316 Stainless Steel.

Paper ID #050

Surface Property Enhancement of AA 6061-T6 Alloy Using Friction Stir Processing with Fe-Based Chip and Zircoat Powder

Bappa Das*, Biranchi N. Panda, Uday S. Dixit
Department of Mechanical Engineering, Indian Institute of Technology Guwahati
Assam, 781039, India
*bappadas@iitg.ac.in

Abstract. Friction stir processing (FSP) is a popular, easy-to-use and affordable solid-phase processing technique for changing the surface characteristics of materials. Aluminum metal matrix composites (AMMCs) are employed in a variety of engineering applications due to their increased stiffness, wear resistance and specific strength. Surface AMMCs are developed on AA 6061-T6 aluminum (Al)alloy using FSP for improving the surface characteristics including the grain refinement. In the present work, AMMCs were fabricated by dispersing Fe-based chip and Zircoat-M Powder (procured from M/s Jyoti Ceramic, Nasik, India) through FSP route. The optical micrographs showed a uniform distribution of reinforcement in the base matrix. The maximum surface roughness of 6.18 μm was observed in the base matrix after FSP with Fe-based chip compared to 4.24 μm in the FSP of base matrix without any reinforcement. By dispersing Fe-based chip and Zircoat-M together a hardness of 294 HV could be achieved against 77 HV for base Al alloy. The yield strength of the hybrid composite was 254 MPa compared to 212 MPa of the base Al alloy. The minimum wear mass loss and wear depth of 0.041 g and 50.74 μm, respectively, was found in hybrid composite.
Keywords: Friction stir processing, hardness, surface roughness, tensile strength, wear.

Paper ID #052

Analysis of Bending Angle in Laser Forming of Thin Al 6061-T6 sheets

U. Nath, V. Yadav*
Department of Mechanical Engineering, Maulana Azad National Institute of Technology
Bhopal, Madhya Pradesh, India- 462003
*vyadav@manit.ac.in

Abstract. This paper covers a physics-based analytical approach to investigate the influence of process factors on the bending angle of Al 6061-T6 sheets under laser thermal forming process. Due to the fact that Al 6061-T6 alloy sheets have more deformability and high strength properties, they have been studied in this paper. The results obtained with the analytical approach is verified by experimental tests under the considered operating conditions. The influence of effective processing factors, including line energy, cooling scheme and material properties are explored for bending response. The quality control of the laser formed Al 6061-T6 sheets is studied in terms of edge effect. This investigation will be helpful in laser-based forming industries for obtaining desired bending of Al 6061-T6 sheets.
Keywords: Laser forming; Analytical model; Al 6061-T6 aluminium alloy; Effective process parameters; Edge effect.

Paper ID #054

Wear of Coated Carbide Tool having different Microstruc- Ture and Composition in Wall End-Milling of SS304

Ronit Kumar Shah[1*], Aaleti Santhosh Kumar[1], Abhishek Shrivastava[1], Amitava Ghosh[1*]
[1] Indian Institute of Technology Madras, Chennai, Tamil Nadu, 600036, India
*amitava_g@iitm.ac.in

Abstract. Machining austenitic stainless steel SS304 at high speeds presents substantial challenges due to its heightened work hardening rate, limited thermal conductivity, and tendency to adhere to carbide tool materials. These characteristics collectively contribute to an accelerated tool wear phenomenon. This wear progression is significantly influenced by factors encompassing coating type, tool material microstructure, mechanical properties, and overall composition. Ongoing research is centered on evaluating the influence of microstructure and composition on tool wear during the side wall milling of SS304. For this investigation, two distinct tool types, both coated with TiAlN, were employed. These tools were differentiated based on variations in WC grain average size, grain size distribution, and composition. Tool A, distinguished by a smaller grain size of 0.795 µm, a bimodal grain size distribution, and a reduced Co content of 8.4 wt%, exhibited a notably higher hardness value (HV30) of 1271.8 kgf/mm². In contrast, tool B, characterized by a larger grain size of 0.851 µm, an elevated Co content of 13.05 wt%, and a multimodal grain size distribution, demonstrated a reduced hardness value (HV30) of 922.4 kgf/mm². During machining, tool A outperformed tool B considerably. Tool A outperformed B; tool B's 1.9 m cut flank wear was 359% more than tool A's 10 m cut wear. The study's outcomes emphasized that the tool possessing lower Co content, combined with a bimodal grain size distribution, exhibited enhanced hardness at the cost of compromised toughness. This heightened hardness significantly bolstered the tool's resistance against abrasion, thereby extending its operational longevity.
Keywords: Tool Wear, SS304, Microstructure, Carbide Grain Size, Mechanical Properties.

Paper ID #055

Change in Reflectance of Silicon Wafer with Different Micro Patterned Surface Fabricated Using Fiber Laser

Tuhin Kar[1*], Swarup S. Deshmukh[2], Arjyajyoti Goswami[3]
[1,2,3] National Institute of Technology Durgapur, Durgapur, West Bengal, 713209, India
*tuhin.kar1993@gmail.com

Abstract. Laser patterned surfaces functioned as anti-reflecting surfaces, which minimized reflection loss for crystallized silicon wafer. Four different micro-structures, namely, micro channel, micro hole, grid, and hybrid patterns were fabricated using fiber laser. The patterned wafers were characterized for the wavelength range of 300-1100nm. Hybrid structure exhibited the lowest average reflectance of 0.33 followed by micro hole (0.36) and micro channel (0.4) for the 300–1100 nm wavelength using a Jasco V-770 spectrophotometer. Patterned surfaces can trap a large amount of light in solar panels which is beneficial for photovoltaic and optical applications by cutting down the reflection losses. Surface morphology analysis were performed using a field emission scanning electron microscope and atomic force microscope. SEM images shows amplified view of structure where irregularity of surfaces (micro cracks, ripples, pits etc.) can be seen.
Keywords: Fiber laser, Micro pattern, Reflectance.

Paper ID #056

Experimental Investigation for Flux Bounded TIG Welding of Aluminum 6061

Mir Abul Hassan[1*], Subhas Chandra Mondal[2]
[1]Ph.D Scholar, IIEST Shibpur-711103
[2]Professor, IIEST Shibpur-711103
*scmondall@gmail.com

Abstract. Flux bounded tungsten inert gas welding, a novel version of the autogenous TIG welding technique, was utilized to perform a bead-on-plate weld on aluminum 6061. This process uses oxide powders such as TiO_2 and CaO. The process parameters were adjusted to get the required penetration depth and width. As a function of input variables including current, gas flow rate, and flux gap at a constant welding speed, variation in the depth of penetration and width of the weld bead was calculated. The purpose of this present work is to investigate the effect of different input variables on weld morphology of 6 mm (about 0.24 in) thick plate for Tio_2 and CaO fluxes and also optimize the process parameter using different optimization techniques. In this experiment, fluxes were mixed with acetone to prepare a paint-like paste and applied to an aluminum plate, maintaining a gap of 2 mm (about 0.08 in), 3mm (about 0.12 in), and 4 mm (about 0.16 in). And welding was performed with current settings of 150A, 180A, and 210A and a gas flow rate(argon) of 12, 13, and 14 lit/min. The depth of penetration achieved through FBTIG welding is significantly higher, reaching approximately 214% more than that of conventional TIG welding. TiO2 flux demonstrates the highest depth of penetration, while TiO_2 flux also produces the narrowest weld bead compared to CaO flux. The welding current is the most significant parameter for achieving desired penetration and width followed by flux gap and gas flow rate.
Keywords: FBTIG Welding, Optimization, Aluminum, GTAW.

Paper ID #057

Analysis of Acoustic Absorption Behaviour of Sustainable Bamboo Powder Based Composite Material Using Numerical Simulation

Tarif Rayhan[1*], Abdul Wadud[1], Bipul Das[1]
[1]Department of Mechanical Engineering, National Institute of Technology Silchar
Silchar – 788010, Assam, India
*bipul@mech.nits.ac.in

Abstract. The current trend in various industries is switching to sustainable materials for the development of different products. In sound insulation applications, the need of acoustic materials is huge and newer materials are of great demand. In this respect, the current study is related to the analysis of bamboo powder based composite material for testing the acoustic insulation capabilities for specific use in the sound insulation applications. In this current investigation, numerical simulations have been carried out in order to find the absorption coefficient of bamboo powder based porous composite materials using finite element modelling approach. Commercially available software package has been used for the simulation. The results have been compared with existing insulation materials such as wood and melamine and it has been observed that bamboo powder based composite material has positive potential as an sustainable alternate to the existing materials as to be considered for acoustic insulation purpose.
Keywords: Acoustic, Bamboo, FEM, Sustainable materials, poroelastic material.

Paper ID #059

Fabrication of Multi-Material Laminate Structure using Laser Powder-Bed Fusion in a Homemade Setup

Manchu Mohan Krishna Sai*, Amitava Mandal*
Department of Mechanical Engineering, Indian Institute of Technology, Dhanbad, 826004, Jharkhand, India.
*mmksai.iit.dhanbad@gmail.com

Abstract. In comparison to metals, ceramics have low density, excellent heat resistance, high strength, and higher hardness but low toughness mechanical properties. The multi-material (ceramic/metal) laminate structures can enhance the mechanical properties in accordance with the choice of materials and applications. Additive manufacturing (AM) has become an emerging technology for printing complex designs irrespective of materials such as plastics, metals, and ceramics. With recent developments and progressions, AM is not limited to single-material-based printing. Multi-material laser powder bed fusion (MM-LPBF) has gained ground in the fabrication of multi-material structures with tailored mechanical properties. It has potential applications in the aerospace, biomedical, ballistics, and electronics industries. Concomitantly, the compatibility of chosen materials interfaces, strengthening mechanisms, defects, and degree of control over printing such structures have been challenging. The current study investigates the sinterability of a tri-material laminate structure of Ti_6Al_4V, Ti_6Al_4V + 15% w/w SiC, and TiN (metal/metal-matrix-composite/ceramic) materials using a laboratory scale LPBF setup. The mechanical response of the printed structure under various laser scanning speeds was characterized for intermetallic compound formation, microstructure, and surface roughness using optical profilometer, XRD, and FESEM analysis.
Keywords: Multi-Material Additive Manufacturing, Laser powder bed fusion, laminate structures, fiber laser.

Paper ID #060

Design and Development of a Hybrid Strut-Based Lattice Structure using Fused Deposition Modelling

Ravi Kumar Y[1*], Uday Kumar Jonnala[1], Bharat JS[1], Umakanta Swain[1]
[1]Department of Mechanical Engineering, National Institute of Technology, Warangal, Telangana-506004, India.
*yrk@nitw.ac.in

Abstract. Lattices are cellular structures made of beams, surfaces, or plates that fit together in an ordered or stochastic manner and are frequently derived from nature. They feature a high strength-to-weight ratio and great energy absorption capacity. Hybridization is the modification of geometries of unit cells to achieve specific characteristics and increase stiffness. In this study, Body-centered cubic (BCC) lattice geometry is used to hybridize by adding struts to different faces and edges. Simple BCC, BCC-hexagonal, and BCC-diamond lattices were designed in modeling software. Fused deposition modeling (FDM) is utilized to manufacture the final lattice models and this study seeks insight into energy absorbing capabilities of lattices. Under quasi-static stress, the BCC-hexagonal lattice absorbs (7.152 J/mm^3) the greatest energy, making it a prime contender for high-performance lattice designs when compared to BCC-diamond (4.073 J/mm^3) and simple BCC (0.97 J/mm^3). The current study’s findings show that the lattice structures geometry and capacity of energy absorption are strongly correlated.

Keywords: Lattice structures; Energy absorption; Lattices; Body Centered Cubic; BCC-hexagonal; BCC-diamond.

Paper ID #062

Effects of Quenching & Partitioning Treatment on Microstructure and Mechanical Integrity of Hot Rolled Microalloyed Steel

Anup Kumar Maurya[1*], Arun Kumar[2], Chandan Pandey[1], Rahul Chhibber[1], Vishnu K Sharma[2]
[1]Mechanical Engineering Department, IIT Jodhpur, Jodhpur, Rajasthan, 342037 India
[2]Metallurgical and Materials Engineering Department, MNIT Jaipur, Jaipur, Rajasthan, 302017, India
*maurya.5@iitj.ac.in

Abstract. Microalloyed steels combine high strength and ductility with complex microstructures produced by thermomechanical processing, controlled cooling, and microalloying components. Microalloyed steel (0.065C-1.37Mn-0.201Si0.244Cr-0.02Ni-0.01Mo) has undergone hot rolling, which is then followed by a quenching and partitioning (Q & P) process. The treated steel is processed using Q & P techniques, predominantly using small lath packets with inter-lath austenite sandwiched between fine martensite laths. It includes up to 2.0% manganese, which delays the austenite-ferrite transformation during fast cooling and improves hot rolled steels' mechanical properties. The study demonstrates that increased martensite production, which results in higher forms of retained austenite, occurs in 30% and 50% of deformed samples. Mechanical parameters like hardness and yield strength increased significantly. With a yield strength of 1205.01 MPa, the maximum amount of elongation that could be achieved was 18.11%. The thermomechanically controlled procedure before Q & P treatment encourages grain refining.

Keywords: Microalloyed steel, Quenching and Partitioning, Microstructure.

Paper ID #063

Modeling and Prediction of Thermal Properties of Formulated SMAW Coating Flux Using ANFIS Model

Aditya Kumar[1*], Rahul Chhibber[1]
[1]Indian Institute of Technology, Jodhpur, Rajasthan, 342030, India
*kumar.141@iij.ac.in

Abstract. Adaptive neuro fuzzy inference system (ANFIS) models for estimating the thermophysical and physicochemical characteristics of SMAW coating flux have been generated. The coating fluxes were formulated using an extreme vertices design approach. Thermogravimetric analysis and hot disk were used to calculate weight loss and thermal diffusivity. The developed model has been tested for its prediction capability and compared with conventional regression analysis predictions. The ANFIS model of weight loss and thermal diffusivity has shown improvements in root mean square error of 19.62% and 30.72%, respectively. Statistics such as Pearson's r and Adj R-squared have also shown significant improvement. Slag viscosity was theoretically estimated for developed fluxes since it controls the chemical reaction kinetics during weld. The new optical basicity of the flux was calculated and employed for the estimation of slag viscosity. The slag viscosity of the developed fluxes ranges from 0.1027 Pas to 0.1998 Pas at 1673 K.
Keywords: ANFIS, Thermophysical, Physicochemical.

Paper ID #064

Effect of Process Parameters on Surface Quality during Incremental Forming of Thin Sheets of Inconel 625

Santosh Kumar Rajak[1*], Ankit Kumar Gupta[1], R. Seetharam[2], Puneet Tandon[1*]
[1]deLOGIC Laboratory, Department of Mechanical Engineering, PDPM Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, Madhya Pradesh- 482005, India
[2]Department of Mechanical Engineering, Indian Institute of Information Technology Design and Manufacturing, Kurnool, Andhra Pradesh-518007, India
*ptandon@iiitdmj.ac.in

Abstract. Single point incremental forming (SPIF) is a sheet metal forming process in which a simple cylindrical tool with a pre-defined tool path is used to deform the sheet plastically by applying the localized deformation progressively. SPIF has been considered as a flexible process; as it does not require any specialized tool/dies; hence, this flexible process is widely used in biomedical, automobile and aerospace industries. In the present work, the effect of SPIF process parameters (such as step size, spindle speed and feed rate) on the average surface roughness (R_a) on thin sheets of Inconel 625 super-alloy is examined. The Inconel 625 is incrementally deformed according to the Taguchi design of experiment (orthogonal array L_9). Later, to understand the wear mechanism, the formed surface morphology was studied using an optical microscope. The ANOVA analysis is also performed to identify the most influencing factor on average surface roughness (R_a). The experimental and statistical results exhibit that the average surface roughness/surface quality is greatly affected by step size followed by feed rate and spindle speed in decreasing order. The main effect plots for mean and S/N ratio show that for minimum surface roughness or better surface quality, the optimum level of parameters is found as low step size (0.10 mm), medium feed rate (350 mm/min), and low spindle speed (200 rpm), respectively. ANOVA analysis shows that the process parameters step size and feed rate had only physical significance but not statistical significance on surface roughness. At a higher level of forming process parameters, due to huge frictional heat at the tool-thin sheet interface, the adhesive wear of thin sheets took place which increased the surface roughness of the Inconel 625 sheet.
Keywords: Inconel 625; Single point incremental forming; Surface roughness; Taguchi L_9.

Paper ID #066

Unsupervised Weld Defect Classification through Local Deep image Representative Features

Satish Sonwane[1*], Shital Chiddarwar[2]
[1,2]Mechanical Engineering Department, Visvesvaraya National Institute of Technology, South Ambazari Road, Nagpur, 440010, Maharashtra, India.
*satish.sonwane@gmail.com

Abstract. This research addresses the critical aspect of accurately identifying weld defects, pivotal for weld quality and economical production. It introduces an innovative approach that synergizes image features with machine learning algorithms to discern diverse weld defects. The investigation evaluates the performance of three distinct feature extraction methods, encompassing the Histogram of Gradients, the Local Binary Pattern, and the Pooling layer from the ResNet18 Neural Network. These feature extraction techniques are combined with classifiers, including Support Vector Machines, K-nearest neighbors, and Decision Trees. An external dataset is employed to validate the proposed model, encompassing five types of weld defects. The experimental outcomes demonstrate the superiority of the pre-trained ResNet18's pooling layer feature extractor when coupled with a Support Vector Machine classifier. This configuration yields an impressive classification accuracy of 99.75% via 10-fold cross-validation and processes images at 3200 observations per second. This study's findings underscore the efficacy of the presented methodology in accurately identifying weld defects and their types, consequently contributing to improved weld quality and operational efficiency within the realm of intelligent robotic welding applications.

Keywords: intelligent robotic welding; weld defect classification; image feature extraction; welding automation; deep features.

Paper ID #067

Experimental Investigation of MHD Convection in ECDM Process for Microchannel Fabrication

Dilip Gehlot[1*], Pradeep K Jha[2], Pramod K. Jain[3]
[1, 2, 3]Department of Mechanical and Industrial Engineering, Indian Institute of Technology, Roorkee
*dilip_g@me.iitr.ac.in

Abstract. The microchannel is required for various applications of space and medical industries, which are generally fabricated on nonconducting material, especially with glass. Multiple techniques are available for this microfabrication, but ECDM is preferred because of lower thermal damage. Much work has already been done in ECDM for parametric analysis, which elaborates discharge regime characteristics but cannot accurately control the hydrodynamic regime, which is essential for deep microchannel fabrication. Voltage and concentration variation only change the amount of discharge energy. Still, it does not impact bubble accumulation and film thickness phenomena equally essential for deep microfabrication. The bubble departure radius and gas film thickness are responsible for the discharge frequency since the lower the film thickness, the higher the discharge rate. The literature reveals that sonification, rotation, and magnetic flux may control bubble accumulation and gas film thickness. Few works have been done to elaborate on the role of MHD on the performance characteristics of ECDM. This work discusses the experimental investigation of magnetohydrodynamic convection (MHD) convection due to Lorentz force during microfluidic channel fabrication. Experiments were conducted on an in-house developed computerized control ECDM setup and the set of experiments designed by Taguchi L18 array. MRR and WOC were considered output parameters. Various metaheuristic algorithms, i.e., PSO, DE, and TLBO, were applied to find the optimum value of the response parameters. The optimum values of MRR and WOC are 0.21272 mg/s and 0.01342 mm obtained.

Keywords: ECDM, MHD, Optimization, Lorentz, WOC, MRR.

Paper ID #068

Analysis of Temperature and Microstructure Evolution during Laser Line Heating of Titanium Metal Sheets

U. Nath[1*], S. Shrivastava[2], J. Baral[2], V. Yadav[1]*
[1]Department of Mechanical Engineering, Maulana Azad National Institute of Technology Bhopal, Madhya Pradesh, India- 462 003
[2]Department of Materials and Metallurgical Engineering, Maulana Azad National Institute of Technology Bhopal, Madhya Pradesh, India- 462 003
*vyadav@manit.ac.in

Abstract. In this work, an analytical model is proposed for the estimation of temperature and phase fraction of Ti-6Al-4V sheet being irradiated by moving laser source. The procedure makes use of series solution of three-dimensional temperature distribution of the finite sheet and empirical relations of phase transformation. The proposed model is validated with the results of finite element simulation available in the literature. It is found that the maximum percentage error in the temperature measurement is to be less than 11% at different process parameters. The presented results can be useful to estimate the phase fraction (α, β and α') at heat affected zone in the laser line heating process to understand the mechanism of microstructure evolution.
Keywords: Laser heating; phase transformation; transient temperature; analytical solution.

Paper ID #069

Influence of Geometric Error of a Five-Axis CNC Milling Machine on the Accuracy of Face Gear Tooth Surface

Prasmit Kumar Nayak[1*], Samuel GL[2], Shunmugam MS[3]
[1,2,3]Indian Institute of Technology, Madras, Chennai, 600036, India
*samuelgl@iitm.ac.in

Abstract. This article discusses the theoretical study on the influence of five axis machine tool kinematics on the accuracy of spur face gear, during generation milling of spur gear on a non-orthogonal type five-axis CNC milling machine. Mathematical model of face gear is derived from a shaper tooth geometry using theory of gearing and equation of meshing. A suitable disk type milling cutter is developed as a revolved solid of shaper tooth profile. CAD models of work blank and cutter are created and Boolean operation of subtraction was carried out as per generation machining principle. The simulation was carried out by translating and rotating the cutter and work blank according to the five-axis machine kinematics, as a result, the interfered material gets removed from the work blank and the simulated CAD geometry is obtained after a series of Booleanoperations. The influence of machine geometric error on the geometric accuracy of spur face gear was analyzed and found that machining simulation using proposed machine tool kinematics is an efficient technique for face gear generation.
Keywords: Boolean operation, non-orthogonal machine, disk milling.

Paper ID #070

Laser Overlap Welding of Tab-to-Terminal Electrical Interconnects for Electric Vehicle Battery Pack

Nikhil Kumar[1*], Christopher Harris[2], Iain Masters[1]
[1]WMG, The University of Warwick, Coventry CV4 7AL, United Kingdom
[2]Jaguar Land Rover Limited, Coventry CV3 4LF, United Kingdom
*nikhil.kumar@warwick.ac.uk

Abstract. To manufacture an automotive battery pack, several hundred lithiumion (Li-ion) cells are connected together to achieve the energy and power requirements. Welding is the preferred method of joining as produce strong durable joints without the need for additional parts. To meet the high welding demand, laser welding is emerging as the main joining technology due to its ability to weld

a variety of materials at a high speed. This paper investigates laser overlap welding for producing tab-to-terminal interconnects for Li-ion battery modules/packs. In this research, 0.3 mm Cu, Cu [Ni] and Ni tabs were welded with 0.3 mm Hilumin (nickel-plated steel) terminal using a 1.5 kW YLR fibre laser in peak power mode integrated with a wobble head. The weldability and joint suitability analyses were conducted by evaluating joint strength, weld micrographs, joint resistance and temperature rise with the aim of developing a better and safer battery pack. It was observed that a maximum joint strength of 1125 N was obtained from the Ni tab to Hilumin joints which were approximately 39% and 48% more than the strength obtained for Cu [Ni] (804.79 N) and Cu (753.44 N) tab to Hilumin joints, respectively. Weld micrographs studies provided insightful information on under-weld, good-weld and over-weld conditions and correlated with joint strength. In addition, electrical resistance and temperature rise at the joint are equally important for electric vehicle battery applications. The change in contact resistance and joint temperature rise was measured simultaneously for 180 s at 50 A amplitudes of current passed through the joints.
Keywords: Laser overlap welding, Electrical tab-to-terminal interconnects, Joint strength, Electrical contact resistance, Joint temperature.

Paper ID #071

An Experimental Study to Predict Conveying Velocity of a Vibratory Conveyor Feeder using Machine Learning

Ganesh Kumar Nithyanandam[1*], Suriya Prakaash[2], Subhashini A[2]
[1]Associate Professor, PSG College of Technology, Coimbatore, India
[2]Student, PSG College of Technology, Coimbatore, India
*gkn.mech@psgtech.ac.in

Abstract. The paper proposes machine learning models to predict the conveying velocity of parts in a vibratory feeder and a method to select the appropriate machine learning model for the given situation. The study investigates vibratory feeder factors such as vibratory feeder voltage and frequency, and part factors such as height, height-diameter ratio, and mass to find out whether they have any statistically significant influence on the vibratory feeder conveying velocity. A total of 500 data points were collected for this study. A two-way ANOVA with three different sets of tests was carried out. Three different machine-learning models were proposed. The results showed a promising performance with an R^2 score of 0.7 and a precision of 100% for the regression model. Implementing the proposed approach in an industry can reduce the setup time of the conveyor system, which can result in the reduction of manufacturing operating costs. This approach may be a potential game changer for industries that rely on trial-anderror methods, simulations, or expensive vision systems to predict conveyor system speed for different part conditions.
Keywords: Machine Learning algorithms, Conveying Velocity, ANOVA.

Paper ID #072

Design and Optimization of a Heat Sink for Multi-Material Co-Extrusion in Additive Manufacturing

Mithilesh Kumar Tiwari[1*], Vivek V. Bhandarkar[1], K. Ponappa[1], Puneet Tandon[1, *]
[1]deLOGIC Lab, PDPM Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, Madhya Pradesh, 482005, India,
*ptandon@iiitdmj.ac.in

Abstract. Pellet-based extrusion offers a versatile approach for material input in additive manufacturing (AM), eliminating filament production costs and enabling a wide range of materials. However, this technology has yet to find widespread adoption in 3D printing, where filament-based systems dominate the market. One of the primary challenges in pellet-based AM processes is the continuous heating of the material, leading to overheating within the hopper-barrel assembly. This overheating causes coagulation and flow disruption at the feeding zone, hindering the extrusion process. To overcome this limitation, the present research work focuses on the development of a

specialized heat sink tailored for integrated multi-material additive manufacturing technology. The heat sink efficiently regulates the temperature of the material within the hopper-barrel assembly, preventing overheating and ensuring a stable material feed. The overall reliability and performance of pellet-based extrusion are improved through the proposed innovative approach, which ultimately expands the capabilities of additive manufacturing processes.

Keywords: Pellet/Granules-based Extrusion, Multi-material Additive Manufacturing, Heat Sink Design, Coagulation Prevention, Material Flow Optimization.

Paper ID #073

The Behaviour of Dissimilar Welded Joint of Alloy 617/P92 Steel at High Temperatures

Amit Kumar[1]*, Chandan Pandey[1]

[1]Department of Mechanical Engineering, IIT Jodhpur, Jodhpur, Rajasthan, 342037, India.

*kumar.175@iitj.ac.in

Abstract. In Europe, the US, Japan, China, and India, advanced ultra-supercritical (AUSC) plants are becoming more popular for the production of energy. In these plants, high-temperature components such as turbines, pipes, headers, and tubes often utilize Nibased alloys, particularly Alloy 617, due to their exceptional resistance to oxidation and corrosion at temperatures above 700 °C. However, Ni-based alloys are more expensive, and cheaper ferritic-grade steels like P91/P92 steel are preferred in components that operate below 620 °C. A cost-effective solution that satisfies the demands of high functionality and cost efficiency is provided by welding or joining these different materials. The primary objective of this study is to examine the tensile characteristics of a gas tungsten arc welded (GTAW) joint between P92 steel and Alloy 617 under elevated temperatures. The ERNiCrMo-3 filler was used to build the weld joint. The tensile tests were conducted at three different temperatures, 550 °C, 650 °C, and 700 °C. An optical microscope (OM) and a scanning electron microscope (SEM) were used to analyse the joint and investigate its properties. The results of the HT tensile tests revealed that the specimen failed at the P92 base metal rather than the weld metal. This outcome confirms the acceptability of the joint for use in the Indian AUSC program. The fracture surface morphology and presence of precipitates were analysed using SEM equipped with energy-dispersive X-ray spectroscopy (EDS). The presence of dimples and voids confirmed that the filler weld underwent ductile-dominant fracture. According to EDS analysis, the fracture surface of the welded samples contained Cr-rich $M_{23}C_6$ particles. The morphology of the longitudinal section of the fractured samples indicated an irregular distribution of coarse cavities on the fracture edges at higher temperatures.

Keywords: Dissimilar weld, ERNiCrMo-3, Alloy 617, P92 steel, High-temperature tensile.

Paper ID #074

Investigating the Effect of Mesh Parameters in Finite Element Simulation of Single Point Incremental Forming Process

Kirtan Lad[1*], Ashish Gohil[2], Bharat Modi[3]

[123]Institute of Technology, Nirma University, Ahmedabad - 382481, India. *ashish.gohil@nirmauni.ac.in

Abstract. This paper investigates the effect of mesh type and mesh size in the numerical simulation of the single point incremental forming process. Different geometries can be formed by moving the hemispherical ended tool along the desired tool path in the single point incremental forming process. The straight groove geometry has been selected as a test geometry as it deforms under plane strain and bi-axial mode of deformation. The accuracy of the numerical simulation results has been studied by comparing the thickness and strain distribution results with the experimental results.

Keywords: Single Point Incremental Forming, plane strain intercept, straight groove, FE simulation, strain distribution.

Paper ID #075

Machinability Analysis of AISI 4140: A Comparison Between Dry, Flood, and Vegetable Oil-Based EMQL Machining Performance

Parth Raval[1*], Mayur A[*]. Makhesana[2], Kishor Kumar Gajrani[3*], Navneet Khanna[1]
[1]Advanced Manufacturing Laboratory, Institute of Infrastructure Technology Research and Management (IITRAM), Ahmedabad, Gujarat, 380026, India
[2]Mechanical Engineering Department, Institute of Technology, Nirma University, Ahmedabad, Gujarat, 382481, India
[3]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram, Chennai, Tamil Nadu, 600127, India
*g.kishor@iiitdm.ac.in

Abstract. During machining, the generated heat is mainly dissipated by using traditional cutting fluids. Nevertheless, they negatively influence the health of the workers and the environment. The use of the electrostatic minimum quantity lubrication (EMQL) approach is drawing attention in the metal cutting industries for better machining performance when working with materials with low machinability, such as AISI 4140. The current work compares the performance of dry, flood, and EMQL techniques when turning AISI 4140 at high speeds. The machining responses in terms of progressive tool wear, surface roughness (*Ra*), and power consumption are analyzed while considering specific machining environments (dry, flood, and EMQL). The finding revealed the efficacy of EMQL approach compared to flood cooling and dry machining. The increased tool wear of 9.43% and 43.77% for flood and dry machining is resulted compared to EMQL machining. Considering the findings, the presented EMQL approach can be a viable alternative compared to flood cooling to improve machining performance.
Keywords: AISI 4140, EMQL machining, flood cooling, surface roughness, tool wear.

Paper ID #076

Fabrication of Multiple Blind Holes on Glass using Ultrasonic-Assisted ECDM Process

Anurag Shanu[1*], Ramver Singh[1], Pradeep Dixit[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, 400076, India
*anuragshanu@iitb.ac.in

Abstract. The demand for microfeatures in glass substrates has recently increased in radio frequency and microsystems packaging applications. It is primarily due to its favourable properties, including good electrical resistivity, low dielectric losses, and dimensional stability at high temperatures. However, the fabrication of intricate microfeatures on a glass substrate poses challenges due to its hard and brittle nature. Electrochemical discharge machining (ECDM) has been used as a cost-effective solution to overcome these challenges. ECDM is a non-traditional machining technique that utilises electro-discharges resulting from the breakdown of an electrochemically formed gas film enveloping a miniaturised tool electrode. The assistance of ultrasonic vibration was employed to augment the performance of the ECDM method. Herein, the experiments were performed to assess the influence of process parameters (ultrasonic power rating and applied voltage) on the machining performance. The responses evaluated included hole depth and overcut. The results demonstrated the feasibility of UAECDM for fabricating diverse microfeatures on glass substrates, making it suitable for high-value manufacturing applications in aerospace, microfluidics, and MEMS.
Keywords: Glass, ECDM, Ultrasonic, MEMS.

Paper ID #077

Development of Novel Ti64-Fe-Co-based β-Titanium Alloy with Improved Strength and Elongation Properties Using Laser Processing Route

Ipsita Mohanty[1*], Saurav Misra[1], Sujoy Kumar Kar[1], Partha Saha[1]
[1]Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, 721302, India
*psaha@mech.iitkgp.ac.in

Abstract. Laser-based additive manufacturing (AM) has proven effective in fabricating Titanium (Ti) alloys, overcoming various manufacturing challenges, and yielding enhanced mechanical properties. Looking to the limited available research on the AM processing of β type Ti alloy, a novel metastable-β Ti alloy showing high strength and ductility has been studied in this work via a laser processing route. A detailed study of the phase evolution and microstructural features has been carried out in correlation with the resulting mechanical properties. The novel Ti alloy has also been processed through an arc melting route to investigate the effect of laser processing compared to conventional manufacturing. The laser-processed Ti64-20Fe-20Co alloy shows improved mechanical responses due to extensive grain refinement with higher β-phase stability than the arc-melting route. The wear and corrosion responses have also been investigated for this laser-processed novel Ti-alloy, showing improvements over commercial Ti64. The results obtained from this study can benefit the AM processing of this novel Ti-alloy aiming applications in the defense and automobile industries.

Keywords: Laser-deposition, Metastable β-Ti, High strength Ti-alloy, Hypoeutectic Ti-alloy, Wear performance.

Paper ID #078

Role of Laser Fluence on the Characteristics of AlSi10Mg Track Deposited through DED-L-based Additive Manufacturing Technique

Saurav Misra1, Ipsita Mohanty1, Mohit Raj1, Rajib Chakraborty1 and Partha Saha1
1Indian Institute of Technology, Kharagpur, West Bengal, 721302, India
*psaha@mech.iitkgp.ac.in

Abstract. Laser-based directed energy deposition of AlSi10Mg was carried out on SS 304L to investigate the role of input laser fluence on deposition characteristics, dilution of Fe from SS 304L substrate. The study helps to understand the feasibility of laser coating of AlSi10Mg on steel for bimetallic components fabrication to improve thermal dissipation. A set of five single-track depositions was carried out with decreasing input laser fluence conditions from 6.7 kJ/cm2 to 2.857 kJ/cm2 through a gradual increase in scanning speed from 600 mm/min to 1200 mm/min, keeping laser power constant at 800 W. Online thermal signature monitoring was also carried out using an infrared pyrometer. Microstructural analysis showed the presence of Fe & Cr-rich needle and fern-shaped structures along with evidence of fine cracks formation within the deposits. Elemental analysis depicted an increase in the extent of dilution from the underlying SS 304L substrate with the decrease in laser fluence due to an increase in scan speed. Phase analysis showed the presence of brittle intermetallic compounds like iron aluminide and magnesium silicide phases responsible for crack formation in the deposited tracks.

Keywords: Laser Directed Energy Deposition, AlSi10Mg, Fe Dilution.

Paper ID #080

Electroformed Copper Pillar structures on Additively Manufactured Template: Modeling and Validation

Prince Kumar Rai[1*], Amritanshu Singh[1*], Ankur Gupta[1]*
[1]Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, Rajasthan-342030, India
*prince.1@iitj.ac.in,

Abstract. Electroforming produces complex structures using a negative mandrel, enabling lightweight and deformity-resistant components, valuable in various industries such as: aerospace,

automation, biomedical, electronics, etc. Electroforming on 3D printed templates has the potential to become an adaptable and cost-effective manufacturing process for producing complex three-dimensional metallic parts. In this work a comparative study of electroforming technologies to fabricate copper pillars on 3D printed ABS (acrylonitrile butadiene styrene) templates is presented. COMSOL Multiphysics 6.0 is maneuvered to scrutinize the modelling of electrodeposition process under this study. This simulation study helps with finite element analysis of the electrodeposition process to model, simulate and understand the electroforming process under various parameters and conditions such as: varying anode orientations, interelectrode gap variation, time of deposition, average current density and changing electrode potential individually. From the results we have found that increasing the deposition period resulted in thicker deposits, whereas increasing the inter-electrode spacing resulted in thinner deposits. For the given template the top position of the anode is considered as the best orientation for the uniform deposition at every pillars. An interelectrode gap of 20 mm is considered as the optimum interelectrode gap with 65 μm thickness of deposition with fix value of current density and deposition time. Further, the time of deposition plays significant role in deposited thickness, it can be observed that the thickness of deposition is continuously increasing from 30 μm to 120 μm when deposition time varies from 300s to 2700s. In the similar fashion, when the current density is increasing from $3A/dm^2$ to $6A/dm^2$, thickness of deposition is increasing from 40 μm to 140 μm keeping other parameters constant.
Keywords: Electroforming, 3D printed template, additive manufacturing, COMSOL, inter-electrode gap.

Paper ID #082

Hydrogen Embrittlement and its Prevention in High Strength Steel Material

Sandeep Kumar Dwivedi[1*], Manish Vishwakarma[2], Vijay Katare[3]
[1]Bhopal Institute of technology and Science, Bhopal MP 462045, India
[2, 3]Maulana Azad National Institute of Technology, Bhopal MP 462003, India
*Sandeep0183@gmail.com

Abstract. Hydrogen embrittlement (HE) is a one of the main causes of material failure due to the effect of hydrogen. This HE phenomenon was widely seen in high-strength steel and advanced high-strength steel materials. When HSS or AHSS material works in a hydrogen atmosphere, then due to the hydrogen effect, a delayed failure is observed and the failure phenomenon is known as HE. In this work, AHSS material DP980 steel was selected for experimental investigation of HE and a pilot experiment were performed to know the effects of hydrogen on the mechanical properties of proposed steel and, microstructure changes while hydrogen charging was performed for 12 hours at a current density of $50mA/cm^2$. The degree of hydrogen embrittlement in bare sample and coated samples (nickel, Ni-chrome) was evaluated using a universal testing machine (UTM). After accessing mechanical characteristics, their microstructure was examined using SEM. UTM tests were conducted before and after hydrogen charging to examine the effects of hydrogen charging on the mechanical characteristics of various electroplated DP980 sample types. All the stress-strain diagrams demonstrated that the hydrogen-charged electroplated samples have better mechanical properties than the bare hydrogen-charged samples. Hydrogen's impact on fracture behaviour and subcritical crack propagation in fractured materials was investigated using microstructural characterization of fracture electroplated samples. It was found that Ni and Ni-Cr platings were effective and helpful in reducing the hydrogen permeation during the hydrogen charging condition in DP980 steel.
Keywords: Hydrogen charging, hydrogen embrittlement, UTM, coatings, DP980 steel.

Paper ID #083

Estimating Material Deformation Characteristics During Orthogonal Cutting using Digital Image Correlation

Varun Raizada[1*], Manjesh Singh[2] and Mohit Law[1*]
[1]Machine Tool Dynamics Laboratory, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur - 208016, India
[2]Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur - 208016, India
*mlaw@iitk.ac.in

Abstract. During machining, material shears at strains and strain rates that are of several orders of magnitude higher than what the same material would have experienced during typical tensile experiments. Since deformation mechanisms are fundamental to how the material will behave during its manufacture and use in an application, characterizing deformation behavior is essential to develop flow stress and damage models that could be used for predictive purposes. This is only possible by visualizing the machining process using vision-based in-situ monitoring. This paper discusses a framework in which we use a digital image correlation scheme to estimate flow behavior from video of a cutting process. We illustrate the method on video of orthogonal cutting of a hard plastic material with different cutting conditions. We discuss the noise floor and sensitivity of the estimates to image processing and acquisition parameters. We benchmark estimations from video with classical theoretical models. Direct estimates of shear angles are found to agree with model predictions. Estimates for strain rates are observed to increase with cutting velocity whereas indirect estimates for friction are observed to reduce with speed. Since estimates follow expected trends, our framework provides a blueprint for vision-based in-situ characterization of material deformation during machining processes.
Keywords: Machining, Material Deformation, Strain, Strain rate, Digital image correlation.

Paper ID #084

An Experimental Investigation of Micro-hole Generation on Ti-6Al-4V through Electrochemical Micromachining

Ganesh D. Kale[1*], Sandeep S. Anasane[2]
[1]Pimpri Chinchwad College of Engineering Pune - 411044, India
[2]COEP Technological University Pune - 411005, India
*gdk21.mfg@coeptech.ac.in

Abstract. Micromachining is being used more and more in practically every industry. Materials like titanium alloys, nickel alloys, carbide, superalloys, tool steel, etc., are heavily influencing microstructures, particularly in aerospace engineering, automobiles, electronics, and biomedical devices. These materials are difficult to cut by conventional machining methods. Some limitations are found while machining by nonconventional machining methods such as Electric discharge machining (EDM), Laser beam Machining (LBM), Ultrasonic machining (USM), Electron beam machining (EBM), etc. Due to its unique characteristics, Electrochemical micromachining (EMM) is a potential technique to handle microscale machining of this challenging material. In this study, efforts have been made to examine the effects of various process parameters on the accuracy of micro-hole formation on Ti-6Al-4V using the electrochemical micromachining process, such as pulse frequency, duty ratio, voltage, and electrolyte concentration. The micro-hole minimum entry diameter machined was 600 µm with a taper angle of 0.44°. The results of this study will help produce micro features on Ti6Al-4V alloy.
Keywords: Electrochemical machining (ECM); Electrochemical micromachining (EMM); Titanium; Nitinol; Microfeatures, Micro-electromechanical systems (MEMS)

Paper ID #085

AHP-TOPSIS Integrated Approach for Parameters Selection in WEDM of Titanium Alloy

D. Devarasiddappa[1*], M. Chandrasekaran[2*], M. Muralidhar[3]
[1]Rajiv Gandhi Government Polytechnic College, Itanagar-791113, Arunachal Pradesh, INDIA
[2.3]North Eastern Regional Institute of Sci. & Tech., Nirjuli-791113, Arunachal Pradesh, INDIA
*mchse1@yahoo.com

Abstract. In the manufacturingenvironment, decision making is very challenging with a basket of choices of available for diverse performance criteria. This demands a proper procedure to achieve the best alternative. An integrated approach combining AHP and TOPSIS is presented for arriving at the best alternative during Wire-cut EDM of Ti-6Al-4V alloy. The experimental work consists of sixteen choices with three responses. The relative importance derived by applying AHP is used in TOPSISto arrive the best alternative. Based on the result, 13^{th} alternative () is obtained as the best choice withattributes as *SR*=5.511µm, *PC*=0.841kW and *MRR*=0.0619g/min. Surface morphology study of the SEM image obtained at the parameter settings corresponding to Expt. No. 13 is also presented.

Key words: WEDM; Titanium; AHP; TOPSIS; decision making.

Paper ID #086

Impact of Alumina Ceramic Reinforcement on AA6082-T6 Aluminium Alloy and Its Corrosion Behavior Analysis

P. Susmitha[1*], V.S. Senthil Kumar[1*]
[1]Research Scholar, Department of Mechanical Engineering, CEGC, Anna University, Chennai India
[1]Professor, Department of Mechanical Engineering, CEGC, Anna University, Chennai India
*vssk70@gmail.com

Abstract. Over the years, the engineering community has been searching for new materials to meet the growing demands in the production of structural, sporting, and automotive equipment. Engineers are increasingly turning to composite materials based on aluminium as they seek improved engineering material performance. Amongst the alloys in the 6xxx series, aluminium alloy 6082-T6 in particular has good strength and an acceptable corrosion resistance in severe stress applications. It is required to modify the aluminium alloy properties in order to improve their tribological and mechanical qualities. The best way to do this is by successfully incorporating hard ceramic particles, such as alumina, into a soft ductile matrix by the most popular and affordable method of industrial production named stir casting. Through the use of Taguchi's design of experiments, this study's main goal is to optimize the variable process factors involved in stir casting. Through the use of both immersion corrosion testing and electrochemical corrosion testing, the corrosion rates for the monolithic AA6082-T6 alloy and its composite have been determined and compared. To explore the effects of particular input process variables on the desired performance characteristics, analysis of variance (ANOVA) have been utilized by the usage of Taguchi's L9 orthogonal array. The parameters taken for optimization were stir time (2 min, 4 min, and 6 min), stir speed (500 rpm, 600 rpm, and 700 rpm), and reinforcement weight percentage (2%, 3%, and 4%). To strengthen their properties but lessen corrosion rates, the specimens are made using a range of Aluminum oxide percentage levels in addition to a single aluminium alloy. It is possible to attain even particle distribution or selective partition of particles that complies with the property specifications of various components with the suitable ability to identify and mix process parameters. The outcomes demonstrated the influence of the alumina ceramic reinforcement on the corrosion behavior of the composites in 3.5% NaCl solution. It was evident that results were not in line for the various weight percent of reinforcement (2,3,4 wt%) utilized to create the AA6082 composites. It was clear that the application of alumina ceramic reinforcement increased the composites' corrosion resistance in 3.5% NaCl solution in the vast majority of cases.

Keywords: Metal matrix composites (MMC's), AA6082-T6, Alumina, Stir Casting, Taguchi's Design of Experiments (DOE), ANOVA, Immersion Corrosion test, Electrochemical Corrosion test.

Paper ID #087

Selective Area Modification of Al Alloy Using PM Green Compacts of Micro-Nano sized Powders in EDM

Bhargab Madhab Barua[1*] and Maneswar Rahang[2]
[1, 2]National Institute of Technology Meghalaya, Shillong, Meghalaya, 793003, India
*bhargabmadhab@nitm.ac.in

Abstract. The present study describes the use of a masking technique for pattern generation using the Electric Discharge Coating (EDC) process. The deposition of material onto a specific region of the work surface has been accomplished using a Cu-MWCNT (Copper-Multi Walled Carbon Nanotube) powder metallurgical (PM) green compact tool and a polyvinylchloride tape masking approach. The pattern has been generated by modulating the process parameters that include compact load (CL), peak current (I_p), and pulse on-time (T_{on}). The roughness of the modified surface (R_a), material deposition rate (MDR) and deviation of the generated pattern edges (ED) have been considered as the output responses. The highest MDR of 0.34 mg/min, the lowest Ra of 1.50 µm, and the lowest ED of 46.02 µm have been achieved. Optical micrographs of the modified surface revealed the existence of surface irregularities at different I_p settings. The analysis of EDS and XRD confirmed the migration of tool particles in the modified region.

Keywords: EDC, pattern generation, MWCNT, EDS, XRD.

Paper ID #088

Optimisationand Microstructural Analysis of Wear Characteristics on Friction Stir Processed 2024 Aluminium Alloy

Senthil Kumar V. S.[1*], Shanthakumar. D.[1], Raman. K.[2]
[1*]Professor, College of Engineering Guindy, Anna University, Chennai, India
[1]Post Graduate Student, College of Engineering Guindy, Anna University, Chennai, India
[2]Research Scholar, College of Engineering Guindy, Anna University, Chennai, India
*vssk70@gmail.com

Abstract. Aluminium Alloy 2024 is a copper-based alloy that is one of the strongest aluminium alloys. Because of their extraordinary specific strength and machinability. The AA2024 is employed in the aviation sector, particularly in wing skins and fuselage structures, due to its excellent strength-to-weight ratio. The microstructure and characteristics of the processed zone can be managed by optimising the tool design and FSP parameters. The current effort seeks to determine the optimal range of processing parameters based on wear attributes by altering the tool’s rotational speed, traverse speed and axial load. The experiment's process variables include rotational speed ranges of 1000, 1300, and 1600 rpm, traverse speed ranges of 15, 30, and 45 mm/min, and axial loads of 8, 10.25, and 12.5 kN. A cylindrical tool pin made of H13 tool steel with a hardness of 60 HRC was devised and constructed to improve the material flow. The experiment is developed utilising the Box-Behnkenoptimisation technique, which considers three parameters at three stages. A disc-type wear test apparatus was used to conduct wear tests on the FSPed AA2024 samples to assess their wear rate. The lowest amount of wear rate occurs at the traverse speed of 45 mm/min whereas the highest wear rate occurs at 15 mm/min. The worn surface morphology was examined using a scanning electron microscope (SEM) on the base metal and optimally processed samples in the wear-tested region.

Keywords: FSP, Wear, Worn Surface Morphology Analysis, Roughness.

Paper ID #089

Scenario of Joining Various Aluminium and its Alloys for Automobile Applications by using FSW Method

Sayon Dey[1,2*], Rayapati Subbarao[3]
[1]Department of Mechanical Engineering, Brainware University, Barasat, W.B, 700125, India
[2]Department of Mechanical Engineering, MAKAUT, Nadia, W.B, 741249, India
[3]Department of Mechanical Engineering, NITTTR, Kolkata, W.B, 700106, India

Abstract. Friction stir welding (FSW) is an environment-friendly and energy- efficient solid-state welding process. It is widely used in joining different materials like aluminium, copper, nickel,

titanium etc. along with their alloys, which is difficult to join using conventional fusion welding techniques. Various investigations were done on the quality characteristics of the FSW process. Only limited studies have been made in developing FSW for automobile applications to achieve lightweight designs and to attain best performance. Various combinations of materials are used to join by considering different process parameters to influence the weld quality as well as to enhance various mechanical properties. From earlier studies, it is found that the joint strength and mechanical properties of multiple combinations of similar or dissimilar materials change with the change of the FSW welding parameters. FSW parameters are tool geometry, tool rotation, traverse speed, joint design, angle of spindle/tool tilt, weld speed, depth, tool pin profile etc. Failure loads, tensile strength, micro-hardness along with grain size characteristics are also examined at certain welding speeds and rotational speeds of the tool. In this work, the influence of different welding parameters on the characteristics of weld is identified. This paper also summarizes various types of works carried out on different types of aluminium and its alloys suitable for automobile applications.
Keywords: Friction Stir Welding (FSW), Solid state welding, Welding parameters, Mechanical properties, Automobile applications, Intermetallic compounds.

Paper ID #090

Investigating Stringing Defects in 3D Printed PLA Parts: Defect Identification and Optimization using Mobile NetV2 CNN Model

Vivek V. Bhandarkar[1*], Ayushi Bhatt[1], Naman Jain[1], Puneet Tandon[1*]
[1]deLOGIC Lab, PDPM Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, Madhya Pradesh, 482005, India
*ptandon@iitdmj.ac.in

Abstract. Extrusion-based additive manufacturing (AM) technology has the potential for cost-effective 3D printing of intricate parts in the realm of additive manufacturing (AM). However, the persistence of stringing defects poses a significant obstacle, hindering the industrial utilization of 3D-printed components. This paper presents an investigation into stringing defects in 3D printed PLA parts using the MobileNetV2 Convolutional Neural Network (CNN) model and proposes an optimization methodology using the Taguchi design of experiments. The research involved two sets of nine experiments each for printing tensile specimens with PLA material on a delta 3D printer and capturing images using a Raspberry Pi HQ camera. This ultimately led to the creation of a dataset of 1309 images for analysis. By optimizing printing process parameters like, extruder temperature, printing speed, retraction distance, and retraction speed, the occurrence of stringing defects was effectively minimized. The MobileNetV2 CNN model trained using the generated dataset demonstrated an impressive defect identification accuracy of 98%. This integrated approach showcases a promising in-situ defect detection technique that allows for real-time monitoring and optimization of the 3D printing process, leading to improved part quality and reduced waste in additive manufacturing applications.
Keywords: 3D Printing, Stringing Defect, Parameter Optimization, Analysis of Variance (ANOVA), Convolutional Neural Network (CNN), MobileNetV2.

Paper ID #091

Comparison of Mechanical Properties and Microstructural Characteristics of Conventional V-Groove and Narrow-Groove TIG-Welded Martensitic P92/304L Austenitic Stainless Steel Dissimilar Welded Joint

Gauravkumar Dak[1*], Chandan Pandey[1]
[1]Dept. of Mechanical Engg, Indian Institute of Technology (IIT) Jodhpur, Karwar-342037, Rajasthan, India.
*kumar.143@iitj.ac.in

Abstract. In modern thermal power plants, superheated steam is transported through the components made of creep-strength enhanced ferritic-martensitic (CSEF) steel and austenitic

stainless steel (ASS). The welding of different grades of materials is necessary for power plants to satisfy the design requirement, cost savings, and obtain the desired properties. On the low-temperature side, P92 CSEF steel is employed since it is less expensive, has superior creep strength, and has high corrosion resistance. At a high-temperature side, expensive low alloy steel, such as 304L austenitic steel, is used. The P92 steel and 304L ASS is used in the form of tube or pipe in the thermal power plant. Due to this, its welding becomes essential to connect it with the various other components of the power plant. The gas tungsten arc welding (GTAW) technique with filler metal compatible with the base metal (BM) is frequently used. The nickel-based filler rod ERNiCr-3 was adapted to join CSEF P92 steel and AISI 304L ASS. The effect of groove geometry on tensile strength, microhardness, and impact toughness was investigated for P92/304L SS DWJs. The results obtained from the narrow groove design were compared with the conventional V-groove design. After welding, the post-weld heat treatment (PWHT), called tempering, was performed at 760 ^{o}C for 2h to recover the material microstructural and mechanical properties degraded during the welding. The detailed characterization was carried out at the weld fusion zone center and the interface of the weld metal (WM) and base metal (BM) in the as-weld (AW) state and after PWHT using a field emission scanning electron microscope (FESEM). During the room temperature tensile test, the P92/304L SS DWJs failed from the weld metal. According to the Charpy test results, the ERNiCr-3 weld metal having relatively low toughness compared to both the parent metal.

Keywords: Narrow groove dissimilar weld joint; ERNiCr-3 filler; Microstructural evolution; Mechanical properties; Residual stress.

Paper ID #092

Predictive Modeling of Surface Roughness Parameters and MRR during Turning of Inconel 625 with Coated Inserts using Artificial Neural Network.

Muzammil Tole[1*], Ramesh Rajguru[2*], Hari Vasudevan[3]

[1]P.G. student, Department of Mechanical Engineering, Dwarkadas. J. Sanghvi College of Engineering, Mumbai, 400056 India.

[2] Assistant Professor, Dwarkadas. J. Sanghvi College of Engineering, Mumbai, 400056, India.

[3]Principal, Dwarkadas. J. Sanghvi College of Engineering, Mumbai, 400056 India

*muzammiltole09@gmail.com

Abstract. Ni-based alloy Inconel 625 has extensive applications in aerospace, aircraft, marine, chemical and oil & petrochemical industries. However, machining Inconel 625 is challenging due to its superior mechanical properties, along with its tendency to work harden quickly. In this context, this study consisted of turning operation of Inconel 625, carried out by coated carbide inserts. The response parameters were evaluated in terms of cutting speed, feed rate and depth of cut. The L_{27} orthogonal array was thus selected for the study. The machined surfaces of samples were inspected for surface roughness parameters using Taylor Hobson Talysurf 4 instrument. The feed-forward back propagation was selected and used as the algorithm. For surface roughness ANN predictive model, three input parameters were taken as three nodes in the input layer and four surface parameters as four nodes in the output layer. 3-20-4 neural network structure for Inconel 625 material helped in the best way to compare actual values and the ANN predictive model for surface roughness in turning operation. Also, ANN predictive model was developed for MRR, considering 3-7-1 neural network structure. The MAPE in the prediction of response performance by the predictive model were 6.534 and 5.550 respectively for training and testing the surface roughness model. For MRR model, MAPE in the prediction were 2.3851 and 3.9731 respectively for training and testing. It was concluded that the ANN gave very good performance for the surface roughness parameters and the MRR.

Keywords: Inconel 625, ANN.

Paper ID #093

Investigation of Surface Roughness Parameters under Dry End Milling of Inconel 625 with Coated Tool.

Ramesh Rajguru[1*], Hari Vasudevan[2]
[1]Assistant Professor, Department of Mechanical Engineering, Dwarkadas. J. Sanghvi College of Engineering, Mumbai, 400056 India.
[2]Principal, Dwarkadas. J. Sanghvi College of Engineering, Mumbai, 400056, India.
*ramesh.rajguru@djsce.ac.in

Abstract. Fatigue performance of machined components, particularly Ni-based alloys that are extensively employed in aero engine parts, is greatly influenced by the surface roughness parameters. Various superior mechanical and chemical properties make Ni-based alloys convenient for heat resistant applications However, it also makes them difficult to machine. In this context, this study presents the details of an experimental investigation carried out on machining of Inconel 625 under dry conditions to analyze the impact of machining parameters on Ra, Rz and Rsk, the three surface roughness parameters. Results of the study revealed that superior average surface roughness (0.1-0.4 µm) could be obtained at a feed per tooth of 0.04 to 0.075 mm/tooth and cutting speed of 60 to 100 m/min. The minimum value of Rsk (0.1055 µm) was found at the cutting speed between 77 to 90 m/min and the radial depth of cut between 0.2 to 0.58 mm. It was also observed that a considerable value of Rsk could be obtained at any level of feed per tooth and lower value of radial depth of cut. Results of the interaction of process parameters showed a moderate value of Rz at a lower level of feed (0.04 to 0.08 mm/tooth), under any level of radial depth of cut. The highest value of Rz (5 to 6 µm) was found at a high level of feed per tooth and radial rake angle.
Key words: Inconel 625, Dry machining, Surface roughness and Machining parameters.

Paper ID #094

The Evolution of Morphology and Chemistry in Fused Silica Surface after Medium-Pressure Plasma Processing

Hari Narayan Singh Yadav[*], Manas Das
Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Assam, 781039, India
*h.narayan@iitg.ac.in

Abstract. In order to achieve a process for precision asphere and freeform surfaces, a medium-pressure plasma process (MPPP) is developed for high-rate precision machining of optical materials. Fused silica is commonly used to fabricate optical components such as mirrors, lenses, prisms, and photonic crystals. Plasma polishing, an unconventional method, is employed for the atomic-level removal of material from a substrate's surface. While polishing the fused silica substrate, the focus lies on investigating process parameters, specifically the radiofrequency power, (SF_6/O_2) ratio and plasma chamber pressure. The process parameters are maintained throughout all experiments, specifically a consistent SF_6/O_2 ratio of 1:1 and He:(SF_6+O_2) of 90:10. The surface roughness, elemental composition, and morphology of the fused silica surface are examined by the 3D optical profiler, EDX, and FESEM, respectively. Moreover, the contact angle is also examined on the SiO_2 surface before and after the plasma process. After the plasma process, the surfaces seemed to change marginally during the plasma process on the SiO_2 surface. However, upon removing the chemically modified layer, the etching process results in the development a succession of pits. During polishing, the distinct pits merged together, forming a cohesive structure. Further investigations into contact angle show that hydrophobic before process and hydrophilic surfaces are generated after plasma polishing.
Keywords: Optical material, Plasma, Fused silica, Roughness, EDX, FESEM.

Paper ID #095

Performance Evaluation of Various Tool Materials and EDM Parameters for Fabrication of Large-Area Microtextured Surfaces

Ranajit Mahanti [1*], Rahul Singh[1], Manas Das [1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Assam 781039, India
*r.mahanti@iitg.ac.in

Abstract. The present study aims to investigate the role of different tool electrode materials such as mild steel, copper, and tungsten copper on the electrical discharge machining (EDM) performance of H13 steel alloy for the production of micro-textured surfaces that improve the lubrication properties by reducing the wear and tear. This study includes the preliminary experiments for the selection of process parameters for different tool electrodes and parametric investigation in die-sinking EDM to fabricate micro-textured surfaces. The parameters including peak current and pulse on-time are considered as control variables, whereas surface roughness (SR) and diametral overcut (OC) of machined surfaces are considered as responses. Peak current and pulse on-time are varied at six different levels to observe the variation of the responses, while other parameters are kept constant during experiments. A constant gap voltage of 40 V and a machining depth of 0.5 mm are considered for all pilot experiments. The sensitivity of the parameters on responses is analyzed for the selected parameter ranges. Peak current is the most sensitive parameter followed by the pulse ontime. Finally, a large area of the micro-textured surface is produced on H13 steel alloy using the optimum die-sinking EDM parameters and fabricated compound tool of the best-performed material.
Keywords: Electrical discharge machining, Textured-surfaces, Machining variables, H13 steel, Tool materials.

Paper ID #096

Effectiveness of Fixture Design on Cooling of Viscoelastic Soft Polymer during Cryogenic Assisted Micro-Milling Process

Partha Sarathi Mallick[1*], Karali Patra[2*]
[1,2]Indian Institute of Technology Patna, Department of Mechanical Engineering, Micro-fabrication Laboratory, Patna, India, 801106
*kpatra@iitp.ac.in

Abstract. Fixture design was found to be critical in cooling of soft viscoelastic polymers below its glass transition temperature (T_g) in their subsurface layers. The frictional heat generated at the tool-workpiece interface causes unpredictable deformations during machining. Sublayers cooling technique through design of fixture is proposed in the current study to provide structural stiffness of the soft polymer workpiece at larger depth of cut. The effectiveness of cooling in improvement of stiffness is quantified and compared with the type of microchannel formed over soft polymer by normal fixture. The cleanliness of the microchannel machined by cryogenic cooling is investigated. Use of new fixture in maintaining beneath layers of the machined surface stiffer effectively removed the soft polymer material during cryogenic machining process and generates clean machined surface. Cooling the soft polymer workpiece by liquid nitrogen (LN_2) to about -115^{0}C improved the machined surface finish. Accordingly, burrs formation can be avoided using novel fixture with controlled cryogenic cooling system.
Keywords: Fixture design, cryogenic machining, glass transition temperature (T_g), soft polymer.

Paper ID #097

Modelling and Parametric Analysis for WEDM during Machining of Heat treated AZ31 Alloy

Dhirendra Pratap Singh[1*], Sanjay Mishra[1], Yadvendra Kumar Mishra[2]
[1]Department of mechanical Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur, Uttar Pradesh, 273010, India
[2]Department of mechanical Engineering, NIMS UNIVERSITY, Jaipur, Rajasthan, 303121, India
*dhirendrapratapsingh043@gmail.com

Abstract. The biodegradable AZ31b Magnesium alloy was use in aerospace due to higher strength to low weight ratio, but it is limited in use due to high corrosive material, since by unconventional machining we cannot achieve good geometrical characteristics. So, we use unconventional WEDM, in which spark erosion is used to remove material and achieve a better surface finish. In this work, we perform the experiment on both without heat treated and heat-treated AZ31b alloys. For heat treatment, we heated the material above recrystallization temperature, i.e., at 500 °C, for 3 hours. After that, it cooled in the air at room temperature. After that, the BBD approach of RSM was used to develop the experimental model by considering four input parameters at three levels (T_{on} = 5–15 µs, T_{off}= 4-10 µs, I= 1- 5A, WS = 3.12-10.4 m/sec for response KW (kerf width), KWD (kerf width deviation), and TA (taper angle), which were investigated by response surface plots. And from ANOVA analysis, it reveals that for KW, T_{on}*I, T_{on}*WS, and T_{off}*I, and for KWD, T_{off}*T_{on}, T_{on}*I, and T_{on}*WS plays a significant role for both materials. For TA T_{on}*WS for WHT AZ31 alloy, and T_{on}*WS, T_{off}*WS plays a significant role for HT3H500 ^{0}C AZ31.
Keywords: WEDM, Kerf width, Kerf width deviation, Taper Angle.

Paper ID #098

Investigation into WECM of Nitinol SMA Using Ozonated Nano$_3$ Electrolyte

Naresh Besekar[1*] and B. Bhattacharyya[2]
[1, 2]Department of Production Engineering, Jadavpur University, Kolkata-700032, India
*nareshwbesekar@gmail.com

Abstract. Wire electrochemical machining (WECM) was created to address micromachining issues as a result of technological innovation. Ozone (O_3) is enhanced to increase its oxidizing capability, corrosive behavior, and overall machining performance in basic aqueous neutral electrolytes. In order to improve machining performance, this paper explains the effect of ozonated aqueous solution of $NaNO_3$ in the WECM for nitinol shape memory alloy (SMA). The quality of machined microgrooves is examined for surface topography, dimensional precision, and homogeneity. The experiments were conducted using a 1mm thick nitinol specimen and 50µm smooth cylindrical tungsten wire as electrode. Output responses were measured, and machined microgrooves parameters were carefully examined under an optical microscope and CCI profilometer for their dimensions, i.e., average width and mean depth and surface roughness, and graphs were plotted to understand the effect of ozonated $NaNO_3$ electrolyte with different electrolyte concentration and pulse voltages in comparison to non ozonated $NaNO_3$ electrolyte. The minimum average surface roughness (Ra) of 0.1542µm has been obtained using 0.2M $NaNO_3$ ozonated electrolyte at 5V pulse voltage compared to surface roughness (Ra) of 0.3857µm using non ozonated electrolyte. It shows more than 60% improvement in the surface quality of nitinol using 0.2M $NaNO_3$ ozonated electrolyte. Further, the width overcut has been reduced to great extent with improvement of groove depth by more than 50% using ozonated electrolyte compared to nonozonated $NaNO_3$ electrolyte shows expeditiously removal of sludge and dissolved products and increased efficacy of dissolution than non-ozonated electrolytes. Also, the homogeneous micro-slit of 124µm average slit width has been successfully fabricated using ozonated electrolyte.
Keywords: WECM, Wire Electrochemical Machining, Nitinol SMA, Ozonated Electrolyte.

Paper ID #099

Investigation in the Effect of Texturing on Indigenously Developed PVD Tin Coatings on Cutting Tool and Its Effect on the Machining of Nimonic 90

Gaurav Kumar*, Rishabh Raj Srivastava, S Ghosh, PV Rao
Department of Mechanical Engineering, Indian Institute of Technology Delhi
New Delhi 110016, India
*Gaurav.kumar@mech.iitd.ac.in

Abstract. In recent years, much work has been done on surfaces to improve their properties. One such surface improvement process involves coating of the surfaces with various materials through deposition processes. These surface deposition techniques are essential nowadays; they enhance or impart additional properties to the base material. Their application consists of different manufactured parts that can be used directly in cutting tool industries, small workplaces, electronics, etc. Physical Vapour Deposition is one such way to develop a coating on a substrate to improve its properties. The present work is a comparative study of the indigenously developed titanium nitride coatings produced by cathodic arc evaporation onto different substrates with different surface conditions. Cathodic arc evaporation is a type of physical vapour deposition technique in which a high current generates an arc between the anode and cathode which is the target material to accomplish the coating. The surface texturing of the tungsten carbide substrate is first done. Then deposition is done in nitrogen gas environment with a titanium target so that through such reactive sputtering process the desired titanium nitride is deposited over the substrate. X-Ray Diffraction technique first confirms the development of titanium nitride, which is then checked for nanoindentation and then the comparison between textured, and non-textured cutting tool insert is analysed based on the end milling of Nimonic 90 alloy, a difficult-to-machine material. The cutting environment is kept as nanofluid-based minimum quantity lubrication, and the nanoparticles used are of alumina, the solvent is DI water, and a suitable surfactant is used to increase the stability of the nanofluid. The cutting force, cutting temperature, surface roughness, and tool wear is studied and compared with an uncoated tool, and then it is seen that the coated tool reduces the cutting forces, surface roughness, and tool wear.

Keywords: Reactive Sputtering, Nimonic 90, Nanofluid, Minimum Quantity Lubrication, Texturing.

Paper ID #100

A Comparative Performance Study of Die Sink EDM and Near Dry EDM Processes in Machining of NIMONIC-90

Muniraju M[1*], Gangadharudu Talla[2], Eslavath Hathi Ram Naik[3]
[1, 2, 3]National Institute of Technology, Warangal, Telangana, 506004, India
*gtalla@nitw.ac.in

Abstract. Electrical Discharge Machining (EDM) is a nonconventional method that involves melting and vaporizing work materials. It is particularly useful for machining materials that are extremely hard because there is no physical interaction between the tool electrode and workpiece. However, traditional EDM has several drawbacks, including slow material removal rates and sub-par surface finishes. To address these concerns, the near-dry EDM (NDEDM) approach has been developed, which uses a two-phase dielectric medium to improve stability compared to conventional EDM. The current studyfocuses on the use of the NDEDM approach for NIMONIC-90 alloys. Both EDM and NDEDM operations were conducted with careful manipulation of key machining parameters, including the current (Ip), pulse-on time (Ton), and pulse-off time (Toff), while the discharge voltage remained constant. Spark erosion oil was used as the dielectric fluid for EDM, whereas NDEDM used a mixture of liquid and compressed air. The NDEDM setup was augmented with a minimum-quantity lubrication unit (MQL) to produce mist. The evaluation criteria for both methods included material removal rate (MRR), surface roughness (SR), radial

overcut (ROC), microscopic image analysis, and comparison. The surface topography was examined using Scanning Electron Microscopy (SEM) in both cases, and crater formation was observed in both scenarios. The design of experiments (DOE) approach was used to systematically alter three variables: current (I), pulse-on time (Ton), and pulse-off time (Toff), based on a central composite design guided by response surface methodology. The results showed that near-dry EDM led to significant improvements, with a material removal rate witnessing an improvement of up to 25%, surface roughness experiencing a 20% reduction, and radial overcut registering a 5.6% increase compared to traditional die-sink EDM. The findings indicated that near-dry EDM yields marked enhancements in the material removal rate and surface roughness compared with conventional die-sink EDM.
Keywords: NIMONIC-90 alloy, near-dry EDM, material removal rate, surface roughness, response surface methodology.

Paper ID #101

Deformation Behaviour and Elastic Energy Absorption Capability of Additively Manufactured Strut-Based and Voronoi Lattice Structures on FDM

Sankineni Rakesh[1*], Qazi NaziruddinZamiruddin[1] and Y Ravi Kumar[1]
[1]Department of Mechanical Engineering, National Institute of Technology, Warangal - 506004, India
*rsankineni@student.nitw.ac.in

Abstract. Additive manufacturing can fabricate lattice structures with complex geometries as well as unique properties. The lattice structure is composed of a unit cell which is filled in a space along the three axes with no gaps. In these structures, the unit cell orientation considered either periodic known as strutbased structures or random known as Voronoi structures. A comparison of mechanical behaviour and energy absorption capability was carried out between strut-based structures and Voronoi structures. The strut-based structures considered here are Octet Truss (OT), rhombic-dodeca-hedron (RDDH) and diamond (DM). The Voronoi structures can be characterized as stochastic and non-stochastic. These structures were designed and printed with the same relative density as strut-based structures, on fused deposition modelling (FDM) technology. Acrylonitrile butadiene styrene (ABS) and poly-lactic acid (PLA) are the materials used to print the structures. The printed lattice structures were quasi-statically tested in compression. The experimental results showed that mechanical properties and deformation mechanisms depend on the number of unit cells, unit cell type, cell orientation, bulk material properties and printing direction. The fracture behaviour was noted as elastic buckling, strut collapse and de-bonding of weak layers. The lattice structures are categorized as bending-dominated and stretching-dominated structures. The material reactions to the mechanical properties of the Voronoi structures were studied. By considering all the results, the best lattice structure with high elastic energy absorption capability was used to design the wrist splint for real-time applications.
Keywords: Additive Manufacturing, FDM, Voronoi, PLA, ABS, Lattice structures, Energy absorption capability and Wrist Splint.

Paper ID #102

Comparative Study of Multi-response Parametric Optimization of EDM Processes using Preying Behaviour Metaheuristic Algorithms

Devendra Pendokhare[1, 2 *], Shankar Chakraborty[1]
[1]Department of Production Engineering, Jadavpur University, Kolkata, West Bengal, 700032, India
[2]Department of Mechanical Engineering, Government Polytechnic, Thane, Maharashtra, 400612, India
*dgp.124@gmail.com

Abstract. Electrical discharge machining (EDM), which has a number of distinctive characteristics, has established itself as one of the effective non-conventional machining techniques for producing complex profile geometries on a variety of advanced engineering materials to meet the needs of modern engineering industries. This study mainly focuses on recently developed preying behavior metaheuristic algorithms, namely, sailfish optimization algorithm, harris hawk optimizer, aquila optimization algorithm, bat optimizer, and grey wolf optimizer. The experimental dataset deals with the electrical discharge machining using Al-SiC metal matrix composite to investigate the three response parameters these are material removal rate, surface roughness, and overcut. 34 experimental trials, based on the Box-Behnken design method are conducted by considering five process variables, discharge current, gap voltage, pulse-on-time, pulse-off-time, and flushing pressure. The results of single and multi-objective optimization, are validated using Friedman's mean rank test, and evaluated in terms of quality of the solutions, convergence speed, and computing effort. The grey wolf optimizer is found the best optimization algorithm over other four algorithms. The percentage of improvement in optimal results for the grey wolf optimizer, in case of single objective optimization are 5.91%, 29.3%, and 26.01% for material removal rate, surface roughness, and overcut respectively. For multi-objectives, they achieve 29.41%, 29.76%, and 32.57%.
Keywords: Optimization, Metaheuristic algorithms, Preying, EDM process.

Paper ID #103

Machining of Zirconia Ceramic with a USMM Process Using SiC Abrasives: An Experimental Investigation and Simulation

Bikash Banerjee[1*], Santosh Kumar[2], Subhadip Pradhan[3,] Somnath Das[4], Debabrata Dhupal[1] and Biswanath Doloi[2]
[1]Department of Production Engineering, Veer Surendra Sai University of Technology, Burla, Odisha, 768018, India
[2]Engineering Department, Jadavpur University, Kolkata, West Bengal 700032, India
[3]Department of Mechanical Engineering, Indian Institute of Engineering Science and Technology, Shibpur, Howrah 711103, India
[4]Mechanical Engineering Department, Swami Vivekananda Institute of Science and Technology, Kolkata 700145, India
*ddhupal_pe@vssut.ac.in

Abstract. The ultrasonic micro-machining (USMM) process has established its superiority over those other machining techniques as a unique strategy. Due to the superior properties of zirconia ceramic material, it is used in many industries, like aerospace, automotive, and process industries. This research paper presents experimental analysis for through hole generation on engineering ceramic i.e., zirconia (ZrO_2) with the best quality using the USMM process. Circular-type zirconia of 25 mm diameter and 1 mm thickness and silicon carbide (SiC) of 15 µm has used as workpiece material and abrasive materials respectively. In this machining process, the tool feed rate, power rating, and slurry concentration has considered as input parameters for determining the material removal rate (MRR), over cut (OC) and taper angle (TA), which are the output responses. Finite element analysis (FEA) has been done to determine the stress and strain affected zones during the

impact of an abrasive particle on the target surface. Each parameter's effect has been examined in this experimental investigation. The most important factor has also been determined using analysis of variance (ANOVA). Moreover, scanning electron microscopic view was considered for the generation of machined holes during USMM process.

Keywords: Ultrasonic micro-machining (USMM); Zirconia (ZrO2); Silicon carbide (SiC); Finite element analysis (FEA), SEM.

Paper ID #104

Prediction of Thermophysical Behaviour of Laboratory- Developed SMAW Coatings of Electrode for Marine Applications

Sudish Mishra1*, Rahul Chhibber1

1MED, IIT Jodhpur, Rajasthan-342030, India, Tel: 0291-2449072

*mishra.12@iitj.ac.in

Abstract. The demand for constructing complex offshore structures using various materials to endure and sustain the challenging and aggressive offshore environment has increased in recent years. For welding duplex stainless steel, SMAW electrodes have been developed. The 27-electrode coating composition is designed using the mixture design approach. The Hot-Disc apparatus was used to measure the thermophysical properties of each coating powder, including thermal conductivity, thermal diffusivity, and specific heat. A thermogravimetric analyzer (TGA) was also employed to analyze weight loss and enthalpy changes. To predict the thermophysical and physicochemical behavior, such as thermal conductivity, density, specific heat, thermal diffusivity, enthalpy change, and weight loss characteristics, based on electrode compositions, a prediction model based on an artificial neural network (ANN) was developed in this study. The input variables for the model included the electrode coating composition percentage, while the output variables comprised the thermophysical and physicochemical properties. To do predictive modeling, an ANN is used to compare the ANN's prediction accuracy to that of regression analysis. Compared to regression, the ANN model exhibited an average improvement in mean square error. The artificial neural network method shows more effective modeling skills, as evidenced by the visible reduction in the mean absolute percentage error for the test data.

Keywords: Thermophysical properties, Marine application, Artificial Neural network (ANN).

Paper ID #105

Fabrication of porous Aluminum structures using Laser Powder Bed Fusion for Electronic Applications

Nobel Karmakar*, Rajat Sharma, Poonam Sundriyal*, and C.S. Kumar*

Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, West Bengal, India, 721302

*psundriyal@mech.iitkgp.ac.in

Abstract. The use of cellular structures made of aluminum alloy can be found in a wide variety of applications, including the framework of automobile bodies, the insulation of highway noise, heat exchangers, and lightweight conformal pressure tanks. In this study, the manufacturability and performance of periodic cellular lattice structures made of AlSi10Mg were manufactured using Laser powder bed fusion (L-PBF). The structures that were made using L-PBF have a high degree of geometric congruence with the original design models. The findings of this research indicate that laser sintering can be utilized in producing high-quality, porous, large surface area and lightweight aluminum structural components with controllable unit size and volume fraction. The developed structures have huge potential in electronic and structural applications.

Keywords: Additive Manufacturing, AlSi10Mg, Porous Structures, Laser-based Powder Bed Fusion Process.

Paper ID #106

Study on Effects of Additive Manufacturing Process Conditions on Part Properties for Engineering Applications

Abhishek Raj[1*], Bobby Tyagi[1], Akash Jain[1] , Pushpendra Yadav[2], Ankit Sahai[1] ,
Rahul Swarup Sharma[1]
[1]Dayalbagh Educational Institute, Dayalbagh-282005, Agra, UP
[2]SRMS CET Bareilly UP
*a.rajdanish1228@gmail.com

Abstract. The present research study focused on examining the impact of postprocessing, i.e., annealing on Polylactic acid (PLA) parts processed through additive manufacturing for engineering applications. The parts are fabricated corresponding to two variable criteria: layer size and infill density. The Hydra 300 system is used for sample fabrication. The comparative analysis is performed for mechanical properties corresponding to annealed and non-annealed conditions of specimens. The studies show that post-processing positively affects the mechanical properties of PLA products for engineering applications. The specimens with 60% infill density provided 6.015%, 11.748%, and -1.834% improved strengths than un-annealed specimens, corresponding to layer size 0.2 mm, 0.3mm, and 0.4 mm, respectively. In a similar manner, the specimens with 90% infill density provided 6.761 %, 7.184 %, and 5.427% improved strengths than un-annealed specimens, corresponding to layer size 0.2 mm, 0.3mm, and 0.4 mm, respectively. These findings highlight the positive impact of annealing for engineering applications, emphasizing the potential to optimize PLA components through post-processing techniques.

Keywords: PLA, Additive manufacturing.

Paper ID #107

Optimisation of Machining Process Parameters of AA7475 composites

M.Dhanunjaya[1*], G. Sunil Kumar Reddy[2], Nityapuja Reddy[3], A. Sreenivasulu Reddy[4*],
[1234]Department of Mechanical Engineering, S.V. University College of Engineering, Tirupati, Ap -517501
*allampati_sr@rediffmail.com

Abstract. The composite materials have advantages over conventional materials due to their higher specific properties such as tensile, flexural and impact strengths, stiffness and fatigue properties. Metal matrix composites are made by introducing a reinforcing material in the metal matrix. In this paper the aluminum alloy 7475 based metal matrix composites were manufactured through stir casting process by adding the reinforcement materials with varying weight percentages of boron nitride, titanium carbide and tungsten carbide. In the present work highlight the effect of EDM machining process parameters current, voltage, pulse-on time, pulse-off time, standard of distance and different coolants to be varied for the better estimation of output parameters such as Material Removal Rate, Kerf width, Surface Roughness etc., and also the effect of CNC drilling process parameters being estimated for getting better output parameters by using Taguchi techniques. Grey Relation Analysis (GRA) is applied to optimize the process parameters. Fitness and adequacy of the experimentation has tested through the analysis of variance (ANOVA).

Keywords: AA7475, process parameters, responses, drilling, GRA, ANOVA, EDM.

Paper ID #108

Analysis of Temperature Effect for FDM printed parts using ABS material in Additive Manufacturing.

Sanjay Sharma[*], Ishbirsingh, Suketu Jani[*],
Mechanical Engineering Department, Indus University Automobile Engineering Department Ahmedabad
*SanjaySharma.23.rs@indusuni.ac.in

Abstract. This paper covers the brief review of FDM 3D printer in additive Manufacturing and the effect of printing temperature while printing the parts and also the effect of change in temperature of printed layer while printing. Up till now, prevalent method in manufacturing industry was

subtractive methods. However, there is another manufacturing method that may challenge traditional subtractive methods and that is additive manufacturing or it may also be called 3D printing. Additive manufacturing is defined as to building a product by melting plastic materials using a beam of energy and laying melted materials on top of layer. This technology is also explained as creating prototypes by adding materials layer by layer. Fused Deposition Modelling (FDM) were introduced in the late 1980s but strength is the major problem. They are used very rarely as industry ready products. Many composite materials are used in FDM but still the major drawback is the strength of component. There is various application of FDM printed parts and it is one of the low cost printer.

FDM 3D-printing, is an additive manufacturing technology that is being increasingly adapted in the engineering industry due to its ability to produce complex design at lower costs as the materials are thermoplastic based. Due to the nature of its successive layer deposition, the analysis of bonding quality is highly dependent on the temperature during printing. In this paper, an experimental investigation is conducted to study the effect of printing temperature on bonding quality with regards to tensile behaviour, surface roughness and dimensional accuracy of the fabricated parts. The test specimens were fabricated using ABS material at different printing temperature ranging from 240°C-260°C at intervals of 10°C. Axial ultimate tensile strength has been measured according to ASTM D638- 1 standard and found that specimen printed at 250°C shows maximum tensile strength of 22.91 N/mm^2. Also, other parameters like surface roughness, maximum bearing load, elongation at breaking load, elongation at maximum load and breaking load for all three temperatures were taken and observed that we get surface roughness of 4.66 microns which is good at 250°C.

Keywords: FDM 3D printing, additive manufacturing.

Paper ID #109

High-Velocity Impact Behavior of Co-Continuous Ceramic Composite with Different Volume Fractions

R. Sindhumathi[1*], V. Krishnaraj[1*], J.P. Escobedo[2], Jayakrishnan Nampoothiri[1], A.S. Prasanth[1]
[1]PSG College of Technology, Peelamedu, Coimbatore, Tamil Nadu, India-641004
[2]School of Engineering and Information Technology, The University of New South Wales, Canberra, ACT-2600, Australia
*vkr.prod@psgtech.ac.in

Abstract. This article presents an experimental investigation on the dynamic behavior of a co-continuous ceramic composite (C4) produced by infiltrating Al5083 alloy into SiC foams of 10, 20, and 30 pores per inch, respectively. The specimens were subjected to high-velocity (~800 m/s) impact by a spherical steel projectile using a gas gun impact system. The penetration process of the projectile into the C4 composite and the associated energy absorption characteristics were analyzed. The results showed that 30PPI-C4 possessed the highest energy absorption capability (7.17 J/g). Additionally, the 30PPI-C4 showed a 12% increase in specific energy absorption when compared to 10PPI-C4 and 20PPI-C4 because of the smaller grain boundary formation in 30PPI-C4 and the dislocation strengthening.

Keywords: C4 composite, Al5083 alloy, SiC foam, Specific energy absorption.

Paper ID #110

Direct Bonding of Cu to Cu for High-Technology Applications

R. Dipin Kumar[1*], S. Aravindan[1]
[1]Mechanical Engineering Department, IIT Delhi, New Delhi- 110016, India
*dipinkumarr@gmail.com

Abstract. Solid-state diffusion bonding is a technology suitable for joining components having complex internal features such as conformal cooling, compact heat exchangers, and antenna arrays. Owing to its high thermal and electrical conductivity and anti-corrosion characteristics copper is

widely used for thermal management and in telecommunication transmission devices. In this study, diffusion bonding of electrolytic tough pitch (ETP) copper was experimented in an air furnace and vacuum furnace to have a comparative study. The process parameters were bonding temperature of 800℃, dwell time of 75 minutes, and bonding pressure of 10 MPa. The cross-section of the diffusion bonded samples was cut, and specimens were prepared for metallographic analysis. The microstructural analysis was carried out using an optical microscope (OM) and FESEM with EDS. Diffusion bonding in an air furnace resulted in weakly bonded joint with voids on either side of the diffusion zone due to oxidation at the bonding temperature. Metallurgical joint with grain boundary migration at the interface was observed for those bonded in vacuum furnace with the same process parameters. However, thermal annealing has resulted in grain coarsening of the base metal which has to be further addressed.
Keywords: Diffusion bonding, ETP Cu, Interfacial grain boundary, GB migration, GB bulging.

Paper ID #111

Laser Welding of two Transparent Plastics without any Filler Materials

Nitesh Kumar[1,3*], Nikhil Kumar[2], Abhishek Mandal[1], Rajat Shubra Sen[1]
[1]Mechanical Engineering Department, Brainware University, Kolkata -700125, India
[2]WMG, The University of Warwick, Coventry CV4 7AL, United Kingdom
[3]Mechanical Engineering Department Jadavpur University, Kolkata -700032, India
*nitesh.ju@gmail.com

Abstract. The present research investigates Through Transmission Laser Welding (TTLW) of two transparent plastics, Polycarbonate and Acrylic, forming a lap joint. A 12 W Nd: YVO_4 laser with 1064 nm wavelength has been used for the welding. The effect of welding parameters such as scanning speed, laser power and laser frequency are studied. The weld quality has been assessed by measuring the depth of penetrations of the weld joints. A quadratic model has been developed using Response Surface Methodology (RSM) to correlate the welding parameters with the responses. Analysis-of-Variance (ANOVA) is utilized to determine the significant parameter/s on the responses. The developed model has been used to optimize the ideal welding conditions to achieve an improved depth of penetration.
Keywords: Through Transmission Laser Welding (TTLW), Depth of Penetration, RSM, ANOVA, Optimization.

Paper ID #113

A Numerical Analysis of Self-Piercing Riveting of Aluminium alloys using Aluminium alloys

Sunny Singh[*], Swaraj Pritam Swain, Abhishek Kumar Biswal, Boddepalli Durga Rao*
Parala Maharaja Engineering College, Brahmapur, Odisha-761003, India
*durga.me@pmec.ac.in

Abstract. Self-Piercing riveting (SPR) is a cold forming process that is used in joining of ductile materials or the materials with low melting points. In this process, the rivet pierces through stacks of sheets and flares into the bottom sheet, making a joint and fixing the stack of sheets together. With recent increase in demand of Self-Piercing Riveting (SPR) in the automotive industries to manufacture Body-in-White (BIW) of a vehicle using Aluminium alloys, to decrease weight of the body while also maintaining the strength of the material being joined that might get altered while using Hot forming process. With increase in demand, there is also a problem arising with recycling of the body. Aluminium Rivets are used to join Aluminium sheets. This also allows to reduce the overall weight of the vehicle to some extent, as there are usually more than thousand Self-piercing rivet joints in the vehicle. So, we used sheets of Al 6061-T6 to join using Aluminium rivets with the help of Self-Piercing Riveting joining process, using variable types of die and rivets. ABAQUS/CAE Explicit software is used for the numerical analysis of the Self-Piercing Riveting Simulation, using 2D axisymmetric method since the Self-Piercing Riveting setup is symmetric along the axis of the rivet. Which allows to reduce simulation load and time, while also reducing simulation cost which is usually encountered in Industries. Thus, reducing recycling problems.

Keywords: Self-Piercing Riveting, Aluminium Alloys, Aluminum Rivets, Numerical Simulation, ABAQUS, FEA, Joint Feasibility, Joint Quality.

Paper ID #114

Design & Manufacturing of a 3D Printer Filament Extruder - Shredded Waste Plastic Management

Richa Pandey[1*], Ravi Kumar[2], Mani Karan Sen[3], Naveen Kumar[4]
[1]Assistant Professor, Mechanical Department, BIT Mesra, Ranchi, Jharkhand (835215), India
[2]Student, MechanicalEngineering, BIT Mesra, Ranchi, Jharkhand (835215), India
[3]Student, MechanicalEngineering, BIT Mesra, Ranchi, Jharkhand (835215), India
[4]Student, MechanicalEngineering, BIT Mesra, Ranchi, Jharkhand (835215), India
*richapandey@bitmesra.ac.in

Abstract. Plastic waste is one of the biggest concerns the world is facing today. To address this issue, we propose a solution that involves recycling plastic waste into filaments suitable for 3D printers through the process of extrusion. In this paper, we present the design and development of a low-cost plastic extrusion machine, which enables the transformation of waste plastics into usable 3D printing filaments. Our approach involves a comprehensive review of existing literature on the potential of converting plastic waste into 3D printer filaments and the challenges associated with the production process. The main objective is to demonstrate the feasibility of reusing the plastics waste for 3D printing, contributing to waste reduction. This has been extended to design an extruder for final sysnthesis of the recycled and waste plastic.

Keywords: Plastic Waste, Recycling, Extrusion Machine, Waste Management, Filament, 3D Printing.

Paper ID #115

Microstructure Alteration and Crystallographic Texture Evolution in NMQL Assisted End Milling of Incoloy 925

Shravan Kumar Yadav[1*], Sudarsan Ghosh[1], Aravindan Sivanandam[1]
[1]Mechanical Engineering Department, Indian Institute of Technology Delhi, New Delhi, Delhi, 110016, India
*shravanyadav1444@gmail.com

Abstract. In the ideal situation, the machining of any component is performed to meet the functional requirements of a part. However, due to the nature of the material removal mechanism (thermo-mechanical effects), it alters the microstructure and evolves crystallographic texture. Produced texture converts the isotropic to anisotropic properties of the material and thus affects the performance of the part. In order to control the microstructure alteration and evolution of texture during the end milling of Incoloy 925, biodegradable oil-based nanofluid under the MQL (minimum quantity lubrication) technique has been used in this study. Results show that cutting temperature and force have been reduced in the NMQL (nanofluid minimum quantity lubrication) environment compared to dry and pure oil based MQL conditions. Consequently, the depth of microstructure alteration and texture evolution are controlled.

Keywords: NMQL, Microstructure, Crystallographic texture.

Paper ID #116

Effects on Mechanical Properties of Natural Fiber Reinforced Epoxy

Sanjay Rath[1*], Tusarkanta Sahoo[2], Priya Ranjan Panda[3], B. Durga Rao[4]
[1, 2, 3, 4]Parala Maharaja Engineering College, Berhampur, Odisha, 761003, India
*priyaranjanpanda0@gmail.com

Abstract. The increasing demand for sustainable and eco-friendly materials has led to extensive research on natural fiber composites as a viable alternative to synthetic materials. This project aims to analyse the mechanical properties of a natural fiber composite using jute and coconut coir. In this

study jute and coconut coir are selected as reinforcing agents due to their abundant availability, low cost, and desirable mechanical properties. The natural fibers are extracted, processed, and combined with a polymer matrix to form composite specimens. The fabrication process involves hand lay-up technique for ensuring uniform fiber dispersion within the matrix. The mechanical properties of the natural fiber composite are assessed through various tests, including tensile, flexural, impact and hardness test. The tensile strength, flexural strength, impact resistance, and hardness of the composite specimens are measured and compared with the specimen of solely epoxy resin. The results obtained from this study will contribute to the understanding of the mechanical behaviour and potential applications of natural fiber composites. The findings will aid in optimizing the fiber-reinforced composite materials for various engineering applications, including automotive components, construction materials, and consumer products, among others. Furthermore, the use of sustainable natural fibers can help reduce environmental impact and promote the development of a circular economy.

Keywords: Natural fiber composites, Jute, Coconut coir, Mechanical properties, Sustainable materials, Fiber-reinforced composites.

Paper ID #117

Characterization of Tin Coating Deposited by Cathodic Arc Evaporation under various process Parameter conditions

Arti Sahu[1*], Sudarsan Ghosh[1], Sivanandam Aravindan[1]
[1]Indian Institute of Technology, Delhi 110016, India
*artisahu311aug@gmail.com

Abstract. In this study, the deposition of TiN coating was done on Ti-6Al-4V alloy substrates by using the cathodic arc evaporation technique under varying process parameters conditions to improve Ti alloy's surface properties (hardness and wear resistance). The aim was to investigate the effect of various process parameters on the microstructure and mechanical properties of TiN coating. The Coating morphology, phases, and chemical composition were examined by field emission scanning electron microscopy (FESEM), X-ray diffraction (XRD), and energy dispersive X-ray spectroscopy (EDX), respectively. Nano hardness of the coating was investigated with the diamond Berkovich indenter using the Oliver and Pharr method. Moreover, the surface roughness of the coatings was measured by SPM images in a Nano-indentation hardness tester. The coefficient of friction (COF) of the coated surface was examined by a reciprocating ball on plate wear test using an alumina ball as the counter surface. Coating deposited at higher bias voltage and temperature (80 V and 350°C) shows high hardness, good surface finish, and low COF as compared to the coating deposited at lower bias voltage and temperature (0 V and 150°C)

Keywords: Cathodic Arc Evaporation, Titanium Nitride, Ti-6Al-4V alloy, Nano-hardness, COF.

Paper ID #118

Effect of High-Entropy Alloy Nanoparticles on the Microstructure and Mechanical behaviour of AA7150 Nanocomposite

Deepak Kumar[1*], R Seetharam[2*], K Ponappa[1]
[1]Severe Plastic Deformation Laboratory, Department of Mechanical engineering, PDPM Indian Institute of Information Technology Design and Manufacturing, Jabalpur, Madhya Pradesh, 482005, India
[2]Department of Mechanical engineering, Indian Institute of Information Technology Design and Manufacturing Kurnool Andhra Pradesh, 518002, India
*seetharam@iiitk.ac.in

Abstract. In the present study, an AA7150-based nanocomposite was prepared by incorporating high entropy alloy (HEA) nanoparticles ($Al4CrFeMnTi_{0.25}$) through an ultrasonic stir casting process to study the microstructure evolution and mechanical properties. Efforts have been made to prepare nanocomposite with high strength, maximize uniform and smooth interface for efficient

load transfer and minimize reinforcement agglomerations. A novel technique of ultrasonic assisted two stage stir casting was used to fabricate AA7150-HEAp nanocomposite to increase the effectiveness and uniform distribution of high entropy alloys (HEAs) as reinforcing agents in metal matrix composites. This study described the effect of HEA nanoparticles on the improvement of the microstructure, density, microhardness, porosity, and ultimate tensile strength of the nanocomposite. The incorporation of HEAp into AA7150 resulted in a fine-grained and dense (relative density: 98.13) nanocomposite. The addition of HEAp in the AA7150 matrix also improved the microhardness and ultimate tensile strength.

Keywords: AA7150, High Entropy Alloys, Ultrasonic assisted two stage stir casting, Microhardness, Tensile test.

Paper ID #119

Mode-I Fracture Behavior of 3D Printed PEEK using Energy-partitioning Technique

Gaurav Sharma[1*], Amol Vuppuluri[1], Kurra Suresh[1]

[1]Birla Institute of Technology and Science (BITS)-Pilani, Hyderabad Campus, Telengana-500078, India

*p20200464@hyderabad.bits-pilani.ac.in

Abstract. A paradigm shift is taking place in the manufacturing sector where 3D printing is replacing the conventional manufacturing techniques for fabricating critical components owing to the numerous advantages offered by the 3D printing process. However, the multifold of associated process variables make it imperative to characterize the 3D printed components before their application in different fields. High strength-to-weight ratio and economical fabrication are the primary requirements while manufacturing these 3D printed components and therefore, metals are being replaced with 3D printed high strength polymers and their composites. Fused deposition modeling (FDM) is the most widely accepted fabrication process for 3D printing these high-performance thermoplastics. Among the variety of thermoplastics, the 3D printed polyether-ether-ketone (PEEK) has shown promising mechanical characteristics. However, there is still need to analyze fracture behavior and crack growth in 3D printed PEEK components under different stimuli. This current study deals with the implementation of a novel fracture behavior assessment technique called essential work of fracture (EWF) for characterizing the reliability and structural integrity of 3D printed PEEK specimens under Mode-I loading conditions having 0^o (material deposition path is parallel to the loading direction) and 90^o (material deposition path is perpendicular to the loading direction) raster orientations. This article provides a fundamental guidance to design and materials engineers regarding the selection of the optimum raster orientation for 3D printing PEEK components with high fracture toughness.

Keywords: Polyether-ether-ketone, Essential Work of Fracture, Energy-partitioning.

Paper ID #120

Meso-level Surface Alloying of Hastelloy C 276 using WS_2 powder mixed dielectric through µ-EDM set-up

Souradeep Dutta[1*], Deba Kumar Sarma[2]

[1]National Institute of Technology Meghalaya, Department of Mechanical Engineering, Shillong, Meghalaya,

[2]National Institute of Technology Meghalaya, Department of Mechanical Engineering, Shillong, Meghalaya,

*souradeepdutta@nitm.ac.in

Abstract. Hastelloy C 276 (HC 276) is a nickel-based alloy with a huge application in the aerospace and nuclear industry due to its corrosion resistance at higher temperatures. Surface modification is essential for the HC 276 due to its lower surface hardness and wear resistance. It increases its application and life cycle. So, the present study investigates the influence of process variables named gap voltage (V), pulse on time (t_{on}) and powder concentration (p) on the material deposition rate (MDR), surface roughness (R_a) and micro-hardness (MH) duringmeso-level surface

alloying of HC 276 byWS_2 powder added dielectric. Muti-response optimization tool Taguchi's grey relational analysis (GRA) and hybrid optimization tool grey relational based genetic algorithm (GRGA) are applied to optimize the machining variables for minimum R_a and maximum MDR and MH. The proposed GRGA method improves all the responses in a significant manner and provides a superior finish of the coated surface on HC 276.
Keywords: Hastelloy C 276, surface alloying, optimization.

Paper ID #121

Finite Element Modal Analysis of Axisymmetric Hollow Sonotrode used in USM Machine

Pradeepti Vishwakarma[1*], Vinod Yadava[2]
[1, 2]Motilal Nehru National Institute of Technology Allahabad, Prayagraj, Uttar Pradesh, 211004, India
*hsv.pradeepti@gmail.com

Abstract. Ultrasonic Machining (USM) process is a competent technique to machine hard, brittle, conductive, and non-conductive materials with intricate profile and good surface finish. The present study touches the area of designing and development of a profiled hollow Sonotrode, which is capable of making protrusions, used in USM machines to magnify the amplitude of vibration and transfer it from the transducer end to the tool end. The length of the paraboloid hollow cylindrical sonotrode profile, for fixed top end and bottom end area, is determined by solving a second order general differential equation governing its profile and applying boundary conditions to it. Subsequently, the gain in amplitude is also determined from the general differential equation using numerical method. Further the Modal analysis is carried out to find the natural frequencies and the mode shapes of the developed 3D profile of the sonotrode using ANSYS R19.2 Workbench software. The natural frequency for longitudinal mode shape is found to be approximately equal to the frequency for which the sonotrode was designed.
Keywords: Ultrasonic Machining (USM) process, paraboloid hollow cylindrical sonotrode, Modal analysis, resonance (natural) frequency, length.

Paper ID #123

Electrochemical Micromachining and Potentiodynamic Polarization Analysis of Nitinol Shape Memory Alloy in Ethylene Glycol-based Neutral Solutions

Abhijeet Sethi[1*], Biswesh Ranjan Acharya[1], Partha Saha[1]
[1]Department of Mechanical Engineering, India Institute of Technology Kharagpur,
West Bengal, India 721302
*psaha@mech.iitkgp.ac.in

Abstract. Nickel-Titanium (Nitinol) stands out as a superior shape memory alloy (SMA) for micro electro-mechanical systems (MEMS) in biomedical industry due to its shape memory effect, superelasticity, and biocompatibility. However, the temperature-responsive properties of Nitinol make traditional machining challenging. Electrochemical micromachining (ECMM), which effectively processes conductive materials irrespective of their hardness, offers a solution for the fabrication of microfeatures in Nitinol. This research explores into electrochemical dissolution of Nitinol in various ethylene glycol (EG)-based industrial neutral electrolytes, specifically EG + NaCl, EG + $NaNO_3$, and EG + NaBr, to understand their impact on ECMM. Experiments involved fabricating microchannels at three levels of applied voltages using these electrolytes keeping all other parameters constant. Successful microchannels were achieved with both EG + NaCl and EG + $NaNO_3$ electrolytes, with the latter showing the smoothest surface at a roughness (Ra) of 0.276 μm, marking it as optimal for ECMM of Nitinol. Conversely, EG + NaBr electrolyte resulted in an inferior microchannels, proving less effective for anodic dissolution of Nitinol. Potentiodynamic polarization tests through linear sweep voltammetry (LSV) indicated broader passivation in the EG + NaCl and EG + NaBr solutions, limiting Nitinol dissolution, whereas EG + $NaNO_3$ presented minimal passivation, promoting efficient dissolution.
Keywords: Electrochemical Micromachining, Nitinol, Ethylene Glycol.

Paper ID #125

Experimental Studies on AA7475 Composites

M.Dhanunjaya[1*], B. Nitya puja Reddy[2], N. Yaswanth[3], A. Sreenivasulu Reddy[4]*,
[1, 2, 3, 4]Department of Mechanical Engineering, S.V. University College of Engineering, Tirupati, Ap -517501
*allampati_sr@rediffmail.com

Abstract. Aluminium metal matrix composites have been emerging as the best materials in the application of aerospace, automobile, marine, chemical, and transportation industries due to their lightweight, high strength, and hardness. Different AMMCs developed to improve their tribological and mechanical performance. In this work for AA7475 base metal, reinforcements can be added in weight percentage in elements of Titanium Carbide (Tic), Tungsten Carbide (WC) and Boron Nitride (BN), which gives attractive physical and mechanical properties such as tensile strength, hardness, electrical conductivity and compression strength and also wear rate is predicted using pin-on-disc method. AMMCs are prepared by using stir casting method. The above-mentioned properties have been tested using Universal Testing Machine, Brinell hardness testing machine and Pin-on-disc machine. It is observed that the tested results are found quite satisfactory. Taguchi Design of Experiments (DOE) was developed for the estimation of wear behaviour through pin-on-disc dry sliding wear test. By considering S/N ratio (smaller-the-better) in the designed experiments for regulating the process parameters i.e., composition, load and sliding distance for the prediction of optimised responses i.e., weight loss, specific wear rate and frictional coefficient. After analysing the test results through GRA, it is concluded that load and sliding distance were the most depending parameters.

Keywords: Stir Casting, mechanical properties, wear rate, optimization.

Paper ID #126

Experimental and Computational Investigation of J-integral Al-7075

Vineet Kumar[1*], Ankit Saini[2]
[1]GBPEC Delhi, Delhi, Delhi, 110020, India
[2]IIT Roorkee, Roorkee, UK, 263145, India
*vineetrose@gmail.com

Abstract. In this paper J integral of Al 6075 T6 was computed through experimentally performing the compact tension (CT) specimen test in which stress intensity factor and J-integral parameters calculated by CT test. The fracture toughness criterion (CT samples) is choosing for calculating J-integral results. The results are also found through finite element analysis using Abaqus software and results are validated with experimental data which are much closed to this. The fracture analysis is carried out using dis-placement boundary loading condition, considered for evaluating J integral at 3D contours obtained in model.

Keywords: J-integral, CT Test, FEM and Al 6075 alloy.

Paper ID #127

Influence of reduced Graphene oxide (rGO) modified CFRP composites during Abrasive Water Jet Machining

Rajesh Kumar Verma[1*], Shivi Kesarwani[2]
[1]Department of Mechanical Engineering, School of Engineering, Harcourt Butler Technical University, Kanpur, 208002, India
[2]Department of Mechanical Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur, 273010, India
*rkvme@hbtu.ac.in

Abstract. The present research examines the effect of reduced graphene oxide (rGO) as reinforcement in carbon fiber-reinforced polymer (CFRP) composites, as well as the relationship between abrasive water-jet machining (AWJM) parameters and delamination variables. Statistical investigations of ANOVA illustrates that the *Entry (Dfi) and Exit (Dfo)Delamination Factors* are

considerably influenced by rGO wt.%, Stand-off Distance (SoD), and Traverse Rate (T_r), with major interactions between rGO and T_r. The *R-squared* values of the constructed models are close to 97%, demonstrating their dependability. Delamination in CFRP composites during a water wedge motion is investigated. This explores shock waves, inter-ply bond failure, and AWJM. Optimization based on a desirability function identifies settings that reduce delamination to a minimum, providing advantageous guidance for improving CFRP composite machining generally and rGO inclusion in particular. The aerospace, automotive, and structural engineering sectors are just a few that stand to gain from the insights gained from this study of machining science and composite materials.
Keywords: CFRP, rGO nanofiller, Nanocomposite, AWJM, Entry and Exit Delamination.

Paper ID #128

Investigation on Mechanical properties of Bio-polymer Nanocomposites for Artificial Bio-Bearing (ABB) applications

Rajesh Kumar Verma[1*], Devendra Kumar Singh[2]
[1]Department of Mechanical Engineering, School of Engineering, Harcourt Butler Technical University, Kanpur-208002, India
[2]Department of Mechanical Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur-273010, India
*rkvme@hbtu.ac.in

Abstract. In the 21st century, biomaterials are rapidly changing to full fill the varying needs of medical sectors. Many medical research and technology areas, including dentistry and orthopedics, have shown a keen interest in polymeric biomaterials. Polymeric biomaterials are frequently used to restore the function of damaged bone or organs. It aids recovery, improves functionality, and rectifies abnormalities caused by birth, accidents, and illness. For biomaterial applications exposed to continuous loading conditions, this study demonstrates the development of a unique hybrid thermoplastic composite. Herein, the materials' dynamic mechanical and Compressive properties investigated for their end use feasibility. The mechanical properties of five variants of reduced Graphene Oxide (rGO)/Ultrahigh molecular weight polyethylene (UHMWPE) composites compared to pure UHMWPE. Composite samples with various rGO content (0 to 3%) are developed by adopting liquid phase ultrasonication followed by hot press moulding. The resulting composites were examined using Scanning electron microscopy (SEM), dynamic mechanical analysis (DMA), and compression testing. A detailed understanding of the structure/properties relations is necessary to develop various load-bearing components (Finger joints, Knee joints, hip joints). Consequently, performing an in-depth analysis of the viscoelastic properties of the composite is necessary. According to DMA results at 37^0C, the 1 wt.% rGO /UHMWPE nanocomposite is superior to pure UHMWPE in terms of storage modulus (79.55%) and Compressive modulus of 0.5 GPa. The incorporation of rGO into Artificial Bio-Bearing (ABB) materials has enhanced their dynamic mechanical and Compression abilities, allowing them to be used in a wider variety of human body parts. Bone plates, joint replacements, ligaments, dental implants, biosensors, artificial hearts, and blood tubes are potential applications for these materials in the medical field. It could be promoted as bio nanocomposites to the industrial sector for the creation of efficient and low-priced prostheses and implant products.
Keywords: Bio nanocomposites, reduced Graphene Oxide (rGO), UHMWPE, Dynamic mechanical analysis, Compressive.

Paper ID #129

Optimization of Process parameters and Investigations of Bead Geometries of GMAW-Based Wire–Arc Additive Manufactured 316L Stainless Steels

Gaurav Kishor[1*], Khumri Hatim Mustafabhai[1], Krishna Kishore Mugada[1*], Vishvesh Badheka[2]
[1]Dept. of Mech. Eng. Sardar Vallabhbhai National Institute of Technology Surat -395007
[2]Dept. of Mech. Eng. Pandit Deendayal Energy University, Raisan, Gandhinagar-382007
*mugada.krishnakishore@gmail.com

Abstract. Wire arc additive manufacturing (WAAM) has revolutionized various industrial sectors by offering a direct fabrication approach that reduces material usage and deposition time. Surface finish and bead geometry are challenges in parts produced by the WAAM process, to control these limitations appropriate selection of process parameters is very important. This study focuses on the optimization of deposition parameters such as travel speed, current, and gas flow rate for bead geometry (bead height and width) of multilayered SS316L structures fabricated by using a gas metal arc welding-based WAAM process. Optimization of process parameters is carried out using Taguchi's L9 orthogonal array and a linear/quadratic regression equation is developed for prediction of bead height and bead width. Additionally, analysis of variance (ANOVA) was used to assess the sufficiency and robustness of the developed regression equations. Values of R2 and adj. R2 was discovered to be close to unity for both bead width (BW) and bead height (BH) responses, demonstrating the model's suitability. Main effect plots and analysis of variance (ANOVA) identify the most influential parameters and optimal parameter pairs. Travel speed has the maximum impact on bead height, followed by current and gas flow rate, and current exhibits the greatest effect on bead width, followed by travel speed and gas flow rate.

Keywords: WAAM, DED, SS316L, Taguchi method, Orthogonal L9 array, ANOVA, Regression analysis.

Paper ID #130

Numerical Modelling of Cure Kinetics of a Porous Thermoset Polymer

Bhishm Dewangan[*], Nilanjan Das Chakladar
Advanced Composites Engineering Laboratory, Department of Mechanical Engineering,
Indian Institute of Technology Kharagpur, West Bengal, 721302, India
*bhishmdewangan94@gmail.com

Abstract. Porosity has been a key issue in the composites sector, which is greatly affected by each step involved in the composites manufacturing process. In the present study, a multiscale modelling methodology is established to investigate the influence of porosity on the curing and post-curing of thermoset polymer (in this case, epoxy). Abaqus is used to construct a finite element (FE) model combined with a structural-thermal periodic homogenization to estimate the cure kinetics of the epoxy. The novelty lies in the development of a multi-linear constitutive material model, including a random distribution of pores, a user-defined cure kinetics algorithm, and the concept of a dynamically allocated representative volume element (RVE) i.e., dynamic RVE. The cure rate is found to vary across the domain thickness with a magnitude of 1.3 times in the middle of the domain to that at the surface. At 70% cure level, the cure rate is found to be 0.0016 per sec for an epoxy domain of thickness of 4 mm. The residual stress, which is primarily dependent on the linear expansion coefficient of polymer across the temperature gradient, is found to drop by 32.4% and 35% at a porosity of 3% and 5% with respect to no porosity model. The proposed model has the capability to upscale to a composite part cure simulation, given the cure kinetic parameters of the resin involved.
Keywords: Resin, Porosity, Cure modelling.

Paper ID #131

Studies On Different MCDM Techniques in Micro-Electrical Discharge Machining of Titanium Alloy

R. Gunasekaran*, P Hariharan, B. Mouli Prasanth
[1]Department of Mechanical Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu, India
[2]Department of Manufacturing Engineering, College of Engineering Guindy, Anna University, Chennai, India
[3]Department of Electronics and Communication Engineering, Humanitarian Technology Labs, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India
*gunamech6@gmail.com

Abstract. Micro-electrical discharge machining (μEDM) is a precise and versatile process for fabricating complex microstructures on materials like titanium alloy. Selecting optimal machining parameters in micro-EDM is critical for achieving desired machining outcomes. Multiple criteria decision-making (MCDM) techniques provide systematic approaches to address this challenge by evaluating and ranking alternative parameter sets based on their performance across various measures. In this paper, Experimental trials are carried out in micro-EDM using different parameter combinations with 0.5mm Ø copper tool electrode onTitanium alloy (Ti-6Al-4V). The performance measures such as Material Removal Rate (MRR), Hole Taper (HT), Tool Wear Rate (TWR), and Hole Overcut (HO) are considered as evaluation criteria. The experimental data are then used to construct decision matrices specific to each MCDM technique such as COPRAS, MOORA, MAIRCA, and EAMR; then, the parameter sets are ranked and compared to determine the most optimal solution. Method based on the Removal Effects of Criteria (MEREC) and Entropy method are utilized for weighing the criterion. By understanding the performance characteristics of each technique, researchers and practitioners can make informed decisions in selecting the most appropriate MCDM technique for optimizing micro-EDM processes. Ultimately, this study contributesin enhancing the MRR, TWR, HT, and HO in micro-EDM of titanium alloy, leading to advancements in micro-manufacturing applications like aerospace, medicine, and automotive.
Keywords: MCDM, COPRAS, MOORA, MAIRCA, EAMR, MEREC, Entropy.

Paper ID #132

Microstructural Evaluation of $Gd_2Zr_2O_7$ Thermal Barrier Coating Developed by EB-PVD Technique

P. Hariharan[1*], G. Bhavesh[2, *], D. Durgalakshmi[3]
[1]Research Scholar, Department of Manufacturing Engineering, College of Engineering Guindy, Anna University, Chennai, India
[2]Professor, Department of Manufacturing Engineering, College of Engineering Guindy, Anna University, Chennai, India
[3]Assistant Professor, Department of Medical Physics, College of Engineering Guindy, Anna University, Chennai, India
*bhaveshganesan@gmail.com

Abstract. In this study, the nanostructured Gadolinium Zirconate (GZ) was deposited by Electron Beam-Physical Vapor Deposition (EB-PVD) onto the nickel-based superalloy substrate with NiCrAlY bond coat deposited as an intermediate layer by APS technique. The effect of the deposition technique on the microstructure and surface topography of the coatings was studied. A uniform layer of coatings without pores and cracks was achieved with an average roughness (R_a) of 52.599 nm. The cross-sectional SEM images show that the coatings developed comprise of leafy structure with a porosity of 4.57%, validating the dense microstructure of the TBCs. The base material, bond coat, and GZ coatings were further subjected to high-temperature hot corrosion (HTHC) studies under 45 wt.% Na_2SO_4 + 55 wt.% V_2O_5 corrosive salt mixture environment at 850°C for 8 hours. The substrate and bond coat had severe spallation along with higher weight

gain. However, the GZ coatings surface was intact with corrosive products without any spallation of the coating layer accompanied by minimal weight gain protecting the sublayers of the TBC system.

Keywords: Pyrochlore, Gadolinium Zirconate, EB-PVD, Thermal Barrier Coatings, Hot Corrosion.

Paper ID #133

Statistical Investigation on Dispersion Quantification for H13 Steel Particle filled Polymer Composite 3D Printed feature

Siva Prasad Tadi[1*], Jafar Sadiq Shaik[2], Venkata Krishna Devara[1], Ravi Sankar Mamilla[1*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Tirupati, AP – 517619, India
[2]Department of Mechanical Engineering, Adikavi Nannaya University, Rajamahendravaram, Andhra Pradesh – 533296, India
*evmrs@iittp.ac.in

Abstract. Considering many applications, metal additive manufacturing (MAM) is advancing significantly every day. In terms of energy and cost, the current direct MAM methods, like powder bed fusion (PBF) and directed energy deposition (DED), are quite expensive. The alternative method is known as indirect MAM, and it prints the feature using a feedstock (often a filament) made of metal particles and an appropriate binder. The final metallic product is produced by de-bonding and sintering the printed component. Since particle agglomeration will result in dimensional instability of the sintered item, the particle distribution plays an important role in this process. In the present work, three important quantification metrics known as D – index, COV_d and are discussed, which quantify the metal particle dispersion within a polymer matrix. In the present work, a cubic feature of side 12 mm is printed with H13 metal particle-filled polymer filament. The said metrics are calculated at three different locations, and average values of D – index: 0.61542 and COV_d: 0.28805 are reported. The results are compared to the limiting values and found that the particles are not agglomerated. The part is then thermally de-bonded and sintered successfully with an average linear shrinkage of 16.67 %. The post sintering material integrity is verified by conducting indentation hardness at different locations and an average indentation hardness of 3.87 GPa is reported. This study helps metal 3D printing industry to produce structurally integral parts. This pre-assessment acts as a checkpoint before sintering and prevents the end product's dimensional instability.

Keywords: Material extrusion, Polymer matrix composites, Dispersion quantification, Metal additive manufacturing, Sintering.

Paper ID #134

Implementation of Just-In-Time Manufacturing to Produce Custom Components on a Pump Assembly Line Using 3D Printer

Rohit Chandran R[1*], Ganesh Kumar Nithyanandam[2]
[1]PG Scholar, PSG College of Technology, Coimbatore, Tamil Nadu, 641004, India
[2]Associate Professor, PSG College of Technology, Coimbatore, India
*rohitchandran90201@gmail.com

Abstract. The paper proposes the Just in Time manufacturing concept to produce custom components on a conveyor system with little or no human intervention. In a prior study, a testbed demonstrator was developed to transform 98% manually operated pump assembly (in a 1.5-acre space) into 40 feet by 25 feet sixstation line balanced continuous flow [1]. The testbed demonstrator was developed to produce a custom product at an affordable price, faster and with decent quality. A product consists of multiple subcomponents. Each station is designed to perform some specific actions (assemble subcomponents). The fifth station is designated for the 3D Printer where a custom subcomponent is produced in realtime. Based on the customer order for a product

(radial submersible pump), the custom subcomponents (impeller) with parameters such as outer diameter, inner diameter, number of ribs, rib thickness, and color of the rib are considered. A Python script collects these parameter values from the first station, optimizes it to generate an STL file, and stores it in a cloud. Another Python program is used to trigger the 3D Printer to use the STL file located in the cloud using REST API and produce the 3D object (impeller in our case) automatically. In this process, no human intervention happens, and every action is fully automated. Thus, machine-to-machine (M2M) communication occurs in this study. A customer can also monitor the printing process in real-time using a third-party 3D printer controller.
Keywords: Just in Time Manufacturing, Rest API, 3D Printing, M2M, Additive Manufacturing.

Paper ID #135

Modelling of Cranial Implant and its Prototype Development Using Head CT Scan Data

Deepak Kumar[1*], Sriharsha Mishra[2], Amit K Chanduka[3], Gaurav Bartarya[1]
[1]Indian Institute of Technology, Bhubaneswar, Jatni, Khorda, Odisha, 752050, India
[2]National Institute of Technology, Rourkela, Odisha, 769008, India
[3]Department of Neurosurgery, Apollo Hospital, Bhubaneswar, Odisha, 751005, India
*s23me09009@iitbbs.ac.in

Abstract. Recent developments in additive manufacturing technique make it possible to build complex and customized products faster than with traditional methods. Reverse engineering (RE) and computer-aided design are crucial when creating sophisticated, patient-specific implants since they speed up the design process. In this study, computed tomography (CT) data in DICOM format was used to generate a 3D reconstructed model of the skull using the RE method. For implant design the mirror image technique was used. Prior to fabrication, the. stlfiles of the skull and implant were smoothen out and the mesh errors were re- moved using Meshmixer software. Fused deposition modelling based 3D printer was used to fabricate the cranium and the cranial implant using Polylactic acid (PLA) and acrylonitrile styrene acrylate (ASA) materials respectively. Using Ti- 6AL-4V material under a 50N load in static condition, the design capability of the implant was evaluated using the finite element method (FEM). The FEM re- sults demonstrate the feasibility of using an implant design for cranioplasty ap- plication. The prototype of skull and implant was effective in assessing the frac- tured part precisely. This 3D-printed prototype facilitates better surgical planning and expedites the fabrication of real metallic implants.
Keywords: Reverse Engineering, Cranial Implant Design, Finite Element Anal- ysis, Fused Deposition Modeling.

Paper ID #136

An Investigation of Threaded Insert Performance in Additively Manufactured Parts

Hemant Hogade[1*,] Dixita Yadav[1], Yash Gopal Mittal[2], Varad Kadam[1], Abhishek Dagade[1]
[1]Don Bosco Institute of Technology (DBIT), Mumbai - 400070, India
[2]Indian Institute of Technology (IIT) Bombay, Mumbai - 400076, India
*420dixita0041@dbit.in

Abstract Additive Manufacturing (AM) has revolutionized manufacturing by offering the capability to create intricate threedimensional objects in a layer-by-layer fashion, enabling the production of complex parts that were once challenging to manufacture using traditional methods, and hence, has widespread applications across diverse industries. AM also provides unique advantages such as customization, topology optimization, multi-material integration, and the fabrication of complex geometries, making it a transformative force in manufacturing. This research delves into the integration of metal threaded inserts into AM fabricated thermoplastic parts, addressing the challenges and opportunities of metalpolymer joints. Threaded inserts play a crucial role in creating robust connections between metal and plastic, leveraging the strengths of each material. The study investigates various insertion techniques and the impact of heat addition

during installation. Findings reveal that the addition of heat during insertion significantly enhances joint strength, surpassing the performance of pre-designed threads. Surface texture, including knurling and grooves, is shown to influence holding strength, crucial for the reliability of these connections. The research underscores the importance of threaded inserts in metal-polymer joints, offering insights into their optimal usage in AM applications. Future directions involve exploring the influence of infill density on joint performance and investigating alternative geometric orientations for enhanced interlocking tendencies. These findings contribute to the design and manufacturing of robust metal-polymer joints in AM, enhancing their applicability across industries.

Keywords: Additive Manufacturing (AM), Threaded Inserts, Experimental Investigation, Joint Strength, PLA.

Paper ID #137

Effect of Layer Thickness on Tensile Properties for Alumina Particle Reinforced Polymer Composite Using 3D-Printing

Annada Prasad Moharana*, Ratnesh Raj, Swapnil Kumar, Amit Rai Dixit
Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand, 826004, India
*amitraidixit@iitism.ac.in

Abstract. Vat-photopolymerization (VPP) is a photo-curing-based additive manufacturing (AM) technology for generating nano-particle-reinforced photopolymer composites. It can also produce specimens with greater geometrical precision and a decent surface appearance. This study uses VPP based on Digital Light Processing (DLP) technique to fabricate the photopolymer composites and analyze mechanical properties. As a nanofiller, Alumina was added to the photopolymer at a concentration of 1 wt. % and the test pieces were printed at four different layer thicknesses, namely 35, 50, 75, and 100 µm. To illustrate the effect of alumina nanoparticle fillers in the neat photopolymer at varied layer thicknesses, tensile strength, and Young's modulus values were analyzed. It was discovered that thinner layers offered more tensile strength and Young's Modulus. This impact was even more substantial in the alumina/photopolymer composite specimen. Furthermore, using alumina nanoparticles improved the composite's yield strength and Young's Modulus.

Keywords: Vat-photopolymerization, alumina nanoparticles, tensile characterization.

Paper ID #138

A Systematic Review on 4-Dimensional Printing for the Exploration of the Material Structures via Stimulus-Response

Pankaj Kumar[1*], Santosha Kumar Dwivedy[1*], Subham Banerjee[2*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Guwahati
Assam, 781039, India.
[2]Department of Pharmaceutics, National Institute of Pharmaceutical Education and Research Guwahati, Assam 781101, India
*kumar174103134@iitg.ac.in

Abstract. The emergence of four-dimensional printing (4DP) is being fueled by improvements in 3D printed smart materials. The form recovery capabilities of the smart structure can be effectively enhanced by merging stimuli sensitive materials and their functionality into a single printed build. In the literature, three different forms of multi-material constructions are described: those with uniform distribution, gradient distribution, and unique patterns. When activated by outside stimuli like heat, water, or pressure, smart materials have the singular ability to change their shape and characteristics. In order to create 4D smart structures, three-dimensional printing (3DP) technology is utilized. An overview of existing smart material architectures, various types of stimuli, and 3DP technologies are provided in this article.

Keywords: 4-Dimensional Printing, Smart material, Stimuli-responsive materials, Shape recovery.

Paper ID #139

Experimental Investigations on Tool Wear Analysis in Dry Machining of KhN67VMTYu Super Alloy

Allan George[1*], Jayaram C Sasi[1], P B Dhanish[1], Jose Mather[1], Basil Kuriachen[1], Anoop C R[2], George Oommen[3]
[1]Advanced Manufacturing Centre, Department of Mechanical Engineering, National Institute of Technology Calicut, Kerala, Pin: 673601, India
[2]Control System and Components Entity, Liquid Propulsion Systems Centre, Indian Space Research Organisation, Kerala, India
[3]Materials and Manufacturing Entity, Liquid Propulsion Systems Centre, Indian Space Research Organisation, Kerala, India
*allangeorge361@gmail.com

Abstract. KhN67VMTYu is a Nickel based superalloy that finds immense usage in aerospace applications owing to its excellent hardness, strength and wear resistance. However, minimal thermal conductivity and severe work hardening nature makes it extremely difficult to machine which results in severe tool wear issues like chipping and catastrophic failures. Only limited studies have been carried out in the machining aspects area of this alloy as it is used only for very specific applications like manufacture of critical sub-assemblies of turbine, oxidiser and fuel pumps in aerospace vehicles. Hence this study is an effort to identify the significance of machining parameters like speed, feed rate and depth of cut on the overall tool life using a full factorial design. It was observed that apart from speed, feed and depth of cut parameters, the combination of feed and depth of cut parameter had a substantial influence on tool wear progression. Moreover, the tools machined at lowest parametric combinations were observed to have experienced tool failure after 13.5 minutes of machining time while it failed after just 2 minutes due to catastrophic wear when machined at highest parametric conditions of speed, feed and depth of cut values. Severe chipping and crater face depressions across the tool cutting edges at higher parametric conditions contributed severely towards the catastrophic tool failure mechanisms.
Keywords: KhN67VMTYu, turning, wear progression, tool life, chipping.

Paper ID #142

An Experimental Effort Implemented over CVD Tisin Thin Film Coating to Improve Mechanical and Corrosion Properties by Annealing

Spandan Guha[1*], Soham Das[2]
[1]School of Mechanical Engineering, KIIT University, Bhubaneswar, Odisha, India-751024
[2]Department of Mechanical Engineering, Sikkim Manipal Institute of Technology, Sikkim, India-737136
*spandan.guha@yahoo.com

Abstract. In this experimental investigation TiSiN thin film coating has been deposited over p-type cubic-Si (100) wafer through chemical route (chemical vapor deposition-CVD) method in presence of N_2 gas and followed by annealing at 800°C for 4 hours. The synthesis is carried out using TiO_2 and Si_3N_4 (mixed in a crucible rectangular bowl) powders. The deposition was carried at 600°C temperatures. The morphological analysis has suggested that the film's porosity reduced significantly after annealing. The corrosion property of annealed thin film has been improved significantly. The structural property has also been analysed by the XRD process and hardly any other phases from annealed TiSiN thin film compared to deposited TiSiN thin film coating. In the mechanical property analysis of deposited and annealed coating slight changes have been observed in between.
Keywords: TiSiN, CVD, Annealing.

Paper ID #143

Cyclic Oxidation Behavior of Free-Standing Plasma Sprayed Al_2O_3 - Cr_2O_3 Coatings at 1000 ℃ Temperature

Setu Suman[1*], Kazi Sabiruddin[2*]
[1, 2]Department of Mechanical Engineering, Indian Institute of Technology Indore
*skazi@iiti.ac.in

Abstract. This paper investigates the cyclic oxidation behavior of free-standing atmospheric plasma sprayed (APS) Al_2O_3 - Cr_2O_3 coatings deposited by spraying Al_2O_3 - Cr_2O_3 powder mixture with variable Cr_2O_3 content (2 - 6 wt.%) in the feedstock. Oxidation tests are performed up to 50 cycles at 1000 ℃ temperature in a muffle furnace at normal atmosphere. After each oxidation cycle, weight gain of the coatings is measured, and a weight gain plot is obtained with varying cycles. The microstructure and the formation of cracks in the coatings are studied by using scanning electron microscopy (SEM) technique. The different Phases formed in the coatings are analyzed by X-ray diffractometry (XRD). The porosity and the length of crack are estimated by image analysis (Image J) technique. The hardness of the coatings is measured by using Vickers microhardness tester. It is noticed that the weight gain of the coatings is not very significant under the oxidation tests. Even after 50 cycles of oxidation the free-standing coatings are found to be intact without any fragmentation. With an increase in Cr_2O_3 content the oxidation resistance of the coating is found to be reduced. However, at higher cycles in general, the crack length is found to be decreased with an increase in Cr_2O_3 content. Porosity is increased with an increase in the heating cycle. The lowest porosity is observed in the coating with 4 wt.% Cr_2O_3 due to the formation of Al_2O_3 - Cr_2O_3 solid-solution in the as-sprayed coating as noticed in our previous study.
Keywords: Oxidation test, free-standing coating, Al_2O_3 - Cr_2O_3, plasma spraying, SEM, XRD.

Paper ID #144

Unravelling the Processing Parameters for Selective Positioning of Multi-Materials using Laser Decal Transfer based μ-3D Printing

Arpit Kumar Singh[1*], Anshu Sahu[1], K.A. Vyvaswath[1], Kailaash Pandiyan[1],
Palani IyamperumalAnand[1]
[1]Mechatronics and Instrumentation Engineering Lab, Indian Institute of Technology, Indore
*palaniia@iiti.ac.in

Abstract. 3D printing or Additive manufacturing has gained its popularity due to its high design freedom, material freedom, and high degree of complexity. Most of the 3D printing process used wire or powder as raw materials which restrict the further usage of this technology from end applications. With advancement in technologies, a thin film-based laser micro 3D printing is used for the printing of thin film Laser decal transfer can be deployed for transfer of thin film over substrates are possible making it substrate independent. This work focusses on detailed investigation on selective positioning of ZnO ceramic over NiTi interdigitated structure over a thin film of ITO coated over glass using Laser decal transfer technique. A CO_2 laser (λ=10.6 μm) is utilized in the proposed work where detailed investigation in performed on laser processing parameters for effective control over ZnO transfer and its further selective positioning which includes influence of laser fluence and standoff distance is analyzed. Laser pulse overlap has greater effect on formation of heat affected zone and effective material transfer and is analyzed in detail as well.Finally, based on optimized parameters, the capability of selectively controlling and transferring ceramic over metal and sandwiching multiple materials over each other is analyzed.The proposed technology of laser micro-3D printing using novel principle of laser decal transfer would pose greater advantages in complex sensors fabrications with controlled gradient based properties.
Keywords: laser-decal transfer, ZnO Selective positioning, multi-material printing.

Paper ID #145

Implementation of Autonomation and Value Stream Mapping for Productivity Improvement

A. H. Prashanth[1*], Ishwar Bhiradi [2]
[1]Department of Mechatronics, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal 576 104, Karnataka, India
[2]Department of Mechatronics, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal 576 104, Karnataka, India
*ishwar.bhiradi@manipal.edu

Abstract. In the present scenario, every industry is trying to achieve higher productivity due to competitiveness and rigorous regulations by governing bodies towards sustainable development. In a nutshell, productivity is defined as the ratio of output to input. It is possible to achieve by improving the correct things and cultivating them into a habitual routine. Productivity can be improved by regular review of the existing practices, evaluating, and adopting better methods such as lean manufacturing. There are multiple ways by which non-value-added expenditures will be involved in typical manufacturing industries which reduces productivity. The lean manufacturing method mainly helps in identifying such wastes, thereby improving productivity. Kanban, 5S, Kaizen, just-in-time production are all some of well-known lean tools in competitive industry work culture. Similarly, there are two more recent techniques value stream mapping an autonomation gaining popularity due to cost effectiveness and maximum throughput. In the present work, authors have presented the practical approach to implement hybrid value stream mapping and autonomation concept in batch-type of production system at ABC Cranes Pvt. Ltd. India. The study is conducted on a production line dedicated for machining differential housing. The work consists of developing a current state map to understand the existing opportunities to improve the productivity and based on findings two solutions are developed. As per SOP of value stream mapping, implementing future state map has reduced the inventory by 19.2% and change over time by 44.4%. And while analyzing future state map it is observed that quality inspection process is consuming a cycle time of 14.3 min. To reduce this non-value-added time, a novel technique of implementing autonomation concept into future state map is adopted. The tangible benefits received are reduction in cycle time by 34.4 %, lead time by 25.9 % and change over time by 66.7%.
Keywords: Autonomation, Lean Manufacturing, Productivity, Sustainable Development, Value Stream Mapping.

Paper ID #146

A Study of Residual Stress Generation for various Tool Profiles when Machining Steel with Ultrasonic Vibration Assisted Machining

Pranesh Dutta[1*], Gaurav Bartarya[1*]
[1]School of Mechanical Sciences, Indian Institute of Technology Bhubaneswar, Odisha, 752050, India
*bartarya@iitbbs.ac.in

Abstract. The residual stress generation in turned components is an essential factor for the longevity of the finished product under fatigue loading. During machining operations, mechanical and thermal loads mainly generate residual stresses in machined parts. Thermal loads affect the residual stress severely and cause it to be more tensile in nature. Vibration Assisted Turning (VAT) can help to reduce thermal loads during machining. In VAT, the tool has a relative motion of constant engagement and disengagement with the workpiece at a very high frequency, thus providing a cooling cycle for the tool and workpiece in between successive tool engagements. It helps in reducing thermal loads in the machining zone. It also generates a favorable residual stress profile underneath the finished surface which is compressive in nature, thereby improving the usable life of the components under fatigue loading. The current work emphasizes developing a 2D

FE thermo-mechanical model to predict residual stress in conventional and VAT experiments. The model helps to understand the effect of variation in tool vibration amplitude, flank wear, and cutting-edge radius, on workpiece residual stress profiles in the VAT experiment. The residual stress profile predicted for VAT simulations for predefined flank wear was found to be more compressive on the surface and in the subsurface region, which would improve the machined component's life under cyclic loading. The results showed that a worn tool with VAT may produce similar results that a new edge tool would produce in conventional machining thereby increasing the productivity of a cutting tool.
Keywords: Vibration Assisted Machining; FEM; Machining simulation; Residual Stress; Tool geometry.

Paper ID #147

Vision-Based Runout Measurement Method for End Mills

Naman Verma[1*], Pankaj Wahi[2] and Mohit Law[1*]
[1]Machine Tool Dynamics Laboratory, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur - 208016, India
[2]Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur - 208016, India
*mlaw@iitk.ac.in

Abstract. Radial runout in milling arises from the misalignment between the geometric axis of the cutter and its axis of rotation when it is mounted in the machine's spindle with a holder. Runout results in the chip thickness distribution for every tooth being different. Since forces in the milling process are a direct function of the chip thickness distribution, a change in this distribution due to runout also loads every tooth differently. Moreover, since the stability of the cutting process is also governed by the dynamic chip thickness, runout also affects stability. Since runout can cause premature damage to the tool and destabilize an otherwise stable process, it is necessary to measure it. Traditional methods rely on using a dial gauge. However, this method cannot be used to measure speed-dependent dynamic runout, which necessitates the use of non-contact methods. This paper introduces the use of a new vision-based method to measure static and dynamic runout. The central idea is to track the edge of each tooth as it rotates using an edge detection and tracking scheme applied on individual frames of a video recording of the rotating tool. The proposed method is benchmarked with dial gauge measurements for the static case and measurements made with a laser displacement sensor for the speed-dependent case. Measured runout is incorporated in force and stability models to show its influence on cutting forces and stability of a representative end milling process.
Keywords: Runout, Vision, Milling, Cutting forces, Stability.

Paper ID #148

Magnetorheological Ultra-Fine Finishing on the 3D Surface of K9 Optical Glass

Ajay Berry[1*], Anant Kumar Singh[2*], Vinod Mishra[3]
[1,2]Thapar Institute of Engineering and Technology, Patiala - 147001, India
[3]Central Scientific Instruments Organization (CSIO), Chandigarh- 160030, India
*anantsingh@thapar.edu

Abstract. K9 is a high-quality crown glass that can be used in various optical applications due to its very low inclusion content and bubble-free structure. Surface polishing is a promising technique to improve the optical performance of K9 glass by reducing the surface roughness value. Magnetorheological (MR) finishing of optical glasses utilizing MR fluid surpasses traditional finishing techniques in precision and accuracy. Also, the majority of earlier surface finishing work was carried out on flat glass surfaces. The present research focuses on ultra-fine finishing of the 3D

surface of K9 glass workpieces to enhance their optical performance by reducing the surface roughness value. MR finishing process utilizing an MR polishing fluid to improve the surface finish of K9 glass. The optical profilometer measures the surface roughness parameters and topography image of K9 glass before and after 90 minutes of the MR finishing process. The surface area roughness (Sa) values decreased from 38.38 nm to 12.55 nm. The root means square height (Sq) reduced from 56.76 nm to 21.28 nm. Scanning electron microscopy (SEM) is used to investigate the surface morphology of K9 glass before and after MR finishing. The significant improvement in surface roughness parameters that enhance the optical performance of K9 glass is also suitable for optical applications such as microscopy and binoculars.
Keywords: K9 glass, magnetorheological finishing, surface roughness, optical performance.

Paper ID #149

Machinability Analysis in Wire-EDM of Cryogenically Treated Ti6Al4V Alloy

Suryansh Singh[1*], Yatin Jiyani[1], Mithilesh K. Dikshit[1,2,3]*

[1]Department of Mechanical and Aerospace Engineering, Institute of Infrastructure Technology Research and Management (IITRAM), Ahmedabad-380026, India

[2]Advanced Material Processing and Characterization, CADT, IITRAM Ahmedabad-380026, India

[3]Center for Aerospace and Defence, IITRAM, Ahmedabad-380026, India

*dixit.mithilesh@gmail.com

Abstract. Machining of (Ti6Al4V) is quite difficult using the traditional machining techniques due to several reasons such as low thermal conductivity, high cutting forces, and higher tool wear. This could result in substantial heat generation at the machining zone and catastrophic cutting tool failure. The machinability of Ti6Al4V alloy is not adequate when machined using the electrical discharge machining (EDM) due to the high electrical resistivity. Another method to enhance the machinability of Ti6Al4V alloy is the cryogenic treatment. Cryogenic treatment (CT) of Ti6Al4V alloy also enhances the corrosion and wear resistance. Therefore, in the present research Wire-EDM was used to machine cryogenically treated and untreated Ti6Al4V alloys. Rotary central composite design (RCCD), an approach based on response surface methodology (RSM), was used for designing the experiments. Quadratic models were adopted for material removal rate (MRR) using discharge current (*I*), Wire speed (*WS*), and Duty cycle (*DC*) as independent input factors. Discharge current was the most influencing WEDM factor for MRR_CT (CT: cryogenically treated) with a percentage contribution of 58.04%. *DC* was the second most influencing factor accounting for 20.28%. In square terms, *I* had the highest contribution of 0.61%. Similarly, for MRR_UT (UT: untreated) *I* and *WS* have the contribution of 28.83% and 11.43% respectively. In square terms, *I* had the maximum contribution of 52.34%.
Keywords: RCCD, RSM, Wire-EDM, MRR.

Paper ID #150

Influence of Retrogression and Reaging Treatments on the Electrochemical Corrosion Behavior of AA2014/Al_2O_3 Nanocomposites

A. Gnanavelbabu*, E. Vinothkumar, M. Prahadeeswaran

Department of Industrial Engineering, CEG Campus, Anna University

Chennai-600025, India

*dr.agbabu@gmail.com

Abstract. This study examined the electrochemical corrosion behavior of AA2014 Aluminium (Al) alloy reinforced with 1-4 weight percentage (wt.%) of nano Al_2O_3 particles. The materials were fabricated by a stir-ultrasonic-squeeze casting technique. Afterward, T6 and retrogression-re-aging

(RRA) heat treatments are applied to the samples. RRA involves retrogression at temperatures of 200, 220, 240, and 260 °C for 15, 30, 45, and 60 minutes, followed by re-aging at 165 °C for 14 hours. The material's microstructure, density, porosity, and hardness were examined as per the ASTM standards. The dispersion of nanoparticles and the presence of intermetallic phases on the Al matrix were analyzed using High Resolution-Scanning Electron Microscopy (HR-SEM), and X-Ray Diffraction (XRD) techniques. The hardness of the fabricated AA2014/1 wt.% Al_2O_3 (A1), AA2014/2 wt.% Al_2O_3 (A2), AA2014/3 wt.% Al_2O_3 (A3) and AA2014/4 wt.% Al_2O_3 (A4) nanocomposites was increased by 1.21%, 13.17%, 6.47% and 5.18% than as-cast alloy at 220 ^{o}C for 30 minutes (RRA 2) retrogression process due to the existence of a large amount of Grain Precipitates (GP) and η' phase, both of which strengthen the matrix. The Nyquist plot results showed that the A2 composite had a higher arc diameter than other materials, and the arc diameter decreased in the following sequence: A2 > A3 > A4 > A1> A0. The Tafel plot also revealed that sample A2 at RRA 2 heat treatment condition exhibited higher corrosion potential (E_{corr}) (-0.628 V) and lower corrosion current (I_{corr}) (1.646×10^{-9} A/cm^2) and lower corrosion rate (0.001 mm/yr.) than other fabricated materials because of the occurrence of re-precipitated η' phase and thick η phase, act as a shielding layer and minimize the chlorine ion attack on the metal. The SEM images of corroded samples showed crevice corrosion and small pit formation at all heat-treated conditions.
Keywords: Nano-composites, Retrogression, Reaging, Electrochemical Corrosion, AA2014.

Paper ID #151

Application of Machine Learning Techniques in Ecological Grinding of Inconel 718

Manoj Kumar Sinha[1*] and Kamal Kishore[2]
[1]Department of Mechanical Engineering, NIT Kurukshetra – 136119, India
[2]Department of Mechanical Engineering, NIT Hamirpur – 177005
*mksinha@nitkkr.ac.in

Abstract. The demand for superalloy has surged rapidly in almost all sectors, especially for Inconel 718. But properties like high hot strength, hardness, high corrosion resistance and severe strain hardening make it difficult to machine/grind material. The grinding process has a dynamic nature. It has various input parameters that substantially affect the quality of the manufactured product. Apart from the input parameters, the quality of the end product is also influenced by the nature of the grinding environment and material properties. Hence, it is crucial to develop models in the grinding process that can predict the nature of output associated with the given input. Currently, the machine learning (ML) technique and artificial intelligence are widely incorporated in manufacturing to predict the nature of the end product. Therefore, the current study aims to develop and compare ML models for predicting the nature of grinding forces and surface roughness under dry and minimum quantity lubrication (MQL) conditions. The central composite design has been employed to determine the experimental runs for experiments. The support vector machine (SVM) and multilayer perceptron models have been developed for each grinding condition. The performance of both models has been compared based on coefficient of determination, mean absolute error and root mean square error. The study results have shown that the suitability and performance of the SVM model outperformed the MLP model in almost every case. Further, scanning electron microscopy has also been used to investigate the surface morphology of the ground surfaces obtained in each condition.
Keywords: Grinding, Inconel 718, Machine learning techniques, Support vector machine.

Paper ID #152

Investigation of Fabricating Stainless Steel 304L Thin Wall Structure using Laser Marking Assisted Wire Arc Additive Manufacturing Process

Geethapriyan Thangamani[1*], Kailaash Pandiyan C[2], Sayan Doloi[3], Ashwin Wagh[4]
Krishnapal Tomar[5], Palani Iyamperumal Anand[6]
[1]Department of Applied Science and Technology (DISAT), Politecnico Di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy
[2,3,4,5,6]Mechatronics and Instrumentation Laboratory, Department of Mechanical Engineering, Indian Institute of Technology Indore, Indore-453552, India
*devimani.priyan18@gmail.com

Abstract. In this present study, the stainless steel 304L thin wall structure has been fabricated using a laser marking-assisted wire-arc-based additive manufacturing process to study the influence of the number of laser passes (50, 100 and 150 nos.) on microstructure and macrostructure such as surface roughness, depth, wall width and wall height. Laser texturing (Pre-processing treatment) was utilized to modify the surface for enhancement of microstructure and macrostructure on WAAM-fabricated SS304L thin wall structure. From the experimental results, it has been found that the average surface roughness of laser texturing surface with three different numbers of laser passes such as the 50, 100 and 150 nos., are 44.84, 28.62 and 20.45 µm has better than the without treated wire arc additive manufactured SS304L sample. In addition, the depth of laser marked with WAAM fabricated SS304L sample was increased and improved surface energy than without laser marked WAAM sample. Therefore, a uniform and thin wall structure was produced in the pre-processing treatment with an increasing number of passes. Finally, the microstructure was analyzed using an optical microscope.

Keywords: WAAM, Laser marking, SS304L, Surface Roughness, depth, wall thickness and wall height.

Paper ID #153

The Impact of Inorganic Fillers on the Static and Dynamic Mechanical Properties of Polyester Resin Composites

Shania Zehra Naqvi[1*], Janakarajan Ramkumar[2, 3], Kamal K. Kar[1, 2*]
[1]Advanced Nanoengineering Materials Laboratory, Materials Science Programme, Indian Institute of Technology, Kanpur, 208016, India
[2]Department of Mechanical Engineering, Indian Institute of Technology, Kanpur, 208016, India
[3]Department of Design, Indian Institute of Technology, Kanpur, 208016, India
*kamalkk@iitk.ac.in

Abstract. This study aimed to examine the static and dynamic mechanical characteristics of polyester resin when incorporating various fillers, namely china clay, calcite, and precipitated silica, at weight percentages of 5 and 10. The addition of inorganic fillers led to enhanced tensile and flexural characteristics of the composite material. Composite's performance was superior to that of pure polyester resin when subjected to dynamic mechanical conditions. The composite's storage modulus demonstrated elevated values compared to the pristine resin's storage modulus. The improved interfacial adhesion between the matrix and the filler led to a notable increase in the glass transition temperature (Tg), causing it to shift towards higher temperatures. The damping factor, tan δ, demonstrated a greater magnitude in the pure resin due to insufficient heat dissipation. Nevertheless, when fillers were added, the composites exhibited a decrease in peak height or tan δ value.

Keywords: Polymer composite, Inorganic fillers, Dynamic mechanical thermal analysis.

Paper ID #154

Analyzing the Influence of Alloying Elements on the Tribocorrosion Behavior of AZ91D Magnesium Alloy Fabricated by Stir-Ultrasonication-Squeeze Casting

A. Gnanavelbabu*, M. Prahadeeswaran, E. Vinothkumar
Department of Industrial Engineering, CEG Campus, Anna University
Chennai - 600 025, India.
*dr.agbabu@gmail.com

Abstract. This study investigates the influence of alloying elements on the tribocorrosion behaviour of AZ91D Magnesium (Mg) alloy. For fabricating AZ91D Mg alloy and proposed composites a stir- ultrasonication- squeeze casting technique was used and subsequently a heat-treatment process was performed on the materials in an argon gas environment. The distribution of reinforcing particles within the matrix was evaluated using an Optical Microscope (OM) and Scanning Electron Microscope (SEM), while X-Ray Diffraction (XRD) confirmed the presence of reinforcements and development of intermetallic phases like Mg_3Bi_2, Mg_3Sb_2, and Al_4Sr. The composite's physical, mechanical, and corrosion characteristics were analyzed according to ASTM standards. Compared to the AZD alloy, the fabricated AZ91D/1 wt.% Bi (ABi), AZ91D/1 wt.% Sb (ASb), and AZ91D/1 wt.% Sr (ASr) composites exhibited increased hardness by 9.47%, 5.13%, and 12.84%, respectively. Tensile properties similarly improved by 37.90%, 15.60%, and 43.42% for the fabricated composites compared to AZD. Tribocorrosion tests were carried out in a linear reciprocating tribometer with 3.5% NaCl concentration at various exposure durations of 10, 15, 20, and 25 minutes. Corrosion test results indicated that ASr composite displayed superior corrosion resistance, minimal coefficient of friction (COF) (0.20), and reduced potential drop (-0.6 to -0.8 V) at 15 minutes. This was attributed to the presence of β-$Mg_{17}Al_{12}$ which acts as a passive layer and reduces wear and corrosion. Nyquist plot data showcased ASr composites with larger arc diameters, followed by ABi, ASb, and AZD. Tafel plot demonstrated higher corrosion potential (E_{corr}) (-0.1446 V) and lower corrosion current (I_{corr}) (-3.48×10^{-6} A/cm²) for ASr composite due to protective Al_4Sr precipitates, guarding against wear and Cl^- rich environments during tribocorrosion testing. SEM images revealed corrosion pit and crack formation in samples.
Keywords: Mg alloy, alloying element, Tribocorrosion, Open circuit polarization, Tafel Plot.

Paper ID #155

Mechanical Strength and Shrinkage Investigation of Fused Filament Fabricated H13 Die Steel

Subham Kumar Pandey[1*], Deepak Kumar[1], Suryank Dwivedi[1], Amit Rai Dixit[1]
[1]Indian Institute of Technology (Indian School of Mines) Dhanbad-826004, India
*amitraidixit@iitism.ac.in

Abstract. Fused filament fabrication (FFF) can offer an effective, simple, and economical approach for fabricating metal components as compared to powder bed fusion and conventional manufacturing processes. The FFF process employs filament, consisting of a homogenous mixture of metal and polymers-based binders. In this study, H13 filament was employed as a feedstock material, which comprised 90% by weight H13 and 10% by weight of a binder system. The objective of this study is to investigate shrinkage analysis and the mechanical performance of parts fabricated through the FFF technique, utilizing various infill patterns. All printed sample shows an isotropic shrinkage of about 17% after thermal de-binding and sintering. Sintering enables the removal of the binder from the green parts and, also reduces the surface roughness by 6 µm. During the compressive test, the yielding of the sample did not occur, but instead, a barreling effect was observed. The maximum stress encountered during the compressive test was 685Mpa, 575.41Mpa, and 671.5Mpa for gyroid, rectilinear, and triangular, respectively. Whereas the ultimate tensile strength of the gyroid, rectilinear, and triangular were found to be 609.48 MPa, 603.92 MPa, and

591.24 MPa, respectively. The relatively low tensile properties can be attributed to manufacturing defects present in the gauge region, specifically voids and porosity.

Keywords: Fuse Filament Fabrication (FFF), HI3 Steel, Mechanical characterization.

Paper ID #156

Single Point Incremental Forming of CRCA-Tailor welded sheets

Yogesh Kumar Dewangan[1*], Ritesh Banjare[1], Kaushik Banyopadhyay[1]
[1]Indian Institute of Technology Bhilai, 491001, Durg, Chhattisgarh, India
*kausik@iitbhilai.ac.in

Abstract. The requirement of increased strength with reduced weight in the automotive industry has given the opportunity to the researchers to develop/design new materials and structures. Tailor welded blanks (TWB) is one of the promising manufacturing strategies to meet such conflicting requirements. In the present study, TWB of CRCA steel with different thickness combination was fabricated using laser welding technique. An assessment of the weld quality was done using metallographic studies and tensile test. Ductility of the welded joint was found to be reduced maximum by 83% and the hardness was increased to 133% in comparison to the base metal. An attempt was made to form a D shape geometry by performing single point incremental forming (SPIF) on TWB. Reduced formability and no weldline movement were the main observations made from this study.

Keywords: Tailor welded blank, Incremental forming, formability, metallograph.

Paper ID #157

Design and Analysis of a New Magnetorheological Worm Gear Type Finishing Process for Improved Productivity

Shubham Khatri[1*], Jagjeet Singh[2], Anant Kumar Singh[3*]
[1,2,3]Department of Mechanical Engineering, Thapar Institute of Engineering and Technology, Patiala 147004, India
*anantsingh@thapar.edu

Abstract. Achieving precise gear tooth profiles greatly influences the quality of products in gear manufacturing, playing a pivotal role in the industry. In extremely precise manufacturing processes, laboratory equipment, aircraft, and defence-related devices use precisely finished gears. The shaped precision of the finished gear tooth directly impacts its performance. The 14-tooth EN24 spur gear is surface-finished using an innovative magnetorheological worm gear profile finishing (MRWGPF) tool. The newly designed MRWGPF tool is capable of finishing all gear tooth profiles in a continuous cycle. Hardened EN24 material finds significant utility in various industrial applications, particularly in the manufacturing of gears such as spur, bevel, and helical gears. The surface profilometer SJ400 is used to analyze the reduction of roughness parameters (Ra, Rq, and Rz) of spur gear. The surface morphology analysis is conducted to observe and make comparisons of the actual and finished surfaces of the EN24 gear profile. The current magnetorheological finishing (MRF) procedure is successful in removing grinding burns and all surface defects from the initial surface of the gear. The parameters roughness are reduced from Ra = 0.97 μm, Rq = 1.20 μm, Rz = 5.3 μm to Ra = 0.07 μm, Rq = 0.10 μm, Rz = 0.6 μm after 60 minutes. This can enhance the profile's life and reliability. This might potentially lead to an enhancement in the gear profile's performance. It may reduce noise, vibrations, and wear rate, as well as friction and temperature during the operation at high speed.

Keywords: Gear profile, MRWGPF tool, hardened EN24 spur gear, MR finishing, surface roughness.

Paper ID #158

Prediction of Bending Angle of Ti6Al4V Alloy Sheets Formed Using Multiple Laser Irradiations

Sujit Mulay[1*], Vineet Paliwal[2], N. Ramesh Babu[3*]
[1]Assistant Professor, Pimpri Chinchwad College of Engineering Pune - 411044, India
[2] Research Engineer, Advanced Manufacturing Technology Development Centre, Chennai - 60036, India
[3]Professor, Mechanical Engineering Department, Indian Institute of Technology Madras
Chennai – 600036, India
*nrbabu@iitm.ac.in

Abstract. This study proposes a model to predict the bending angle of Ti6Al4V alloy sheets formed using multiple laser irradiations. The model uses the 1D heat transfer equation to calculate the temperature along the sheet thickness direction by considering the conductive losses. Based on this temperature, the thermal strains and stresses induced along the sheet's thickness are estimated. Finally, the bending angle of the sheet is calculated by balancing the strain energies induced by stress, strain, and the bending moment. For the subsequent irradiations, the temperature-dependent properties of Ti6Al4V alloy were updated based on the initial temperature of sheet. The experimental and predicted bending angle results were compared for Ti6Al4V alloy sheets of varying thicknesses. The proposed model predicts the bending angle with an average percentage error of 8.86% for 2 mm thick Ti6Al4V alloy sheet.

Keywords: Laser bending; Strain energy; Bend angle; Temperature gradient mechanism; Ti6Al4V alloy sheet; Bending moment.

Paper ID #159

The Evaluation of Mechanical and Magnetic Properties of Hot Die Steel after Sustainable Grinding using Barkhausen Emission Technique

Akash Awale[1*], Vikas Diwakar[2], Ashwani Sharma[2], Mohd Zaheer Khan Yusufzai[2],
Meghanshu Vashista[2]
[1]Department of Production and Industrial Engineering, National Institute of Technology Jamshedpur, Jamshedpur-831014, India.
[2]Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi, Varanasi-221005, India
*akashawale.prod@nitjsr.ac.in

Abstract. In the tooling industries, AISI H13 die steel offers enormous opportunities in dies manufacturing owing to their outstanding thermo-mechanical properties. Unfortunately, their low thermal conductivity causes various challenges one of the grinding burn. Besides, non-destructive finished surface characterization is important consideration from an economical, faster, and in-line quality assurance perspective. Such a serious issue was tackled by sustainable grinding with non-destructive characterization. The objective of the current investigation is to assess grinding burn regions of ground surface using micro-magnetic Barkhausen noise (MBN) signal after minimum quantity lubrication (MQL) grinding. The MQL grinding was performed at downfeed 32 µm with MQL- castor oil, MQL- CO+DIW emulsion, and MQL-Al_2O_3 NFs and compared with traditional grinding i.e., wet and dry. Negligible grinding burn effect was found in ground sample, which provides lower roughness, no oxidation of microchip, minor microstructural and hardness variation under MQL-Al_2O_3 NFs. The MBN results like root mean square was established a linear trend with microhardness and its correlation coefficient of 0.989. Furthermore, smaller amplitude and broad peaks were moved towards stronger magnetic field in the MQL-Al_2O_3 NFs grinding.

Keywords: AISI H13 die steel; sustainable grinding; thermal damage; ecofriendly lubricants; micro-magnetic Barkhausen noise.

Paper ID #160

Study of cutting performance of micro drilling of Ti-6Al-4V under different cutting parameter and MQL flow rates

Ashok Kumar 1, Soumya Gangopadhyay2, Purnendu Das3*
1 2 3 Indian Institute of Technology Bhilai, Durg – 491001, India
*purnendu@iitbhilai.ac.in

Abstract. The micromachining of Ti-based alloys, entails several limitations, including tool wear and the risk of catastrophic tool breakage. These issues emerge mostly owing to the small diameter of the micro tool that is used for the machining process. Therefore, this study aims to enhance tool longevity and surface integrity by minimum quantity lubrication (MQL) with varying flow rate with uncoated tungsten carbide (WC) microdrill. UNILUB-2032, a commercial cutting fluid, was utilized throughout the experiments. In order to determine the oversize error & tool wear were analyzed under electron microscopy and energy dispersive X-ray spectroscopy (EDS). Effect of the use MQL-mode of lubrication on machining has been envisaged via micro drilling.
Keywords: Micro drilling, Ti-6Al-4V, MQL, UNILUB-2032

Paper ID #161

Modeling Chip Thickness Ratio and Shear Angle using Hybrid Nanofluids while Machining Inconel 718 under Minimum Quantity Lubrication

Paresh Kulkarni[1*], Satish Chinchanikar[2], Maheshwar Jaybhaye[3]
[1]Vishwakarma Institute of Information Technology and Dr. D.Y. Patil Institute of Engineering, Management, and Research, Pune, Maharashtra, 411048, India
[2]Vishwakarma Institute of Information Technology, Pune, Maharashtra, 411048, India
[3]COEP Technological University, Pune, Maharashtra, 411005, India
*paresh.219p0014@viit.ac.in

Abstract. Inconel 718, a nickel-based superalloy, due to its divergent solitary features, has a variety of applications. However, due to its intrinsic qualities such as high strength, hardness, poorer heat conductivity, and work hardening propensity, the cutting of this alloy is difficult. The most appropriate nanofluid was found using the technique for order preference by similarity to ideal solution (TOPSIS) analysis. Aluminum oxide and multi-wall carbon nanotubes, blended with palm oil, are found to be better options for machining. The study utilized a hybrid nanofluid to examine the shear angle and chip thickness ratio in turning Inconel 718 under minimal quantity lubrication (NFMQL). The chip thickness ratio and shear angle increased with cutting speed and decreased with an increase in feed and depth of cut. The chip thickness ratio and shear angle were predominantly affected by the depth of cut, followed by cutting speed and feed. The correlation coefficient found for the developed mathematical models is close to 0.9, showing that the developed models could be valid in forecasting the chip thickness ratio and shear angle within the parameters' chosen domain. The chip morphology study revealed that loosely coiled chips were produced, which enabled quick heat removal. SEM images showed clean breaking of chip edges with minimal microparticle deposition on the chip surface, owing to the excellent cooling and lubricating properties of the hybrid nanofluids.
Keywords: Chip thickness ratio, Shear angle, MQL, Inconel 718, Nanofluid.

Paper ID #162

Development of Micro-Featured Anti-Wetting Surfaces from Al-RGO Dispersed Polymer Composite

Priyaranjan Sahoo [1*], Nagesh D Patil [2], Purnendu Das [3*]
[1]MTech, Department of Mechanical Engineering, IIT Bhilai
[2]Assistant Professor, Department of Mechanical Engineering, IIT Bhilai
[3]Assistant Professor, Department of Mechanical Engineering, IIT Bhilai
*purnendu@iitbhilai.ac.in

Abstract. Focusing the promising applications of superhydrophobic surfaces, this paper investigates an ample array of research articles to unveil the underlying principles governing their remarkable non-wettability. Subsequent to revealing the principles behind surface's hydrophobicity, i.e., the presence of micro and nano scale surface morphology atop the surface coupled with remarkably low surface energy of the surface, this work presents an easy, cost-effective, and time-efficient methodology for the creation of highly hydrophobic and superhydrophobic surfaces. The strategy is focused to achieve micro and nano scale hierarchical morphologies in the topmost layer of a fabricated surface. The processing route utilizes reduced graphene oxide based hydrophobic micro particles, dispersed atop a coated polydimethylsiloxane (PDMS) layer, facilitates the secure adhesion of these dispersed hydrophobic micro-particles onto the polished aluminium plate. The fluidity of coated layer is a risk for existence of the particles atop the surface, to contribute in the surface morphology as the particles become submerged. Again, the extra solidity of polymer restricts the proper adherence of particles to the surface, to address both, a step of partial curing the polymer is introduced before dispersing the particles. As the degree of partial curing controls the liquidity of the polymer layer, the concentration of the particles on top of the same layer is also dependent on the parameters of partial curing, hence the wettability also. In the later part of this work, the variation of surface wettability is also investigated with partial curing duration for a specific coating condition with a fixed partial curing temperature, and a sweet point is found where the surface shows an equilibrium contact angle with water as high as 151°.
Keyword: Super hydrophobicity, wettability, PDMS, Graphene, curing.

Paper ID #163

Structural Behaviour of Reinforced Polymer through Fused Filament Fabrication

Akash Jain[1*], Bobby Tyagi[1], Abhishek Raj[1], Tapish Raj[1], Ankit Sahai[1], Rahul Swarup Sharma[1]
[1]3D Printing and Additive Manufacturing Lab, Department of Mechanical Engineering, Dayalbagh Educational Institute, Dayalbagh, Agra, Uttar Pradesh-282005, India
*akashjain@dei.ac.in

Abstract. Numerous process factors in fused filament fabrication influence the structural behaviour of the parts, which are going to be used in various industries as structural elements. Poly-lactic acid (PLA) has great potential since it is biodegradable as well as lightweight. However, it has not yet found widespread application due to its subpar structural behaviour. Adding reinforcement is one technique to improve its structural behaviour. In this investigation, the influences of nozzle diameter and infill pattern on the structural performance of the specimens of PLA reinforced with multi-walled carbon nanotubes are examined, especially their flexural, compressive, and impact behaviour. Experimental analysis was used to ascertain the reinforced polymer's impact, compressive, and flexural strength. Data collected during the testing of specimens was subjected to statistical analysis to determine the reliability of the experiment. The specimen's mechanism of fracture was studied with high-end microscopy. The experimental results showed that the highest compression and flexural strength were achieved for the nozzle diameter of 0.6mm and the rectilinear infill pattern, while impact strength was achieved for the nozzle diameter of 0.6mm and the honeycomb infill pattern. The material's significant strength-to-weight ratio, ability to degrade

naturally, and electrical characteristics render it crucial in a wide range of industries, including automotive, aerospace, biomedical, and electronics.
Keywords: Poly-lactic acid, multi-walled carbon nano tubes, nozzle diameter, infill pattern, flexural strength, impact strength, fused filament fabrication.

Paper ID #164

Investigating the Fatigue Behavior of 3D printed Continuous Carbon Fiber Reinforced Polymer (CFRP) Composites

Ankit Dhar Dubey*, Kishore Debnath
Department of Mechanical Engineering, National Institute of Technology, Meghalaya
Shillong - 793003, India
*p22me007@nitm.ac.in

Abstract. 3D printed carbon fiber-reinforced plastic (CFRP) has excellent qualities; yet there is a lack of study on the endurance of these parts, which makes their practical application challenging. In order to evaluate the performance of FDM-printed polymers for structural applications, understanding the underlying mechanism of fatigue is essential. However, comprehensive study on the fatigue behavior of FDM-printed polymeric materials is missing. In this study, we examine the fatigue characteristics of 3D-printed continuous fiber-reinforced Onyx composites. The experiments are conducted on composite samples fabricated using different sets of 3D printing parameters. In this study, a Markforged x7 FDM-based 3D printer is used to fabricate the composite specimen. Composites are fabricated using Markforged flagship material Onyx as the polymer matrix and Carbon fiber as the reinforcement material. Four different 3D printing parameters are used as varying input parameters for the fabrication of composite specimens namely (a) fiber orientation, (b) layup sequence, (c) infill density, and (d) infill geometry. For fatigue fracture testing, different fatigue loading such as 50%, 60%, and 70% of the ultimate tensile strength of the respective composite is applied and the fatigue life of each composite is evaluated. The study shows that triangle infill geometry, 50% infill density, 45^0fiber orientation, and concentrated stacking of carbon fiber is the optimal condition for fatigue performance.
Keywords: 3D printing, Onyx, Carbon fiber, FDM, Fatigue.

Paper ID #165

Fabrication of Composite Materials for Farm Equipment: A Review

Ekta Sharma[1*], Sanwal Singh Meena[1]
[1]Department of Farm Machinery and Power Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan
*ektagbpant@gmail.com

Abstract. Farmers have always used a number of tools in their daily lives, frequently for domestic and agricultural tasks. The majority of agricultural tools used in the 18th and 19th centuries were operated by hand or by animals. Around independence, new developments in tool and machinery designs were seen. Engineering materials known as composites are constructed from two or more constituent elements that have distinctly different physical or chemical characteristics but nevertheless maintain their individuality on a macroscopic scale inside the final construction. This study was mainly targeted on utilization of design, developed, evaluated and manufactured the agriculture machine and tool whose capacity and strength more than other agriculture machines. Machine weighted is light, durable, and economical. Composite material samples have been prepared, considering different properties of materials; thereafter tested for different materials Physical and Mechanical the testing was conducted by using Universal Testing Machine. The study has been undertaken to describe agricultural machinery and tools from the composite material fabricated to new machine and tools to facilitate agriculture during harsh condition. In this paper

study the o physical, chemical, thermal, mechanical, and morphological properties of epoxy resin-based bio-composites.

Keywords: Fiber, composite, matrix, physical, chemical, thermal properties.

Paper ID #166

Mechanical and Microstructural Characterization of Friction Stir Welded Marine Grade Aluminum Alloy by Using Experimental Approach and ALE FE Technique

Rituraj Bhattacharjee[1*], Indrajeet Singh Yadav[1], Ahmed Hammad[2], Pankaj Biswas[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Assam, 781039, India
[2]Department of Naval Architecture and Marine Engineering, Faculty of Engineering, Alexandria University, Alexandria 21544, Egypt
*riturajiitmech@gmail.com

Abstract. Several parameters affect the quality of the Friction Stir welded joints, such as tool rotational speed (TRS) and welding speed (WS). This study investigated the effect of these parameters on the metallurgical and mechanical properties of marine-grade aluminum alloy 5083 joints. As the heat generation increased, dynamic recrystallization refined the grain structure and significantly increased the hardness along the stir zone (SZ). Increasing the TRS of the welding tool increased the average micro-hardness value by 30.17 % while increasing WS reduced it by 30.59 %. Features such as arbitrary Lagrangian-Eulerian (ALE) formulation, adaptive meshing technique, and mass scaling approach have provided a trustworthy and computationally effective FE model. The influence of TRS and WS on thermal history, residual stress prediction, and axial force variation has been thoroughly investigated. A comparison of experimental and numerical axial force variation reveals a 6 % disparity between the two data sets. The results from the proposed numerically developed model matched well with the experimental trials.

Keywords: Marine grade AA5083; FSW; Microstructural and mechanical characterizations; ALE; Temperature distribution; Residual stresses variation**.**

Paper ID #168

Enhancing Low-Frequency Dynamic-Stiffness of Robotic Milling Machine Using Active Damping

Govind N. Sahu[1, 2*], Andreas Otto[1], Steffen Ihlenfeldt[1]
[1]Fraunhofer Institute for Machine Tools and Forming Technology, IWU, Chemnitz, Saxony, 09126, Germany
[2]Department of Mechanical Engineering, Indian Institute of Technology Tirupati, Tirupati, Andhra Pradesh, 517619, India
*govinds@iittp.ac.in

Abstract. Industrial robots have gained prominence due to their large workspace and cost-effectiveness. However, their limited static and dynamic compliance restricts their machining capabilities across various materials. Particularly, the inadequate dynamic stiffness of milling robots results in detrimental phenomena like mode coupling chatter and regenerative chatter, even at shallow cutting depths. These issues detrimentally impact performance, product quality, tool, and may even induce damage to robot components. This study focuses on addressing the challenge of low dynamic stiffness in milling robots by employing active damping. The active control system employs an acceleration sensor to detect vibrations in real-time and an actuator to counteract undesirable oscillations based on the controlled signal. However, the actuator's inherent natural frequencies often align with the robot's structural modes, limiting its efficacy in damping low-frequency vibrations. To overcome this, a compensator is proposed utilizing pole-placement techniques, effectively suppressing actuatorrelated modes, and enhancing suitability for attenuating low-frequency vibrations. Experimental results reveal a substantial enhancement of up to ~103% in

robot dynamic stiffness because stiffness is increased by ~103% at the natural frequency of the robot. This improvement proportionately increases the stability limit and enables chatter-free material removal, consequently elevating the overall performance of the robotic milling system. This advancement holds promise for expanding the capabilities of industrial robots in various machining applications.
Keywords: Active damping, Machining, Chatter, Robotic milling.

Paper ID #170

Comparison-based study of Destructive and Non-Destructive methods of the identification of bead geometry using an optical Microscope

Nitin Patel[1*], Aman Nohwal[1], Sunil Jha[1*]
[1]Indian Institute of Technology, Delhi - 110016, India
*suniljha@iitd.ac.in

Abstract. Arc welding is the primary joining process. It finds new applications in metal 3D printing. To 3D print a metal part, its 3D CAD model is sliced into small layers. Correct thickness and geometry identification of such layers is very crucial. The conventional way of identification of weld bead geometry is a time-consuming method as it involves sectioning, polishing, and etching processes prior to the characterisation of the weld bead. Instead of using this destructive method, a non-destructive method has been adopted to obtain geometric characteristics of weld beads more quickly and more frequently. This can be very useful for Wire arc additive manufacturing performed using advanced welding techniques like Cold metal transfer (CMT). The results of the two methods have been compared and it is found that the results are in close agreement, provided that more observations have been carried out for the non-destructive method of bead geometry identification.
Keywords: Cold metal transfer, Metal inert gas, Computer-aided design, Wire arc additive manufacturing, Optical microscope, and Torch speed.

Paper ID #171

Improvement of Electrochemical Micromachining by Pulse Amplitude Modulation of Step Pulse Waveform

Himadri Sekhar Panda[1*], B. Bhattacharyya[2]
[1,2]Production Engineering Department, Jadavpur University, Kolkata 700032, India
*himadrispanda26@gmail.com

Abstract. Electrochemical micromachining (EMM) has emerged for fabricating and surface structuring of miniaturized components, which is used in different fields of micro-engineering applications. In EMM, appropriate voltage choice is crucial for the improvement of material dissolution localization and the control of stray currents. Higher voltage improves the precise shape of machining, but it increases overcut, taper angle, and surface roughness. Lower voltage minimizes overcut, but it affects the shape of features due to irregular machining. To address these drawbacks, a new pulse amplitude modulation (PAM) of step pulse waveform is designed indigenously with the help of function generator. Herein, each pulse's amplitude during on-time varies from peak to half-peak, and during off-time, it regulates from zero to half-peak. It is a cost-effective method because the function generator is employed as a power source instead of an expensive ultra-high-frequency DC pulse power supply. When the microtool's position is inside the workpiece, the effects of applied voltages are investigated by fabricating micro-dimples and micro-grooves. To verify the feasibility of the PAM technique, machining performance in terms of overcut, taper angle and surface roughness is investigated for different traverse tool feed rates and frequencies. By synchronizing the micro tool feed rate with the PAM technique, it has been noticed

that at 0.5µm/s of traverse tool feed rate, precise micro features can be fabricated with lower surface roughness (Ra), i.e.,
0.0744µm, less taper angle of 15.37^0, and lower groove width overcut of 25.055µm. Whereas, without the PAM method, overcut, taper angle, and surface roughness can be obtained as 55.107µm, 47.72^0, and 0.1567µm, respectively.
Keywords: Electrochemical micromachining, Pulse amplitude modulation, Machining performance.

Paper ID #172

On the Electrochemical Discharge Milling of Polycarbonate using Vertically Upward Tool Feeding Technique

S. Santra[1*], B.R. Sarkar[2], B. Doloi[3], B. Bhattacharyya[4]
[1,2,3,4]Production Engineering Department, Jadavpur University, Kolkata,
West Bengal, 700032, India
*sudip16santra@gmail.com

Abstract. Machining electrically non-conductive materials through electrochemical discharge processes is a widely recognized and prominent machining method. Researchers have addressed several limitations of the existing ECDM process by incorporating techniques such as ultrasonic vibration, tool rotation, and magnetic fields. These approaches aim to control the thickness of the gas film, ultimately achieving controlled electrochemical discharges for improved machining quality. In this particular study, a novel tool feeding technique has been adopted to ensure the presence of gas bubbles at the machining zone and facilitate the removal of machined products from the same area. Utilizing this innovative tool feeding method, Electrochemical Discharge Milling (ECDmilling) was conducted on a thermoplastic polymer like polycarbonate. The study involved varying parameters such as applied voltage, electrolyte concentration, tool feed rate, and the type of electrolyte. The performance of the machining process on polycarbonate was assessed based on the width of the channel and the surface quality of the channel, measured through the Ra value of the surface profile. As a result, a channel with a width of 594.111 µm and a Ra value of 0.410 µm was achieved when using aqueous potassium hydroxide as the electrolyte at 40V, a tool feed rate of 50 µm/sec, and an electrolyte concentration of 20wt%.
Keywords: ECD milling, ECDM, Polycarbonate, Vertically Upward Tool Feeding.

Paper ID #173

Finishing of Bioresorbable Magnesium Alloy by Viscoelastic Polymer Blended Minimal Geometrically Deformable Abrasive Tool

M S Srinivas[1*], K Kartheek[2], S Purushothaman[1], N Venkaiah[1], M R Sankar[1*]
[1]Indian Institute of Technology Tirupati, Tirupati, Andhra Pradesh, 517619, India
[2]Jawaharlal Nehru Technological University, Vizianagaram, Andhra Pradesh, 535003, India
*evmrs@iittp.ac.in

Abstract. Magnesium alloys have garnered widespread acclaim for their unique amalgamation of lightweight attributes and superior mechanical performance. However, notwithstanding their commendable qualities, these alloys face challenges in realizing desired surface finishes due to inherent limitations such as low hardness and heightened chemical reactivity. To address this, surface finishing emerges as a critical step to elevate the chosen magnesium alloy's (ZE41A) surface finish and preserve dimensional precision. Conventional finishing techniques, while partially effective, frequently introduce issues such as deformation or thermal damage when applied to magnesium alloys. To surmount these hurdles and achieve optimal surface quality, a viscoelastic polymer (VEP) blended minimal geometrically deformable abrasive tool emerges as a transformative solution. This study delves into a novel approach of utilizing a VEP blended minimal geometrically deformable abrasive tool for finishing ZE41A. By amalgamating a polymer

matrix with abrasive particles, this ingenious tool conforms seamlessly to intricate geometries and contours, ensuring uniform material removal without risking deformation. Notably, the VEP blended abrasive tool modulates contact pressure, thus minimizing geometrical deformation and unwarranted material removal. In this experimental study, a tailored tool comprising polydimethylsiloxane (PDMS) and silicon carbide (SiC) abrasive is employed. The optimization of the tool is grounded in attaining desired surface finish during the finishing process. Additionally, the investigation scrutinizes finishing parameters - depth of penetration, tool speed, and finishing time – in terms of their impact on surface roughness and tool weight. These insights offer a comprehensive understanding of magnesium alloy (ZE41A) finishing, facilitating the achievement of the desired surface quality.
Keywords: Flexible abrasive finishing, tool wear, surface morphology.

Paper ID #174

Experimental Investigation into Electrochemical Discharge Turning of Cylindrical Glass

Sudip Santra*, Dwarika Pratap Singh, M.N. Ali, Biswanath Doloi, Biplab Ranjan Sarkar
Jadavpur University, Production Engineering Department, Kolkata-700032
*sudip16santra@gmail.com

Abstract. Electrochemical Discharge Turning (ECDT) represents a cuttingedge machining technique that synergizes the fundamentals of electrochemical machining and electrical discharge machining. This innovative method offers a distinctive avenue for precisely machining hard and brittle materials, such as ceramics, glass, and composites, which pose considerable challenges when employing conventional machining approaches. This study delves into the feasibility of employing Electrochemical Discharge Turning (ECDT) for both grooving and turning of glass rods. ECDT exhibits the potential for attaining exceptional precision and accuracy while crafting cylindrical geometries across diverse materials. The applied voltage, electrolyte concentration and revolution of the workpiece were altered during the experimentation using a cylindrical tool electrode. The overarching goal of this research endeavour is to find out better ECDT process parameters to achieve a commendable material removal rate (MRR) while simultaneously enhancing groove width.
Keywords: ECDM, ECDT, Cylindrical Glass, MRR, Groove.

Paper ID #175

Analysis of the Functional Effectiveness of Magnetorheological Polished Polymer Gears

Kunal Arora1, Anant Kumar Singh2*
1,2Department of Mechanical Engineering, Thapar Institute of Engineering and Technology, Patiala 147004, India *anantsingh@thapar.edu

Abstract. Polymer gears (PGs) are widely used in a variety of industries due to their qualities, including their low weight and good damping resistance. The fine finishing of PGs is critical in determining the functionality of the various industrial components. The polymer gear surface is finished in this work using a unique magnetorheological bevel gear finishing (MRBGF) method in the shortest amount of time. Following the trial, the 36-tooth PG surface's average roughness value dropped from 390 nm to 90 nm in 120 minutes after finishing. Further, to analyze the effectiveness of magnetorheological (MR) finishing on the PGs functional efficacy, the gear functional testing setup is developed and demonstrated. One of the unique characteristics of the presently developed gear testing rig is that it constantly monitors the temperature, which is critical for understanding polymer gear behavior. To evaluate the initial ground and final MR finished PG performance, extensive experimental testing was conducted. Further, to analyze the efficacy on the finished

polymer gear surface, a comparative study of temperature variation was done. The results reveal that the MR finished gear surface shows temperature variation performance as compared to the initial ground gear surface. Furthermore, laser Raman analysis revealed that no noticeable chemical changes were caused on the sub-surface level as a result of the MR finishing. All these results signify that MR finishing can be used to enhanced the functional effectiveness or usefulness of polymer gears in industries.

Keywords: Polymer gears, magnetorheological finishing, surface roughness, temperature, Raman analysis.

Paper ID #176

Experimental Investigation on the End Milling of Wire Arc Additive Manufactured Feature

S Purushothaman[1*], M S Srinivas[1], Deepak Singh[2], N Venkaiah[1], M R Sankar[1]*
[1]Indian Institute of Technology Tirupati, Tirupati, Andhra Pradesh, 517619, India
[2]Central Manufacturing Technology Institute, Bengaluru, Karnataka, 560022, India
*evmrs@iittp.ac.in

Abstract. Additive manufacturing is a promising way of producing parts and finds a plethora of applications in different fields such as defence, aerospace, and marine. Among various additive manufacturing techniques, wire arc additive manufacturing (WAAM) is prominent due to its advantages, such as very high deposition rate, feasibility of large-scale metallic parts production, and lower equipment costs. However, this process encounters few challenges such as poor surface quality, distortion, residual stresses, cracks and porosity on the printed features. The WAAMed features can be machined to bring the surface roughness to acceptable levels. Milling is one of the machining operations that can reduce surface roughness. This work aims to evaluate the post-processing performance of WAAMed features using end milling operation. Spindle speed, feed and depth of cut are varied as input parameters, and the surface roughness, hardness, chip morphology and tool wear analysis are considered as output responses for machining. The results showed that the average surface roughness reduced from 3 mm to 1.1 µm. The surface morphological studies were carried out to understand post machined surfaces. The results showed the presence of side flow in the machined surface for different machining conditions. From this work, it can be concluded that the end milling operation can be considered as one of the post-processing operations on WAAMed features for practical applications on industrial scale.

Keywords: Machining, surface morphology, hardness, end milling, modelling, tool wear.

Paper ID #178

Kinematic Simulation of 6-DOF CTEV (Clubfoot) Corrective Orthosis for its Automation Feasibilities during its Integrated Manufacturing

Harlal Singh Mali[1*], Abhilash Bint[1], Shamsher Singh[1]
[1]Malaviya National Institute of Technology, Jaipur, Rajasthan, 342601, India
*harlal.singh@gmail.com

Abstract. Congenital talipes equinovarus (CTEV) is a complicated paediatric foot abnormality that affects 1-6 in 1000 live births. In the last five decades, the non-invasive treatment known as the Ponseti method has been a standard method of treatment that involves serial castings and bilateral braces. The Ponseti approach has a 90% success rate due to its biomechanical expertise. During the casting phase, patients experience repeated clinic visits, patient pain, skin dehydration, ulcers, thermal injuries, swelling, and more. To overcome the above issues, researchers have developed an innovative unilateral CTEV (clubfoot) Orthosis using gear arrangements having six degrees of freedom (DOF). This 6-DOF Orthosis is an alternative to using the Ponseti method of clubfoot treatment. The clinically validated design needs to be automated by incorporation of sensors, actuators, and control units.

This paper attempted modelling and simulation for these six-degrees-of-freedom linkage mechanisms for clubfoot so that automation in the orthosis could be achieved. In order to develop a six-degrees-of-freedom (DOF) linkage mechanism, initially, two and three DOFmechanisms were investigated. This allowed to develop an understanding of combining the motion of assembly in forward and inverse kinematics using the angular motion given to each revolute join. The pivot point of a revolute joint is used in the clubfoot orthosis, and the end-effector's motion on the prescribed trajectory at the given point is traced. The main area of investigation was the trajectory identification, which the child's foot undergoes, and using inverse kinematics to determine the step angle of each joint so that it can be actuated. This will pave the way for integrating hardware for automated and smart CTEV corrective Orthosis manufacturing.

Keywords: Smart orthosis, CTEV, Clubfoot, Trajectory simulation, 6 DOF linkage mechanism.

Paper ID #179

Effect of Cutting Parameters using Uncoated and Coated Carbide Tools on Cutting Force during Micro Milling of AZ31B Magnesium Alloy

Kartik Chandra Bhagat[1*], Aruna Thakur[2], Soumya Gangopadhyay[3]
[1,2]Department of Mechanical and Manufacturing Engineering, National Institute of Advanced Manufacturing Technology, Ranchi, Jharkhand,834003, India
[3]Department of Mechanical Engineering, Indian Institute of Technology, Bhilai, Chhattisgarh, 490001, India
*kcnifft2020@gmail.com

Abstract. Due to inherent properties of magnesium alloys like lightweight, biodegradable, and relatively poor corrosion resistance in human-body fluids, represent an appealing choice for magnesium alloy to consider frequently into some micro components. When compared to other machining operations like grinding and turning, milling is a typical intermittent cutting process that has a unique machining mechanism. As a result, it has a variety of effects on the machinability aspect of advanced materials. Therefore, in this study the machinability characteristics of the AZ31B magnesium alloy are examined during micro milling under dry conditions. To study the effect of cutting parameters during micro milling of AZ31B magnesium alloy on cutting force and surface roughness, experiments have been conducted by varying the spindle speed and feed keeping the depth of cut constant with uncoated and AlTiN coated carbide tools. Two flute and 0.5 mm diameter micro end mills are used as cutting tools. Spindle speeds of 20000, 40000 and 65000 rpm along with three different feeds of 0.5, 2 and 4 µm /tooth are considered as cutting parameter in the present work.

Keywords: Micro-machining, miniaturized components, machinability characteristics, cutting forces, surface roughness.

Paper ID #180

Experimental Analysis for Dimensional Accuracy and Surface Roughness of Nylon-CF Composites Samples Produced by Material Extrusion

Harlal Singh Mali[1*], Vishal Darji[2], Shailesh Suthar[3], Shamsher Singh[4]
[1, 2, 3, 4]Advanced Manufacturing and Mechatronics Lab, Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur, Rajasthan, 302017, India

Abstract. Affordable additive manufacturing technologies are being attempted for manufacturing functional products in various domains including orthoses and prostheses. This paper investigates the dimensional accuracy and surface roughness NylonCF samples produced by material extrusion family of technologies. The influence of seven process parameters, including layer height, infill pattern, infill density, printing speed, printing angle, printing temperature and cooling speed is studied on response characteristics. The L-27 orthogonal array of Taguchi design is used to investigate the effect of process parameters on the variation in various geometrical dimensions like

length, width, and thickness of a specimen fabricated as per ASTM (D-638). The dimensional accuracy is not uniform across all dimensions and layer height effects dimensional accuracy in length, width and thickness. The printing angle affects the accuracy in length and width. The printing temperature only affects the length. The cooling speed found to be affecting width and have no effect on other dimensions. The surface roughness is affected by layer height, printing angle, printing temperature and cooling speed. The results of this study can be useful for production of various functional products particularly orthoses and prostheses.
Keywords: Additive Manufacturing, Dimensional Accuracy, Material Extrusion, Surface Roughness, Taguchi Design.

Paper ID #181

Experimental Study on 3D Printed Gripper with Nitinol Tactile Sensor for an Improved Gripping Performance

Amarnath Balaji[1*], Kashfull Orra[1,2*]
[1]Department of Mechanical Engineering, Indian Institute of Information Technology Design and Manufacturing Kancheepuram, Chennai-600127, India
[2]Center for Smart Manufacturing, Indian Institute of Information Technology Design and Manufacturing Kancheepuram, Chennai-600127, India
*orra@iiitdm.ac.in

Abstract. In this work, an attempt was made to find a suitable gripping pattern for a 3D-printed finger gripper made of PLA material. Experiments were conducted to measure the bending angle and recovery time for different geometric gripping patterns to evaluate the finger gripping performance. The performance of different geometric patterns, namely circular, square and triangle, was evaluated based on the maximum bending angle achieved and the minimum time required for the fingers to recover their original shape. The optimized gripping pattern is then used for the specific application in the current work, and the results of this work were further used to develop a robotic gripper using a shape memory Nitinol alloy as a tactile sensor. Integrating Nitinol wires into the finger gripper, this study can measure the deformation of the wires upon contact with an object and use this information to create a feedback system that can adjust the gripping force appropriately. It was found that there is a significant change in two voltage groups that cause the soft gripper to respond with and without object at 95% confidence level, and the P-value is found to be less than 0.05. This approach allows the use of the Arduino IOT cloud for remote control of the gripper to adjust objects of different shapes and sizes and apply the appropriate force for safe and effective manipulation remotely.
Keywords: 3D-printed, Softgripper, Tactile sensor, Shape memory alloy, PLA material.

Paper ID #182

An Affordable Technique for Measuring and Monitoring of Wire Feed Velocity in Additive Manufacturing

Medha Priyanshu N[1*], Narayanan S A[2], Pradeep Kumar M[3]
[1,2,3]Department of Mechanical Engineering, College of Engineering, Guindy, Anna University, Chennai, Tamil Nadu, 600025, India
*nmpriyanshu@gmail.com
Abstract. With new cutting-edge techniques being used to monitor and regulate numerous parameters (including temperature, pressure, wire feed velocity, etc.), additive manufacturing (AM) has experienced substantial growth over the past four decades, expanding its application across industries. This study examines a new, affordable method for measuring the wire feed velocity in AM procedures for Fused Deposition Modeling (FDM). To measure the wire feed velocity, a Feed Velocity Measurement (FVM) equipment is fabricated and monitored. In order to allow users to monitor the wire feed velocity remotely over the internet in a cyber physical environment, a signal pulse generated by the FVM device is transmitted to the NodeMCU, from which the data is further

communicated by Wi-Fi to the ThingSpeak Cloud platform. This approach offers an affordable solution and this FVM may be effortlessly integrated with the FDM additive manufacturing systems deployed in industry.

Keywords: Feed Velocity Measurement, Additive Manufacturing, Fusion Deposition Modeling, NodeMCU, Cyber-physical Systems, IoT.

Paper ID #183

Experimental and Numerical Investigation of Cu-Be Microchannel Heat Sink for Thermal Performance subjected to Pulsed Flow

Anup Malik*, Shashank Singh, Harlal Singh Mali
Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur
India 302017

Abstract. Due to miniaturisation, microchannel heat sinks play a vital role in high heat dissipation, thereby cooling electronic components. The area-to-volume ratio of microchannels is higher, which enhances heat transfer. This study investigates the effect of coolant flow frequency on heat transfer in a novel microchannel heat sink. Microchannels are fabricated on Copper-Beryllium (Cu-Be) alloy insert using wire electric discharge machine (WEDM). Manufactured device is then assembled and tested on the developed in-house test setup. Results show a rapid decrement in outlet temperature as flow frequency rises for the tested range. Outlet temperature drops by 31.4% when heat flux is 1.2 W/cm^2 and drops by 36% at 4.8 W/cm^2, increasing flow frequency from 20 pulse/min to 70 pulse/min. A complete three-dimensional (3D) numerical model of the device is also developed. The outcomes of simulation and experiment are discovered to be in strong agreement with one another.

Keywords: Microchannels, Heat sink, Pulsed flow, Heat transfer, CFD.

Paper ID #184

Performance Analysis of Different Tool Materials during µ-Electrical-Discharge Milling of Niti Shape Memory Alloy

Satish Chaurasia*, Kishore Debnath
Department of Mechanical Engineering, National Institute of Technology Meghalaya, Shillong, India
*p22me008@nitm.ac.in

Abstract. Nickel-titanium-based NiTi shape memory alloys (SMA) have many industrial applications. However, µ-machining of NiTi SMA poses a significant problem because of an unfavorable combination of shape memory effect and super elasticity. It is challenging to produce µ-channel with dimensionally better accuracy in the NiTi SMA using conventional machining methods. Micro-electric discharge machining (µ-EDM) has gained popularity as a machining method for creating µ-channels in a variety of engineering materials. Despite the widespread use of µ-EDM to create µchannels in hard-to-cut materials, choosing an appropriate tool material is crucial for making the µ-channel with dimensionally accurate features. The effect of five different tool materials, copper (Cu), tungsten copper (WCu), brass (Br), high-speed steel (HSS), and barium copper (BaCu), on the machining performance is investigated in this experimental endeavor. The experiments are replicated three times with each electrode to produce the µ-channels. The µ-milling operation is performed using sesame oil mixed with 2 g/l nickel nanopowder as a dielectric medium. The effect of the tool materials on the dimensional deviation and machining time are studied to evaluate the performance of the different tool materials. The surface morphology of the produced µ-channel is also explored using a field emission scanning electron microscope (FESEM) and energy dispersive X-ray spectroscopy (EDS). After machining, the performance of the different tool materials is analyzed to find the best tool material for µ-ED milling of NiTi SMA.

Keywords: NiTi SMA, µ-EDM, Tool Materials, Dimensional Deviation, and Machining Time.

Paper ID #185

Porosity Control in 4043 Aluminium Alloy Fabricated through Wire Arc Additive Manufacturing Process

Chanchal Chauhan*, Kumar Ujjwal*, Mukul Anand, Alok Kumar Das
Department of Mechanical Engineering, Indian Institute of Technology (ISM) Dhanbad, Jharkhand 826004,
*ujjwal.19dr0076@mech.iitism.ac.in

Abstract. Wire Arc Additive Manufacturing enables cost-effective production of large and customized metal parts with precise shaping; however, working with aluminium presents challenges, especially in addressing porosity. This study investigates the influence of varying shielding gas flow rates on porosity in ER4043-AlSi5 (WT.%) components fabricated through the GTAW-based WAAM process. The results indicated that, as we increase the shielding gas flow rate, the number of pores increases in fabricated aluminium alloy parts due to an increase in cooling rate, which prevents the trapped gases from escaping. Based on observations, at 2 l/min gas flow rate, the number of pores is minimal but more significant compared to parts fabricated at 6 l/min, 10 l/min, and 14 l/min. Distribution of pore area increases when gas flow rate is increased from 2 l/min to 10 l/min, and then it decreases significantly at 14 l/min gas flow rate.
Keywords: Wire Arc Additive Manufacturing,

Paper ID #186

Experimental Investigations into Fiber Laser Marking on PMMA

M.Pandey[1*], B. Doloi[2]
[1,2]Production Engineering Department, Jadavpur University, Kolkata, West Bengal, 700033, India
*mhtpnd93@gmail.com

Abstract. Laser marking is the process to permanently label a surface with 2D barcodes, alphanumeric serial numbers, numbers, logos, etc. for the purpose of identifying parts and products using thermal energy of laser source. The paper deals with the analysis of marking quality on PMMA using fiber laser which had an enormous potential to mark various materials of industrial use. The variation of process variables such as laser irradiation, pulse rate, and scan rate, resulted in the variation of marking quality. The mark intensity analysis conducted on line marking reveals the fact that the variables like laser irradiation, pulse rate and scan rate played a significant role in the marking quality change. Experimental research showed that the laser irradiation of 15 % of 50 W, pulse rate of 120 kHz, and scan rate of 35 mm /s yields better marking quality characteristics.
Keywords: Marking Intensity, Length Deviation, Average Width, Average HAZ thickness.

Paper ID #187

Analysis on Fiber Laser Micro Grooving Characteristics of Ti6Al4V

S. Doloi[1*], M. Pandey[2*], B. Bhattacharyya[3]
[1]Mechanical Engineering Department, IIT Indore, Madhya Pradesh, 45355, India
[2,3]Department of Production Engineering, Jadavpur University, West Bengal, 700032, India
*mhtpnd93@gmail.com

Abstract. Pulsed diode pumped fiber laser provides an outstanding function for diverse micro-machining performance on a variety of engineering materials including super alloy, ceramics, composites etc. Due to its extensive and potential applications of Ti6Al4V in a variety of fields, including automotive, electronics, aerospace, and bio-medical engineering applications, laser micro-grooving on it is in great demand today. The study examines how process variables including laser irradiation, scan rate, pulse rate, and number of passes affect laser micro grooving characteristics like width, length, depth, and HAZ thickness. The better obtained process variables were further utilized to create a micro groove on cylindrical work piece of titanium alloy for its extensive use in industrial applications.
Keywords: Laser grooving, Groove Length, Groove Width, Groove Depth, HAZ thickness.

Paper ID #188

Analysis on Grooving Characteristics of Al5052 Alloy Using Fiber Diode Laser

M. Pandey [1*], S. Anowar [2], B. Doloi[3]
[1,2,3]Production Engineering Department, Jadavpur University, Kolkata, West Bengal, 700033, India
*mhtpnd93@gmail.com

Abstract. Laser grooving is the process to create a groove on the workpiece surface using laser in a minimum possible time with minimal harm for the purpose of application in microfluidic and heat transfer in electronics and biomedical devices. The paper focus on the generation of better quality groove using fiber laser which finds application in many organization due to its compactness, flexibility and lower maintenance cost. Experimental results revealed that better grooving characteristics on the surface of workpiece was observed at a laser irradiation of 45 % of 50 W, pulse rate of 120 kHz and scan rate of 35 mm/s.
Keywords: Fiber laser grooving, Width, Depth, Surface roughness.

Paper ID #189

The Effect of Dressing Methods on the Form Accuracy of Sintered PCD Micro-Grinding Tools

Anang Katyayan[1*], Probir Saha[1], Afzaal Ahmed[2]
[1]Indian Institute of Technology, Patna, Bihar, 801106, India
[2]Indian Institute of Technology, Palakkad, Kerala, 678623, India
*anang_2021me05@iitp.ac.in

Abstract. PCD micro-grinding tools are extensively used in the finishing of brittle materials with wide applications in areas requiring very high surface finish. These micro-tools have several variations in terms of the size of the diamond grits used in the cobalt binder. In the present study, two variations of micro-EDM, namely WEDG, and block-EDG, were employed to dress cylindrical and tapered tools with grit sizes of 5µm and 10µm, respectively. Block-EDG proved to be the superior choice for efficient bulk material removal and significant diametral reduction. In contrast, WEDG exhibited a relatively lower material removal rate but was well-suited for precise finish dressing and truing. Finally, a hybrid approach was adopted for the final production of both types of tools, resulting in dimensionally accurate forms with the required surface quality.
Keywords: PCD micro-tool, WEDG, Block-EDG. Tool dressing.

Paper ID #190

Influence of Welding Sequence on Residual Stresses and Distortions in AA6061-T6 Pipe-to-Plate Joints

Tapas Bajpai[1*], Gajendra Kumar Nhaichaniya[2], Pankaj Kumar Gupta[3] and Jinesh Kumar Jain[4]
[1, 2, 3, 4]Department of Mechanical Engineering, Malaviya National Institute of Technology, JLN Marg, Jaipur, Rajasthan-302017, India
*tapas.mech@mnit.ac.in
Abstract. The present investigation reports on the numerical study of weld sequence optimization in pipe-to-plate aluminium alloy 6061-T6 joints during the gas metal arc (GMA) welding process. A 3D thermal-mechanical finite element (FE) procedure was considered for predicting thermal fields and deformations. Transient temperature distribution, distortions and residual stress were simulated for five different welding sequences using the thermal elasto-plastic approach. Temperature-dependent material properties, heat loss due to conduction, radiation and convection, and Goldak's volumetric heat source are also employed in the model. It was found that selecting a suitable can minimize welding residual stress and angular distortion in pipe-to-plate joints.

Keywords: Pipe-to-plate weld joints; Finite element analysis; Welding sequence; Distortion; Residual stress.

Paper ID #191

Effect of Channel Characteristics Machined using MicroElectro Discharge Machining on Flow Study ID-191

Leera Raju[1*], Aruna K[2], Somashekhar S Hiremath[3]
[1,2,3]Indian Institute of Technology Madras, Chennai, Tamil Nadu, 6360036, India
*somashekhar@iitm.ac.in

Abstract. Micro-channel is one of the important and inevitable parts of common mi-cro-fluidic devices such as micro-reactors, micro-channel heat exchangers, and micro-total analysis systems. Machining microchannels on various engineering materials with the required accuracy is challenging as it requires close control of process parameters. Electro Discharge Machining is an advanced non-conventional process to machine channels on con-ducting materials. In this paper, two bio-compatible materials, especially copper alloy - phosphor bronze and silver were selected to machine microchannels, and a flow study through them has been carried out. An instrumented experimental setup was developed, and experiments were carried out to understand the effect of micro-channel characteristics. PZT micro-pumps were used to pump the fluid in a few ml/min range through the micro-channels. A comparison of flow through the channels before and after the lap-ping process was conducted to study the effect of surface roughness on flow rate.
Keywords: μ-EDM, Micro-channels, PZT micro-pump, Surface roughness, Flow study, Y Channels.

Paper ID #192

Experimental Evaluation, Modelling and Sensitivity Analysis of Temperature in Bone Milling using Elastic-Net Regression

Jaseem Sajidh N. A [1*], Ponnusamy Pandithevan [2*]
[1]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai – 600127, Tamilnadu, INDIA.
[2]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai – 600127, Tamilnadu, INDIA.
*ppthevan@iiitdm.ac.in

Abstract. Bone milling is required to prepare the surgical site for total knee arthroplasty, ankle arthroplasty, bone grafting, and numerous other surgical procedures. Particularly, the procedure of milling bone is significant for the creation of cortical autologous bone grafts. In bone grafting, the harvested bone is utilized to replace the space left by diseased or deficient bone areas. The harvested bone is used as chips, flakes, and fragments. The temperature of the local host bone and the harvested bone fragments should not surpass a threshold value of 47 °C during the bone milling process, since doing so would result in thermal osteonecrosis or the permanent destruction of bone tissue. This research looked at how in-situ bone temperature was affected by end-milling tool diameter, speed, feed rate, and depth of cut. A statistical model using elastic net regression is formed to predict the temperature associated with milling. It is realized that tool diameter, spindle speed, feed rate, and depth of cut affect the temperature by 64.87%, 18.82%, 5.27%, and 11.04% respectively. The proposed statistical model may assist the surgeon in choosing an appropriate set of parameter values for extracting cortical bone from the local host bone without showing any signs of thermal osteonecrosis and for harvesting bone fragments.
Keywords: Arthroplasty; thermal osteonecrosis; bone graft; bone milling.

Paper ID #193

Mechanical Strength Analysis of Adhesive films for Microwave Metamaterial Absorbers

Kajal Chaudhary[1*], J. Ramkumar[2], Kumar, Vaibhav Srivastava[3]
[1]IIT Kanpur, Materials Science Programme, Kanpur, India, 208016
[2]IIT Kanpur, Department of Mechanical Engineering, Kanpur, India, 208016
[3]IIT Kanpur, Department of Electrical Engineering, Kanpur, India, 208016
[*]kajaliitk1@gmail.com

Abstract. The bonding of the heterogeneous layers of polymers to package the tri-layered or multilayered transparent metamaterial absorber is challenging. A broadband metamaterial absorber with 90% absorption within frequency band of 7.93 to 20.72 GHz, employing ITO-PET (Indium Tin Oxide coated Polyethylene Terephthalate) and PDMS interface in the fabricated structure is packaged. Composites of Polyvinyl Butyral (PVB) and 3-aminopropyltriethoxy silane (APTES) are developed to adhere the three layers of metamaterial such that the optical transparency and microwave functionalities are also retained after the packaging. Its composition is optimized to produce an adhesive film with a strength of 26 MPa, which has been shown to provide a lap shear strength greater than 0.14 MPa for the PET-PDMS interfacial bond. With the aid of SEM images of developed adhesives of various compositions, the fracture analysis and mode of failure are described in detail. Finally, the metamaterial absorber is manufactured and packed using an optimal adhesive for which the experimentally measured electromagnetic absorption matches the simulated.
Keywords: APTES, SEM, PET- PDMS

Paper ID #194

Design and Prototyping of a Novel LPG Valve Leakage Testing Machine

Dev Dharmesh Saglani[1*], Rohan N Rachchh[1], Vedant Hinesh Modi[1], Jay Kailas Vakhariya[1], Pushpdant Jain[1*]
[1]School of Mechanical Engineering, VIT Bhopal University, Sehore
Madhya Pradesh-466114, India
*pushpdant@gmail.com

Abstract. The valve in the gas stove plays a key role in its working and is also crucial for the process. A small leakage in the valve can lead to severe accidents or injuries to the one operating and those who are nearby. The objective of the proposed work is to design a novel LPG Valve Leakage Testing Machine. The proposed machine is fully automatic and it will check the leakage in the valve. Based on the input conditions alogwith the results obtained, it will reject valve pieces which have leakage in them and then accept the ones that do not have any leakage. This novel machine will automize the complete testing process and reduce the labour work and testing condition time with authentic results.
Keywords: LPG stoves, Valves, Water bubble method, New product development.

Paper ID #195

Micro Ultrasonic Machining (Micro-USM) of Ti6Al4V Utilizing Multi Tip Micro Tools

Santosh Kumar[1*], B. Doloi[2], B. Bhattacharyya[3]
[1,2,3]Production Engineering Department, Jadavpur University, Kolkata, West Bengal, India
*santosh14fiem@gmail.com

Abstract. Ti6Al4V is broadly used in various industries such as aerospace, spacecraft, biomedical, and automobiles due to their outstanding functionality and its good mechanical properties, corrosion properties and high strength to weight ratio. Micro ultrasonic machining process is non-

traditional machining process which can fabricates micro features on Ti6Al4V effectively. In this paper, multi tips micro-tool has been fabricated to generate multiple micro channels on Ti6Al4V by micro-USM process. The research focuses on exploring the impact of various process parameters, including power rating, abrasive slurry concentration; tool feed rate, and slurry flow rate, on two important aspects: the width overcut and the material removal rate (MRR) when producing microchannels on Ti6Al4V. The utilization of the multi-tip micro-tool significantly enhances the efficiency of micro-USM, leading to improved productivity. The higher value of MRR and lower width overcut achieved as 3.058 mm^3/min and 28 µm respectively during multiple micro channels fabrication.
Keywords: Micro-USM, Multi tip micro tool, Ti6Al4V, MRR, Overcut.

Paper ID #197

Investigation on Ultrasonic Welding as a Post-Processing Approach for Overcoming a Material Extrusion 3D Printer's Build Volume Constraint

Omkar Raj Aryan*, Kishore Debnath, Rabindra Narayan Mahapatra
Department of Mechanical Engineering, National Institute of Technology, Shillong, Meghalaya, 793003, India
*p22me006@nitm.ac.in

Abstract. The additive manufacturing (AM) technique that is most popular for the fabrication of thermoplastic polymer structures is fused deposition modeling (FDM). However, the printer's limited bed size restricts the size of the print, which hinders its use for large and complicated shapes. An excellent approach to this problem is to split the CAD model and join them with a suitable joining technique. In this article, the specimens were 3D printed using M-30 acrylonitrile butadiene styrene (ABS) thermoplastic polymer by varying four distinct printing parameters namely (a) infill pattern, (b) infill angle, (c) infill density, and (d) layer thickness. Then, these specimens were welded to make a lap joint using an ultrasonic welding machine by varying two distinct welding parameters, specifically (a) welding pressure, and (b) welding time. Then, the tensile test was performed for two experiments. In the first experiment, specimens were printed at constant printing parameters and welded by varying one welding parameter at a time while keeping the other parameter constant. The welding parameters that provided optimal joint strength were selected for the second experiment where the specimens were printed by varying printing parameters and welded at these optimal welding conditions. Finally, the results of tensile tests were studied to look into the effect of various welding and printing parameters on the tensile strength of the lap joint of the specimens. The results of the study found that at the welding pressure and time of 3 bars and 3000 ms and printing parameters setting of hexagram infill, 60% infill density, 45^0 infill angle, and layer thickness of 0.127 mm. provided maximum tensile strength of the welded joint.
Keywords: AM, FDM, ABS, Ultrasonic Welding, Lap Joint, Tensile Strength.

Paper ID #198

Effect of Using Different Electrolytes on the Performance of Electrochemical Jet-Drilling of Tungsten

Naorem Ronaldo Singh[1*], Ramver Singh[1], Pradeep Dixit[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, 400076, India
*ronaldo.nao@iitb.ac.in

Abstract. Fast material removal is achieved by the electrochemical jet machining (ECJM) method, which is based on the electrolysis laws of Faraday. The current investigation provides evidence that micro-machining tungsten using the ECJM technique is feasible. A sufficient number of experiments on tungsten were conducted using a micro-needle stainless steel nozzle with an internal diameter of 280 µm to perform a systematic analysis. The experimental outcomes showed that it is feasible to micro-machine tungsten using a neutral electrolyte in ECJM. It thoroughly explains how different electrolytes (NaOH, NaCl, and mixtures of NaCl and NaNO3 with NaOH at a 1:1 ratio) affect the rate of machining and the shape of machined profiles. With several electrolytes at two distinct concentrations, significant differences in the machining profiles were seen. varying amounts of the substance dissolved at varying rates, depending on how alkaline the electrolyte was. The maximum depth of around 240 µm could be reached after 30 seconds of drilling with a 1.0 M aqueous sodium chloride (NaCl) solution.
Keywords: Electrochemical Jet-drilling, Different electrolytes, Tungsten.

Paper ID #199

Investigations of Impact and Hardness Property of the 3D Printed PLA Bio-Composites

Neha Choudhary[1*], Varun Sharma[*2], Pradeep Kumar[3]
[1]Ph.D. Research scholar, Additive and Subtractive Manufacturing lab, Department of Mechanical and Industrial Engineering, IIT Roorkee, Uttarakhand,247667, India.
[2]Assistant Professor, Department of Mechanical and Industrial Engineering, IIT Roorkee, Uttarakhand, 247667, India.
[3]Professor, Department of Mechanical and Industrial Engineering, IIT Roorkee, Uttarakhand, 247667, India
*varuns.fme@iitr.ac.in

Abstract. Fused Deposition Modeling (FDM) has recently attracted much attention in developing polymer-based composites in different fields. The mechanical behaviour of any polymer composite needs to be understood for the particular applications. In the present work, bio-ceramic (alumina and Yttria stabilized zirconia (YSZ)) filled polylactic acid filament was developed. The developed bio-composites' thermal and mechanical characterization (impact strength and hardness) were examined thoroughly by fabricating the specimens using FDM technique. The scanning electron microscope (SEM) has been used to investigate the fracture surface characteristics. It has been found that ceramic reinforced PLA bio-composite filament was successfully developed. The thermal analysis showed no significant change in critical temperatures of biocomposites in comparison to PLA. The impact strength of PLA filled with alumina and zirconia has the highest value (2.19 KJ/m^2) with 21.66% enhancement. The shore D hardness of PLA/alumina composite found to be the highest (71 shore D) is comparison to all other composition due to remarkable hardness of alumina. It is worth mentioning that this work offers a guideline for developing composites with bio-ceramics to improve the mechanical capabilities of neat PLA in different applications including biomedical.
Keywords: Fused Deposition Modeling, Impact strength, Polylactic acid.

Paper ID #200

Machine Learning Service Optimization for a Cloud-Based Additive Manufacturing Process in Neutrosophic Environment

Samriddhya Ray Chowdhury[1*], Shankar Chakraborty[2]
[1]Budge Budge Institute of Technology, Kolkata, West Bengal, 700137, India
[2]Jadavpur University, Kolkata, West Bengal, 700032, India
*raychowdhurysamriddhya@gmail.com

Abstract. For one of the most important aspects for Industry 4.0, cloud-based additive manufacturing (CBAM) deals with many technological and managerial concerns that may inhibit its contribution for sustainable development. In this study, four technical aspects are reviewed as follows: 3D object database, 3D object designs, 3D printing processes, and cloud service security. For certainty, three managerial concerns are considered based on design engineer, database administrator and process engineer. Then, this study puts forward the idea of optimizing the technical challenges to ensure the feasibility of a sustainable 3D printing application in a smart manufacturing context, whereas managerial concerns should be addressed to optimize a 3D printing application. The objective is to maximize the machine learning (ML) service reliability, a smart manufacturing system based on cloud 3D printing should continually provide 3D objects of interest to customers. To infer the categorical vagueness of the decision makers' perfective, neutrosophic sets are introduced for the prominence during the decision making. A popular multi-criteria decision-making (MCDM) method Weighted Aggregates Sum Product Assessment (WASPAS) is adopted for further data analysis and concluding the most preferred machine learning based services for a cloud based additive manufacturing environment. A sensitivity analysis is also performed based on the proposed method.

Keywords: Cloud-based additive manufacturing, Machine learning services, Optimization, Multicriteria group decision making, WASPAS method, Neutrosophic sets.

Paper ID #201

Weldability Study of EN8 Medium Carbon Steel by Manual Metal Arc Welding

Nilkamal Biswas[1*], Subhojit Roy[2], Subhasish Pal[3], Nabajit Banik[4], Surit Roy[5], Oishick Chandra[6], Pranav Kumar[7], Soumojit Dasgupta[8*]
[1,2,3,4,5,6,7,8]JIS College of Engineering, Kalyani, Nadia- 741235, India
*dasguptasoumojit29@gmail.com

Abstract. EN8 medium carbon steel has wide engineering applications. The chemical composition includes 0.4-0.5% carbon, 0.6-1% manganese, and small amounts of silicon, phosphorus, and sulphur. It has good strength, hardness, toughness and weldability. Manual Metal Arc welding is a versatile process that is used to join a wide range of metals and alloys. In this experimental investigation, weldability study of EN8 medium carbon steel by applying Manual Metal Arc Welding using Response Surface Methodology as the Design of Experiment was performed. The weld parameters were Weld Torch angle and Root Gap. Bead geometry parameters i.e. depth of penetration, height of reinforcement and bead width were measured for different combinations of the mentioned factors. Pre-weld hardness of the base metal and postweld hardness at the weld bead and Heat Affected Zone (HAZ) were noted. Analysis of Variance (ANOVA) was used to measure the influence of each factor on the bead geometry.

Keywords: Weldability, Response Surface Methodology, Bead geometry.

Paper ID #203

RAM Analysis of the A-Pan Boiling System in the Sugar Industry

Suyash Singh[1*], Vinod Yadava[2]
[1,2]Motilal Nehru National Institute of Technology Allahabad, Prayagraj-211004, India
*ssuyash977@gmail.com

Abstract. This paper delves into the reliability modeling and availability analysis, examining the A-pan boiling system within the sugar industry as its focal point. This system is composed of four repairable subsystems that are Pan subsystem, Air cooled crystallizer subsystem, Centrifugal subsystem, and Sugar grader subsystem, operate in series. To develop a reliability model, a state transition diagram is constructed, considering the three states of the A-pan boiling system: full capacity, reduced capacity, and failed state. By utilizing Markov's probabilistic approach and developing a state transition diagram, the study established a mathematical model for the availability of A-pan boiling system. The expression for steady-state availability and the examination of constant hazard and repair rates contribute to a more comprehensive grasp of the A-pan boiling system's availability. The identification of the critical subsystem and maintenance priority order facilitates effective maintenance management and enhances the overall reliability of the system.

Keywords: Markov's probabilistic approach, A-pan boiling system, Maintenance management.

Paper ID #204

A Novel Approach Based on Reliability Concepts to Reduce Part Errors by Considering Thermal Errors of Machine Tools

Shashi Bhushan Gunjan[1*], D. S. Srinivasu[1*] and N. Ramesh Babu[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Madras,
Chennai- 600 036, India
*devadula@iitm.ac.in

Abstract. Inherent errors associated with machine tool (MT) significantly hinder its performance. Amongst all the MT errors, thermal error (TE) contributes majorly to the part tolerance band. However, researchers have adopted several solutions to deal with TE, which need (a) significant design upgradation, (b) high computational resources for simulation, or (c) extensive experimental trials for empirical modeling of TE prediction. A thermally stable MT design is an effective solution but requires considerable capital investment; other compensation approaches need real-time temperature input and specially designed electronic modules to predict and compensate for thermal error based on extensive simulation or experimentation data. Hence, this work proposes a novel thermal compensation strategy based on the reliability concept to avoid the complexity of existing approaches in dealing with TE. The proposed approach uses experimental data containing the TE variation with time for particular machining parameters. Then, an allowable value for the TE was defined, and failure events (*when* the *TE crosses the integer multiple of the allowed value*) were identified. Furthermore, the time to failures is fitted with Weibull distribution to find the most probable failure times, which was used to develop a TE prediction model. The developed prediction model does not require real-time sensor input and avoids a specially configured electronic module for the prediction and compensation. The proposed approach was demonstrated on a turning centre for three spindle speeds; 1000, 2000, and 3000 rpm. The TE prediction model showed more than 99% accuracy in prediction to keep the TE under the allowed value.

Keywords: Thermal error, machine tool, time-to-failure

Paper ID #206

The Automatic Classification of SS304 TIG Welding Defects uses Visible-Spectrum Camera Images and Machine-Learning Technology

Aman Nohwal*, Nitin Patel, Sivanandam Aravindan, Sunil Jha*
Department of Mechanical Engineering Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016
*suniljha@mech.iitd.ac.in

Abstract. The detection of weld defects is a crucial aspect of quality control in the welding sector. Welding is a crucial process that is widely used in the manufacturing industry for joining materials in a range of applications. The integrity of welded joints must be ensured, though, as defects could lead to structural failures and safety issues. Finding weld imperfections using conventional visual inspection methods is frequently arbitrary, laborious, and susceptible to human mistakes. Machine learning (ML) and artificial intelligence (AI) technologies have shown a lot of promise in recent years for automating and improving weld defect identification. The use of AI in the detection of weld defects has enormous potential for the manufacturing sector. It increases the effectiveness and efficiency of quality control procedures while lowering the price of human inspection and rework. This work investigates the use of machine learning (ML) algorithms to identify weld defects to improve process accuracy and efficacy. Since it requires human supervision, prioritizes visual inspection, and is carried out in an environment that is controlled. Tungsten inert gas welding is best suited for automation. The technique developed by this study allows for real-time assessment of the effectiveness of tungsten inert gas welding. The device may also be integrated into human mistakes.

Keywords: Weld defect detection, TIG welding, AI, ML, DL, CNN, Feature Extraction, Classification, AI Models, Industrial applications.

Paper ID #207

Solid Particle Erosion Behaviour of Dolomite Dust Filled Hemp-Epoxy Composites

Swaraj Maurya[1*], Sourav Kumar Mahapatra[1], Alok Satapathy[1*]
[1]Department of Mechanical Engineering, National Institute of Technology, Rourkela, India
*alok@nitrkl.ac.in

Abstract. This study investigates the role of incorporating micro-sized dolomite dust particles (a quarry waste) on the erosion behavior of hemp-epoxy composites. Solid particle erosion tests are conducted by varying stand-off-distance (10, 20, 30, and 40 mm), impingement angle (30°, 60°, 75°, and 90°) and impact velocity (30, 60, 90, and 120 m/s) on these composites with different dolomite content (0, 10, 20, and 30 wt.%). Taguchi method is used to determine the optimal parameter combination for minimum erosion rate. The measured data and S/N ratios are also analyzed using analysis of variance (ANOVA). The test results reveal that filler content followed by impact velocity, impingement angle and stand-off distance are the major contributing factors affecting the erosion rate of the composites. A regression model is constructed based on the input and output parameters and is found reasonably accurate in predicting the erosion rate by confirmation experiment. The probable wear mechanisms are identified using scanning electron microscopy of the eroded composite surfaces.

Keywords: Waste dolomite dust; hybrid composite; hemp fiber; erosion wear; air jet erosion tester; ANOVA.

Paper ID #210

Numerical Assessment of Thermo-Mechanical Behavior of a Multi-Layer Additive Manufacturing Process

Prameet Vats[1*], Piyush Kumar Sinha[1], Kishor Kumar Gajrani[1*]
[1]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram, Chennai, Tamil Nadu, 600127, India
*g.kishor@iiitdm.ac.in

Abstract. In this study, a finite element model is used to simulate transient heat transfer in a product during the laser additive manufacturing (AM) process by using commercial software (ANSYS®). The laser is represented mathematically as a moving heat source with a Gaussian energy distribution. This research investigates the effects of laser power and laser scan speed on temperature fluctuations, thermal strain, equivalent stresses, and deformation induced in deposited layers. Furthermore, the model takes into account the temperature dependent thermal parameters (such as density, thermal conductivity, thermal expansion coefficient, and enthalpy). Instead of using a simple straight layer, a plate with circular hole geometry has been used during the simulation to bring more complexity to the geometry. An investigation of mesh sensitivity was also performed. The model was used to evaluate the effects of two different scanning strategies on the temperature, stress, and deformation of the part. The overall deviation in temperature, equivalent stresses, and deformation observed between both in-out and out-in scanning strategies is approximately 6–11% 21%and 23.5%, respectively. The anticipated outcome of this study is a greater comprehension of the impact of AM process parameters and scan strategy on the quality and characteristics of the manufactured products.

Keywords: Additive manufacturing, Deformation, Equivalent stresses, Finite element, Moving heat source, Temperature.

Paper ID #211

Ball Bearing Fault Identification using K-nearest Neighbor Classifier

S. Mandal[1*], R. Kumar, [2] N.B. Hui[3], C. Mishra[4*]
[1,2,3,4]National Institute of Technology Durgapur, Durgapur, West Bengal, 713209, India
*chintamani.mishra@me.nitdgp.ac.in

Abstract. One of the major causes of failure in industrial machinery is fault in rolling element bearings that supports the load. Therefore, a reliable bearing problem diagnosis technique is essential for preventing machinery malfunction. In modern days, using different machine learning (ML) techniques, online monitoring of health status of ball bearing can be easily performed. Among all the ML techniques, K Nearest Neighbor (KNN) is one of the most favoredtechnique in fault diagnosis in rotating machinery, as it is user friendly and robust to the effect of noise. In this article, vibration responses are collected from a bearing test rig for three different fault conditions (outer, inner, and ball fault) of a ball bearing. The useful features are extracted from the vibration signal of healthy as well as faulty bearing which are used to train the KNN model. An accuracy of 96 % is achieved in detecting the condition of bearing that reveals the effectiveness of the proposed model. This trained model can further be utilized for determining the condition of bearings at different operating conditions.

Keywords: Machine Learning, Fault Diagnosis, ball bearing, K Nearest Neighbor.

Paper ID #212

Modelling of Microchannel Cross-Sectional Profile Generated on Ti-6Al-4V Alloy by Micro-Abrasive Waterjet

T. N. Deepu Kumar*, D. S. Srinivasu
Indian Institute of Technology Madras, Chennai, Tamil Nadu, 600036, India
*me18d041@smail.iitm.ac.in

Abstract. Micro-machining of low-to-high aspect ratio (depth/width) microchannels has numerous applications in biomedical, micro-electromechanical-, and microfluidic- systems. Milling micro-features in advanced engineering materials (AEMs) using a conventional micro-machining route is challenging. Specifically, generating a controlled freeform surface with acceptable dimensional tolerance in Ti-alloys is difficult. The necessity to machine a wide range of ductile-behaving AEMs (with minimal residual stress, no heat-affected zone, and relatively minor edge damage) demands alternative technologies. The present study employed micro-abrasive waterjet (μ-AWJ) technology to perform controlled-depth milling of low-to-high aspect ratio microchannels without masking the Ti-6Al-4V target. In addition, a hybrid model is proposed to predict the cross-section profiles (CPs) of the microchannels milled in linear jet pass erosion. The hybrid model includes two modules: (i) *high-energy jet flow dynamics*- which outputs the particle flow properties in the jet plume, and (ii) a *normal jet-impinged erosion*- which predicts the microchannel CPs. Experimentally milled microchannels in single jet pass erosion have an aspect ratio of 0.06-0.19. Model results show that the prediction error in microchannel erosion depth is < 1%, and their CPs with a maximum mean absolute error of < 9.4 μm. A strong conformity is observed between the experimentally generated CPs and model-predicted ones, with a correlation coefficient 0.98. Overall, the study demonstrated the accurate prediction of microchannel CPs using a proposed hybrid model- one of the building blocks. Thus, the model aids in manufacturing a desired microchannel geometry generated by μ-AWJs and serves as an initial step to building freeform surface modules.

Keywords: Micro-AWJs, Micro-Milling, Microchannels, Ti-6Al-4V, Hybrid model.

Paper ID #214

Experimental Comparative Analysis of Conventional and EDM Micro-drilling Process on SLM Produced Maraging Steel

Mohit Godara[1*], Arun S.[1], Jino Joshy[1], Jose Mathew[1], Basil Kuriachen[1]
[1]National Institute of Technology, Calicut, India,673001
*bk@nitc.ac.in

Abstract. Nowadays, Additive Manufacturing (AM)- produced parts are in high demand. But as per application specific requirements, production of micro-holes is still a challenge using Selective Laser Melting (SLM) process. In such cases, different micro-drilling processes can be used, such as conventional and EDM micro-drilling. Apart from that, directional anisotropy is another problem associated with SLM fabricated material. In this study, a comparison of conventional and Electric Discharge Machining (EDM) drilling process has been considered, along with a comparison of parallel and perpendicular to build directions (BD) in terms of surface roughness, overcut, and hole depth. It was found that the average surface roughness in the micro-EDM drilling process was 90.8% higher than the conventional micro-drilling process. Whereas in the case of overcut analysis, diameter of micro the EDM drilled hole was 258% higher than that of the conventional micro-drilled hole. It was also found that no significant effect of BD found in the overcut. Similarly, in the case of conventional micro-drilling, no significant effect of BD was found on hole depth. But in EDM micro-drilling the average depth of parallel to BD was 17% higher than perpendicular to BD. Whereas the average depth of conventional micro-drilled hole was 190% higher than micro EDM drilled hole. Based on the comparison results, it is very difficult to produce good quality holes using micro-EDM process with current optimized process parameters and further optimization of process parameters requires to produce micro holes with dimensional stability. With the help of

post-processing operations, it is possible to reduce the high surface roughness and control in directional anisotropy and due to that it is possibility of using SLM fabricated components in moulds, fuel injection nozzles, micro dies, micro- electro components etc. will improve.

Keywords: Additive Manufacturing, Selective Laser Melting, Directional anisotropy, Micro-drilling, Electric Discharge Machining.

Paper ID #217

Numerical Modelling of Temperature Development in Laser Powder Bed Fusion of Stainless Steel 316L

Akshay Prasad[1*], Jino Joshy[1], Basil Kuriachen[1], Jose Mathew[1]
[1]Advanced Manufacturing Centre, National Institute of Technology, Calicut, India, 673001
*bk@nitc.ac.in

Abstract. LPBF is a powder bed fusion process where the powder material is melted using a high energy moving laser beam which gets solidified upon cooling to produce the final part. Hence the temperature may go beyond the melting point of the material and is subjected to rapid heating and cooling cycles during the process. Numerical simulation is an effective method to predict the field variables such as temperature and stress rather than experimentation that add time and cost. A numerical model is developed to obtain the temperature field during LPBF processing of stainless steel 316L accurately by considering the temperature dependent properties, phase change and heat transfer. Results from the numerical simulation shows that during LPBF temperature rises above melting and then solidifies upon cooling. This clearly validates that rapid heating and cooling cycles are existing during the LPBF process.

Keywords: Laser powder bed fusion, Scanning strategy, Temperature gradient.

Paper ID #220

Influence of Laser Annealed Kapton Polyimide on Non- Contact-Based Actuation of Niti Shape-Memory Alloy Bimorph Based Smart Actuator

Kaushal Gangwar*, Srijan Parashar, Kumari Sunita, Ashwin Wagh, Krishnpal Tomar, I.A Palani*
Mechatronics and Instrumentation Lab, Department of Mechanical Engineering,
Indian Institute of Technology Indore, Madhya Pradesh, India
*mtphd2106103001@iiti.ac.in,

Abstract. The Nickel titanium shape memory alloy bimorph presents better actuation and improved substrate to film adhesion on laser annealing. Laser interaction affects the surface crystallinity and wettability of polyimide, improving bimorph performance. This work is focused on analyzing the annealing process with Nd: YAG laser at 355 nm wavelength for its fluence to achieve better polyimide surface properties. The laser annealing has increased polyimide's surface roughness from 0.075 μm to 0.588 μm for fluence value of 1.83 J/cm². The 82° contact angle of plain polyimide reduced to 62.9° for laser annealing of 1.63 J/cm². Finally, the life of the smart actuator for laser annealing improved by 71.4 % for fabricated bimorph over laser annealed polyimide surface at a fluence of 1.63 J/cm².

Keywords: Laser baser actuation, laser annealing, shape memory alloy.

Paper ID #221

Exploring the Potential of Laser-Assisted Machining on Ti6Al4V: A Numerical and Experimental Study

Muruga Prabu U*, Nagendla Anil Reddy, Avinash Rayavarapu, Afzaal Ahmed, Pramod Kuntikana
Indian Institute of Technology Palakkad, Kerala, 678623, India
*132114005@smail.iitpkd.ac.in

Abstract. Ti6Al4V is a versatile titanium alloy widely used in the aerospace and medical industries due to its excellent mechanical properties, corrosion resistance, and biocompatibility. However, conventional machining techniques are inefficient for Ti6Al4V machining. Laser-assisted machining (LAM) improves machinability by preheating the workpiece before material removal. Investigating the impact of cutting and laser source parameters on cutting forces during LAM is crucial for optimizing the process. FEM simulations can provide insights into the complex thermal interactions during LAM, enabling the prediction and optimization of cutting forces, tool temperatures, material removal rates, and mechanical interactions. FEM simulations allow for the investigation of various process parameters, such as laser power, cutting speed, and tool geometry, to identify optimal conditions for achieving desired machining outcomes. In the current numerical and experimental analysis, we will focus on the impact of feed, speed, and laser power on the resultant machining force during Ti6Al4V machining.
Keywords: Laser-Assisted Machining, Ti6Al4V, finite element analysis.

Paper ID #222

Optimization of the Tuned Mass Damper Cavity Geometry and Its Location of the Passive Damped Boring Bar

Mariselvan[1*], D.S. Srinivasu[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Madras Chennai – 600036, India
*devadula@iitm.ac.in

Abstract. Machining high-aspect ratio holes using a conventional solid boring bar (BB) is a challenging task; hence, the tuned mass damper (TMD) is generally preferred to enable a higher machining stability limit (b_{lim}). In TMD-based passive damped boring bars (PDBB), cavity geometry and its location dictate their performance besides other parameters; however, limited studies are available and to date, an approach for optimizing in combination has not been reported. For this purpose, the present work initially presents a comprehensive study for understanding the effect of the cavity geometry and its location on the BB's (length to diameter (L/D) ratios 7–12) effective modal mass (m_{eff}) of the fundamental governing mode and the TMD's mass ratio (μ- the ratio of absorber mass (m_{abs}) to the m_{eff}). Furthermore, to obtain the optimum values of the cavity geometry and its location, numerical optimization under conditions without and with constraints (*i.e.*, allowable m_{abs}) is performed to maximize the μ of the TMD. The results show that increasing m_{abs} or the μ does not increase the b_{lim} indefinitely since higher m_{abs} require more space within the BB, resulting in a loss of rigidity when the cavity is sub-optimally placed. To assess the optimal cavity geometry quickly, a simplified approach is proposed using the insights gained from a comprehensive study and then numerically optimized for its location. The b_{lim} in the proposed approach was closer to the other optimization approaches performed and further improved for 8 – 10 *L/D* with a maximum of 29.6 % at 8 *L/D*.
Keywords: Boring bar, Passive damping, Tuned mass damper, Numerical optimization.

Paper ID #223

Experimental Investigation on Laser Direct Energy Deposition of Inconel 625 under the Application of Ultrasonic Vibration and Inter-pass laser Remelting

Prabhat Kumar[1*], Shubham Rao[1], Suvradip Mullick[1]
[1]Indian Institute of Technology Bhubaneswar, Khordha, Odisha, 752050, India
*pk43@iitbbs.ac.in

Abstract. The direct energy deposition (DED) technique is a form of additive manufacturing that entails the gradual deposition of materials in a layered manner to produce 3-dimensional objects. The process is also referred to as laser melt deposition or laser-engineered net shaping. Direct energy deposition can affect microstructural evolution and surface properties, causing porosity and cracks, microstructural variation, intermetallic phases, alloy segregation, and anisotropic behavior. Many property-enhancing techniques are utilized to mitigate these problems. In terms of property enhancement, ultrasonic vibration and inter-pass remelting are techniques that have proven effective. Acoustic streaming induced by ultrasonic vibration creates a dynamic atmosphere in the melt pool, refining and uniformly distributing grains and improving material surface characteristics. The inter-pass remelting technique involves melting and solidifying previously deposited layers, causing the material to dissolve and solidify, forming a stronger bond with the layer beneath.
In the present study, the combined effect of ultrasonic vibration and inter-pass remelting has been utilized to enhance the microstructural (grain size, grain structure, and bonding interference) and surface properties (microhardness and wear resistance) of Inconel 625 deposited by direct energy deposition technique.
Keywords: Inconel 625, Laser Direct Energy Deposition, Inter-pass Remelting, Ultrasonic Vibration.

Paper ID #224

EEG-based Color Classification for Industry 4.0 Applications

Mayukh Mondal[1*], Olivia Pal[2], Tamesh Halder[3], Avishek Mukherjee[3], P ravanjan Nayak[3]
Surjya KantaPal[3*], Debashish Chakravarty[3], Sudip Misra[3]
[1]Vellore Institute of Technology, Vellore, India
[2]Michigan State University, Michigan, USA
[3]Indian Institute of Technology Kharagpur, West Bengal, India
*skpal@mech.iitkgp.ac.in

Abstract. Integration of electroencephalography (EEG) in Industry 4.0 use cases is a rapidly emerging concept that promises to overcome the data-centric limitations of conventional solutions and introduce the notion of hybrid solutions that can efficiently combine the consistency of automated deep learning approaches and the flexibility of human intuition. Color classification tasks are common in industrial use cases, especially in the field of manufacturing, and are important in regard to EEG responses as well. Responses to color stimuli can be markedly distinguished, and this poses the scope of developing an EEG-based color classifier that would be able to augment the performance of conventional Industry 4.0 solutions. This article presents a detailed study of the background behind color perception in the brain and use a neuroscience-guided methodology to develop an efficient processing pipeline that delivers 100% accuracy while using hardware with a limited sampling rate and channels while accounting for inter-subject and inter-trial variance.
Keywords: Electroencephalography, Industry 4.0, Brain-Computer Interface, Color classification.

Paper ID #225

Multi Objective Optimization of RMS configuration with Hybrid Approach of NSGA II and TOPSIS

Harshita Gupta*, Venkateswara Rao Komma
Department of Mechanical Engineering, Motilal Nehru National Institute of Technology, Allahabad, Prayagraj UP-211004
*harshita.2021rme15@mnnit.ac.in

Abstract. A reconfigurable manufacturing system (RMS) is a type of manufacturing system that is meant to be extremely adaptable to changing production requirements. Unlike traditional manufacturing systems, which are often dedicated to a specific product or production process, RMS can be quickly reconfigured to accommodate new products, production processes, or changes in production demand. Based on the interconnections between different modules and the capabilities of the machines, the current study presents a technique for assessing the machine usage utilization, reconfigurability, and operating capability of a Reconfigurable machine tool (RMT). The performance parameters and costs are considered as several objectives for optimizing machine assignment. In this work, multi-objective optimization of RMS was performed in two stages. NSGAII is used in the first stage to generate non-dominated solutions. The Pareto frontiers are ranked using a multiple-attribute decision-making approach in the second stage. To rank the provided solutions, the TOPSIS algorithm and entropy theory were employed. According to the outcomes, the combination of the proposed performance indicators and the hybrid technique has great potential for dealing with optimization and cost-benefit concerns in RMS.
Keywords: RMS, Machine utilization, NSGA-II.

Paper ID #226

Comparative Study of Different Flank Face Textures on Coated Carbide Tool during Machining of Hardened H13 Steel

Arunabh Choudhury[1*], Deba Kumar Sarma[1]
[1]National Institute of Technology Meghalaya, Shillong, Meghalaya, 793003, India
*arunabhchoudhury@nitm.ac.in

Abstract. Textures with different faces of the cutting tool are usually introduced to upgrade the machining characteristics of the tools. Surface texturing helps to alter the tribological properties at the chip and tool interface. In this work, different surface textures have been introduced on the flank surface of coated carbide tool. Surface textures are introduced on the flank surface using micro-electric discharge machining (μ-EDM). Machining has been performed using these textured tools and the results are compared with the machining results of non-textured cutting tool. The performance parameters considered for the experiments were flank wear of the tool, surface roughness of the workpiece and the temperature sensed at the tool-workpiece interface. The comparison of results for textured and non-textured tool show that the dot-textured tool performed well compared to the other tools. It is observed surface roughness of the workpiece is lower for the dot-textured insert and the wear on flank surface is also comparatively less. So, it can be said that the introduction of textures help to improve the machining parameters.
Keywords: Flank face textures, Coated carbide, Surface roughness, Flank wear.

Paper ID #227

Fabrication of Titanium Nanotubes for Anti-Fogging Application

Ratan Ahuja[1*], Hrishikesh Jadhav[1], Pramod KC[1], Reshma Yasmin Siddiquie[1], Rakesh G Mote[1], Amit Agrawal[1], Suhas S Joshi[2]

[1]Department of Mechanical Engineering, Indian Institute of Technology Bombay, Mumbai 400076, India

[2]Department of Mechanical Engineering, Indian Institute of Technology Indore, Indore 453552, India

*ratanahuja@iitb.ac.in

Abstract. The design of an anti-fogging surface is imperative to improve visibility on transparent surfaces. Modifying the surface to obtain a hydrophilic surface is an effective way to achieve the anti-fogging functionality. The hydrophilic nature of titanium nanotubes is utilized to realize an anti-fogging surface. In this work, nanotubes are fabricated in a single step, on a titanium (Ti) surface using the anodization method. Two surfaces were fabricated by varying the anodization time and applied voltage. At a lower time and voltage, a surface with nanopores was obtained, while at higher time duration and voltage, a surface with nanotubes was obtained. The surfaces were characterized by using scanning electron microscopy and the shape of the nanotube was studied for given anodization conditions. Both surfaces showed significantly improved anti-fogging ability compared to the polished surface. In the anti-fogging tests, the surface with nanotubes performed better than the surface with nanopores. The nanotube surface demonstrated good anti-fogging properties against the spray test (36 %) and vapour test (33 %) on drying time compared to the polished sample, while the surface with nanopores demonstrated 48 % (spray test) and 53 % (vapour test). Thus, exhibiting good anti-fogging properties

Keywords: Anti-fogging, Anodization, Titanium nanotubes.

Paper ID #228

A Numerical Technique of Analyzing Temperature Distribution in Friction Stir Lap Welding of Al-Mg-Si Alloys under Different Process Parameters

Ankan Das[1*], Himangshu Kalita[1], Sajan Kapil[1], Pankaj Biswas[1]

[1]Department of Mechanical Engineering, Indian Institute of Technology, Guwahati, Assam 781039, India.

*a.das@iitg.ac.in

Abstract. In this article, Coupled Eulerian-Lagrangian approach is adopted for numerical analysis. A finite element model was meticulously developed to replicate the single pass friction stir lap welding of Al-Mg-Si alloys (AA6061-T6). The numerical simulation entailed investigating the lap interface and the dynamic temperature field under two distinct sets of process parameters: a traverse speed of 41 mm/min paired with rotational speeds of 875 rpm and 1230 rpm. The simulation outcomes reveal that increasing the rotational speed amplifies the generation of frictional heat at the interface between the rotating tool shoulder and the substrate. Consequently, increases the temperature of the stirred zone. This heightened heat input induces plastic deformation within the underlying material beneath the tool shoulder, resulting in the formation of a basinlike stirred zone. As the welding process advances, it leaves in its wake a region characterized by elevated stress levels in areas previously welded. Upon the culmination of the welding operation, the plunging region emerges as the epicenter of the highest von Mises stress. Intriguingly, a compelling congruence emerged between the temperature distributions observed in both the experimental and finite element analyses, affirming the reliability of the model. Equally noteworthy is the defect-free nature of the weld surface appearance and cross-section, signifying the success of the welding process.

Keywords: Friction Stir Lap Welding, Aluminum alloy, Numerical Analysis, Mechanical Behavior, Temperature Field.

Paper ID #229

Meniscus Guided Electrochemical Additive Manufacturing

Sri Satya Omkar Dadi[1*], Divyansh Patel [2], Nikhil Bafna[1], Girish Kant[1]
[1]Birla Institute of Technology and Science, Pilani, Rajasthan, 333031, India
[2]Indian Institute of Technology, Bhubaneshwar, Odisha, 752050, India
*dspatel@iitbbs.ac.in

Abstract. The commonly used processes for metal additive manufacturing at the macro scale use thermal energy, which results in the heat-affected zone, thermal stress, recast layers and micro-cracks in the fabricated part. Electrochemical additive manufacturing (ECAM) is a non-thermal and reliable process for nano and microfabrication, where metal ions are reduced for the metal deposition over the previous layer. However, upscaling the ECAM for mesoscale fabrication is challenging and time-consuming due to atom-by-atom metal deposition. The current work presents a novel printing head developed in-house for meniscus-guided electro-chemical additive manufacturing (M-ECAM) of pure copper strips on a nano-polished brass substrate. An electrolyte composition of 1 M CuSO4.5H2O and 0.005 M H2SO4 is used. A parametric study is conducted to assess the printability and the effect of parameters such as voltage, feed rate and flow rate. The parameters are varied at three levels, and linear features are printed layer-by-layer for 100 passes at each parameter combination according to the L_{27} Taguchi standard orthogonal array. Results indicate that voltage is the most influential parameter, and flow and feed rates are the most interdependent parameters for uni-form copper deposition using M-ECAM. A maximum deposition height of 124.171 μm is achieved.
Keywords: Additive manufacturing, Meniscus, Electrochemical deposition.

Paper ID #230

Effect of Loading Orientation on Compressive Strength of Owl FeatherInspired Cellular Structure: Experimental Investigation

Rakesh Kumar Sharma*, Somashekhar S Hiremath*
Department of Mechanical Engineering, Indian Institute of Technology Madras
Chennai-600036, India
*somashekhar@iitm.ac.in

Abstract. Cellular structures are the of porous material that exhibit unique physical and mechanical properties primarily determined by their topology and the volume of fraction rather than their characteristics properties related to the structures and the chemical compositions. In this study, cellular structures were derived from the owl bird's feathers, mimicking the structural design of the owl's feather; using Solidworks, a CAD model was prepared, and further fused filament fabricated (FFF) 3D printing technique was used to create the structures. All the structures are printed with Polylactic acid (PLA) material. Experimental analysis of these structures under uniaxial compressive tests was carried out. The literatures shows that the compressive strength and energy absorption of bio-inspired structures are good as compare to the other cellular structures. We further studied how the change in shape of the strut, which varied between square, hexagonal, and circular, along with variation in loading direction, changes the load bearing capacity and energy absorption capacity under compressive load. The direction of load was varied in three different directions, i.e., along the rachis, perpendicular to the rachis, and perpendicular to the barbs plane. Overall, it was observed that the bio-inspired structure showed significant variation as the load direction changed; the effect of the shape of the strut also showed conclusive results of the hexagon-shaped strut structure being able to absorb maximum energy. These bio-inspired designs have the promise for 3D printed structures application in various fields with superior mechanical properties without compromising the structural strength.
Keywords: Bio-inspiration, cellular structures, 3D printing, uniaxial compressive, tests, specific energy absorption.

Paper ID #231

Synthesis and Characterization of Electroless Ni-P-Al_2O_3 Composite Coating on Aerospace-Grade Mg Alloy for Improving Wear Resistance

Sunny Kumar[1*], Tushar Banerjee[1*], Dharmendra Patel[1]
[1]Department of Production & Industrial Engineering, National Institute of Technology Jamshedpur, Jharkhand 831014, India
*tbanerjee.prod@nitjsr.ac.in

Abstract. In this study, three different coatings viz. Sr-P chemical conversion coating, electroless Ni-P/Sr-P dual layer coating and electroless Ni-P-Al_2O_3/Sr-P coating with composite top layer was deposited on aerospace grade AZ91D Mg alloy for the purpose of enhancing the wear resistance of the later. Surface morphology of the coatings were studied through scanning electron microscopy while the chemical composition was studied with energy dispersive spectroscopy. Structural investigation was conducted through grazing incidence X-ray diffraction. Adhesion and scratch behaviour of the coatings were assessed through scratch test. Coefficient of friction and wear behaviour of the samples were studied through ball-on-disc tribological test against HcHCr steel ball counterbody under 10 N normal load in unlubricated condition. Surface morphological and EDS spectra suggested appearance of Sr-P layer in the form of dispersed flakes. The Ni-P layer however, uniformly enveloped the bottom Sr-P layer. Al_2O_3 nanoparticles were found to be uniformly distributed and embedded in the Ni-P matrix for the composite coating. Presence of Al_2O_3 as separate entity in the Ni-P matrix was also confirmed through GIXRD spectra wherein characteristic peaks of Al_2O_3 were registered. Critical load of adhesion (Lc_3) was highest at 30 N for the Ni-P-Al_2O_3/Sr-P composite layer among the other two coatings. Superior scratch resistance for the same was also revealed from the minimum damage due to scratching. In ball-on-disc test, the uncoated alloy exhibited coefficient of friction of ~0.7, which could be significantly lowered for the Ni-P-Al_2O_3/Sr-P composite layer to ~0.25. Marked reduction in width of the wear track with fewer sliding marks for the composite coating as compared to other samples, indicated excellent wear resistance of the same which was also corroborated through the estimation of wear coefficients.

Keywords: Sr-P conversion coating, Electroless Ni-P coating, Ni-P-Al_2O_3 composite coating.

Paper ID #233

Stability Enhancement of the Boring Bar by Implementing a Particle-Damping Approach

Ramu Ganesan[1*], S Krishna Mohan[2], Chockalingam Singaravelu[3], Varatharajan Prasannavenkadesan[4]
[1]Dr. Kalam Polytechnic College, Thanjavur, Tamil Nadu, 614623, India
[2]E.G.S. Pillay Engineering College, Nagapattinam, Tamil Nadu, 611002, India
[3]Government Polytechnic College, Minicoy, 682 555, Lakshadweep U.T.
[4]Queens University of Belfast, Belfast BT71NN, Northern Ireland
*share2ganesh@gmail.com

Abstract. Chatter, an undesirable phenomenon characterized by unstable vibrations during machining operations, poses a significant challenge in precision manufacturing. This study introduces a novel approach utilizing copper-zinc based particle damping for effective chatter suppression during the boring process. The proposed method leverages the unique viscoelastic behavior of copper-zinc particles, which exhibit exceptional energy dissipation capabilities. Experimental trials conducted on a boring setup demonstrate the remarkable effectiveness of the proposed damping solution. Through comprehensive analysis of excited frequency signatures and displacement measurements, it is evident that the copper-zinc particle damping significantly reduces chatter-induced vibrations, leading to improved machining stability and surface quality. In addition to the quantitative improvements in the stability, the proposed damping technique demonstrates notable advantages including ease of implementation, cost-effectiveness, and adaptability to various machining conditions. The findings presented in this study hold promising

implications for enhancing the performance and efficiency of boring processes across a wide range of industrial applications. This research contributes to the growing body of knowledge in advanced manufacturing techniques and underscores the potential of copperzinc based particle damping as a reliable solution for chatter suppression in machining operations.

Keywords: Passive Damping, Particle Damping, Boring Process.

Paper ID #234

Analyzing Online Thermal Signature for Bead Geometry and Microstructure in Laser Material Deposition (LMD) of NiCoCrAlYHfSi for Gas-Turbine Components

Saikat Nandi[1*], Prasenjit Patra[1], Partha Saha[1], Pranab K Dan[1]
[1]Indian Institute of Technology Kharagpur, Kharagpur, India
*psaha@mech.iitkgp.ac.in

Abstract. The realization of MCrAlY coatings, commonly used in the gas-turbine industry, through laser material deposition (LMD) shows promising potential as compared to conventional processes. For a substrate composition, the coating properties can significantly vary with different laser processing parameters, a selection of which determines the thermal cycle and, in turn, the track geometry and the microstructure. This correlation with the deposition quality helps in predicting and controlling the processing parameters. This study aims to investigate the effect of the laser power and the scan speed on the geometrical and microstructural properties of deposited NiCoCrAlYHfSi on an Inconel718 substrate and to correlate the thermal data of the melt pool with the obtained properties. Both aspect ratio and dilution significantly depended on the scan speed compared to the laser power. The minimum dilution and aspect ratio were obtained as 31% and 3, respectively, for a scan speed of 600 mm/min, whereas the maximum values were achieved as 54% and 6 for a scan speed of 1000 mm/min. More than 40% dilution resulted in the alteration of the significant phase from hard NiAl to a comparatively softer solid solution of Ni (Co, Cr, Fe); the micro-hardness decreased from 510 to 346 $HVN_{0.2}$. A longer melt pool life with a slightly lowered peak temperature can be attributed to an acceptable combination of dilution of 30-35% and an aspect ratio of 3-3.6. In contrast, a very short melt-pool life resulted in severe dilution, which deteriorated the intended properties of the coating.

Keywords: Laser Material Deposition, NiCoCrAlYHfSi, Inconel 718, Dilution, Thermal Signature.

Paper ID #236

A New Mechanistic Approach for Selection of Machining Parameters in Micro Milling for Mitigating Size Effects and Chatter

Vishnu Kumar Singh[1,3*], Priyabrata Sahoo[2], Karali Patra[1]
[1]Mechanical Engineering Department, Indian Institute of Technology Patna, 801106, India
[2]School of Mechanical Sciences, Indian Institute of Technology Goa, 403401, India
[3]Mechanical Engineering Department, Heritage Institute of Technology, Kolkata, 700107, India
*priyabrata@iitgoa.ac.in

Abstract. Micromilling is a mechanical microfabrication technique of removing material in micron range with a submillimetre range cutting tool. Due to the downscaling of the process, the size effect is seen as a significant hindrance that spurs higher specific cutting energy and worsens the surface quality. Further, deflection-driven vibration (transverse vibration) is critical due to the micro end mill's small diameter, which worsens the surface quality and increases the chances of tool breakage. As a whole, size effect, and chatter can be considered the major obstacle in micro milling. This paper adopts a novel mechanistic approach to select the machining parameters (speed, feed, and depth of cut) in micro milling to avoid the influence of size effect and chatter. Feed per tooth is selected by considering the influence of size effect and minimum chip thickness (MUCT) on chip

morphology and specific cutting energy. The depth of cut and rotational speed of the spindle is selected analytically by dynamic stability modeling and differentiating the stable and chatter zone.
Keywords: Mechanistic approach, machining parameters, micro milling, size effect, chatter

Paper ID #237

Maturity Assessment of Industries on the Zero Carbon Emission Development

Gaurav Upadhyay[1*], Cherian Samuel[1], Ajinkya N. Tanksale[2]
[1]IIT(BHU), Varanasi-221005, India
[2]Clarkson University, New York, USA
*gauravupadhyay.rs.mec21@itbhu.ac.in

Abstract. The concept of achieving zero carbon emissions (NCE) was made widely known by the Paris Agreement. This significant agreement was reached during the United Nations Climate Change Conference (COP21) with the aim of minimizing the effects of greenhouse gas emissions. Net zero refers to an ideal condition where the quantity of greenhouse gases (GHGs) discharged into the atmosphere is offset by the amount of GHGs removed. Achieving zero carbon gas emissions can be accomplished by implementing measures to reduce emissions, such as enhancing energy efficiency.

This research paper presents case study related to micro, small, and medium enterprises (MSMEs) to assess their efforts related to climate change. Aim of this article is to aid companies in zero carbon journey. The model consists of three main components: awareness and engagement, knowledge and capabilities, and physical actions.
Keywords: Climate change, Carbon Emission, Industries.

Paper ID #238

Improving Grindability of Stainless- Steel Clad Surface using Sic Wheel

Sudipta Ghosh[1*], Debraj Shaw[2], Santanu Das[3], Sirsendu Mahata[4], Bandana Barman[5]
[1,2,3,4]Department of Mechanical Engineering, Kalyani Government Engineering College,
Kalyani– 741235, West Bengal, India
[5]Department of Electronics and Communication Engineering, Kalyani Government Engineering College,
Kalyani– 741235, West Bengal, India
*sudipta.2016.ghosh@gmail.com

Abstract. Cladding provides a thick protective covering on low cost structural material to improve its surface as well as bulk dependent properties like corrosion resistance, erosion resistance, etc. As clad materials are difficult to conform to desired shape and dimensional accuracy as per technical and aesthetic point of view, grinding of the clad surface may be undertaken to achieve the specified shape, size and accuracy. Objective of this work is to improve grindability of the clad surface made by Gas Metal Arc Welding using AISI-316 stainless steel electrode, while silicon carbide wheel is used for grinding. Experiments are conducted under two environmental conditions that are dry and drop-by-drop lubrication technique which is also known as small quantity lubrication (SQL). During experimentation, several responses are noted like grinding forces, specific grinding energy, presence of crack, grinding ratio, chip forms, etc. Experiments are done under varying infeed, i.e., depth of cut. Experimental results show that specific grinding energy on the whole is found lower in SQL than that in dry condition with an infeed of 10 µm. However, at higher infeed of 15 µm, no remarkable benefit is observed under SQL condition. This may be due to lack of presence of lubricants in the wheel-workpiece interface area, particularly at higher infeed. Therefore, application of SQL can be recommended for grinding stainless steel cladding with 10 µm infeed while using SiC grinding wheel.
Keywords: Grindability, stainless-steel cladding, SiC grinding wheel.

Paper ID #239

Micro-Channel Fabrication in Glass Using Nickel Coated Copper Tool in ECDM Machining and Optimization of Process Parameters

Akhilesh Kumar Tiwari[1*], Sudhansu Sekhar Panda[2]
[1, 2]Department of Mechanical Engineering, Indian Institute of Technology, Patna, Bihta, 801106, India
*akhilesh_2121me02@iitp.ac.in

Abstract. The micro-channel fabrication of glass has been popular due to application in the field of micro-electro mechanical system (MEMS), micro fluidic devices and other bio medical applications. The current study investigates the effect of Ni coated copper (Cu) tool for the micro-channel fabrication in the borosilicate glass using electro-chemical discharge machining (ECDM) process. The increase in melting point of Ni coated tool make it suitable tool for ECDM machining compare to bare copper tool. The important parameters, applied voltage, tool feed rate, duty cycle and pulse frequency, were selected for study. Taguchi's L9 orthogonal array was selected to design the experiments and study the responses, entrance width and micro-channel depth and material removal rate (MRR). Taguchi's method was used to analyses the responses using S/N ratios. The duty cycle was the most influencing factor for both the tool for width of the micro-channel while applied voltage was the most important factor for the channel depth. At 45 V higher channel low width and higher depth was obtained with copper tool while low width was obtained at 39 V for Ni coated copper tool due to high intensity spark and high tool wear of copper tool at higher voltages. Higher voltage and feed rate were found to increase the MRR. The MRR was maximum at 45 V and 3mm/min of feed rate for both the tools.
Keywords: Micro-channel, Ni coated copper tool, ECDM, Taguchi's method.

Paper ID #240

Fracture Identification during Incremental Forming Process using Calibrated Damage Models with Optimized Sample Geometries

Abdul Samad[1*], Shamik Basak[1]
[1]Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247667, India
*shamik.basak@me.iitr.ac.in

Abstract. This study aims to enhance the accuracy in predicting the onset of fracture during the single point incremental forming (SPIF) process for extra deep-draw drawing (EDD) steel sheets. A theoretical fracture locus using the Bao-Wierzbicki (BW) ductile damage model was calibrated and subsequently incorporated into a finite element (FE) model to predict formability at the onset of fracture during the SPIF process. A combination of experimental-numerical methodology was used to calibrate the BW ductile damage criterion, implementing the Hill48 anisotropic yield model. Further, central hole (CH) fracture specimens with varying hole-to-ligament width (HLW) ratios from 0 to 0.3 were used to calibrate the BW damage model. Subsequently, an attempt was made to optimize the fracture specimen geometries in three different aspects: the evolution of stress triaxiality (η) throughout the loading of fracture specimen, prediction of fracture strain, and dome height at the onset of fracture during the SPIF process. It was found that the CH specimen with an HLW ratio of 0.25 exhibited the η value approaching pure uniaxial tension. The BW damage model calibrated with CHD5 geometry accurately predicted the experimental fracture strains compared to other geometries. Further, the calibrated BW curves were incorporated into FE simulations of SPIF, and the CHD5 BW fracture curve showed the lowest prediction error of 3.23%. It was concluded that CHD5 geometry was the optimized CH specimen for EDD steel sheets. Furthermore, all fracture loci and SPIF test data were analyzed in 3D space, and the CHD5 BW locus was concluded as the bestpredicted fracture locus.

Keywords: Single point incremental forming, Extra deep drawing steel, Stress triaxiality, Ductile damage model, Finite element modeling.

Paper ID #241

Effect of Strain Rate on High Temperature Deformation Behavior of Low Carbon Steel

Praveen Gagrai[1*], Jyoti Jha[2], Shanta Chakrabarty[1]*
[1]Kalinga institute of industrial technology, Bhubaneswar, India -751024
[2]Alleima India Pvt Ltd., Pune, Maharashtra- 411012
*shanta.chakrabartyfme@kiit.ac.in

Abstract. The optimal hot working processes in metal forming, demands a comprehensive understanding of hot deformation behaviors, kinetics of metallurgical transformation, and the utilization of processing maps to make informed decisions on key parameters such as strain, strain rate and temperature etc. In this study, the hot deformation behavior of low carbon steel was investigated using plane strain compression tests conducted at three distinct temperatures: 750°C, 850°C, and 950°C, employing the Gleeble-3800 platform. The deformation tests encompassed four different strain rates: 1, 10, 30, and 50 sec-1, aiming to discern the impact of strain rate at elevated temperatures. Deformation was carried out until a maximum true strain of 0.69 was achieved, with the primary objective being the analysis of the material's mechanical response under these specific conditions, particularly considering the influence of temperature and strain rate. The results unveiled critical insights into the hot deformation behavior of low carbon steel. Across all three temperatures, the material exhibited strain hardening behavior, and as the strain rate increased, there was a concurrent decrease in flow stress. This effect was more pronounced at higher temperatures, signifying an augmented ductility. Microstructural analysis highlighted dynamic recrystallization occurring during deformation, yielding finer grains, particularly at higher temperatures and strain rates. The study also found that the strain rate sensitivity increased at elevated temperatures, emphasizing the substantial role of strain rate in dictating the deformation response. Additionally, it was observed that the material's flow stress increased with greater strain, indicating the presence of strain hardening and the processing map depicts that the stability region lies within 750°C-850 °C for higher strain and strain rate. For lower strain and higher strain rate the stability lies towards higher temperature side.
Keyword: Hot deformation, strain rate, strain, temperature, processing map

Paper ID #243

Assessment of Microwave Heat Treatment on Mechanical and Microstructural Behavior of Co-Cr Alloy Dental Parts Fabricated through Selective Laser Melting

Mohit Kumar[1*], Varun Sharma[2]
[1]Additive and Subtractive Manufacturing Lab, Department of Mechanical and Industrial Engineering, IIT Roorkee, Roorkee - 246776, India
[2]Department of Mechanical and Industrial Engineering, IIT Roorkee, Roorkee - 246776, India
*varun.sharma@me.iitr.ac.in

Abstract. Selective laser melting (SLM) is used to fabricate patient-specific, highly precise, accurate dental crown/bridges of Co-Cr-based alloy. However, the quick heating and cooling of SLM-produced parts developed significant quantities of residual stresses, which adversely affected mechanical properties. This study focuses on microwave heat treatment, in order to achieve uniform temperature distribution throughout the material, to maximize the mechanical and microstructural properties, and to reduce power consumption. A comparative study has been performed to investigate the mechanical and microstructural behavior of SLM-printed parts of conventional and microwave heat treatment. The mechanical and microstructural characterization have been performed using micro-hardness and field emission scanning electron microscopy

(FESEM), respectively. Additionally, density and surface characteristics have also been analyzed for microwave post-processed and their counterparts. It has been found that heat treatment showed a significant improvement in mechanical and microstructural properties. The refined grain structure has been observed in microwave heat-treated parts as compared to their counterparts. The uniform heating throughout the material can be the reason for enhancing fine-grain structure of Co-Cr alloy. The present study's outcomes can contribute towards the step of cost-effective and sustainable microwave heat treatment of additively manufactured parts.
Keywords: Selective laser melting, Co-Cr alloy, Heat treatment, Microwave heating.

Paper ID #244

Implementation of Lean Manufacturing to Optimize the Service Level in Oil Companies

David Herrera[1*], María Fernanda Tomas[2]
[1,2]University of Lima, Lima, Peru
*dhbarberena12@gmail.com

Abstract. This research work seeks to implement a Lean Manufacturing management model to improve the service level in oil refining companies in order to optimize the current production chain of the company under study and reduce downtime or human errors. As for the methodology used, it is based on a case study design focused on the study of the pre-test and post-test to identify the main improvements of the same. With respect to the results, this study achieved a 35% reduction in the company's losses.
Keywords: Lean Tools, Service Level, Total Productive Maintenance, Jidoka, Single Minute Exchange of Die.

Paper ID #245

Experimental Investigation and Hybrid Metaheuristic Optimization using ANN-MOJAYA on Corner Accuracy during WEDM for Ti-3Al-2.5V

Anshuman Kumar[1*], Kukkala Vivekananda[2], Chandramani Upadhyay[3], Rajiv Kumar Yadav[4]
[1]Department of Mechanical Engineering, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad - 500090, India
[2]Department of Mechatronics Engineering, Faculty of Science and Technology, ICFAI Foundation for Higher Education, Hyderabad, India.
[3]Department of Mechanical Engineering, National Institute of Technology Rourkela, Rourkela-769008, India
[4]Department of Mechanical Engineering, Ashoka Institute of Technology and Management, Varanasi-221007, India
*anshu.mit06@gmail.com

Abstract. Geometrical accuracy is an impactful parameter that pertains to the machined components utilized in recent equipment. The WEDM is well known and demanding for geometrical accuracy, but it is not always met for difficult-to-machine materials. The geometrical deviation in the machined part can significantly impact the efficiency and lifespan of the finished parts. So, this experimental investigation consequently focused on identifying the optimum parameter setting to achieve the required quality of WEDMed Ti-3Al-2.5V end product. The machining performance selected as cutting speed (Cs), surface roughness (SA), and corner geometrical deviation (CGD) during corner cutting during WEDM using Copper-core-double layer ZnCu50 coating (“Topas plus X”) wire. Here, the design of the experiment has been chosen based on the Taguchi philosophy by varying the machining parameter (i.e. Spark-on Time (STon), Wire-speed (Sw), Servo-Voltage (Sv), Discharge Current (DC) and Wire Tension (WT)) to analyze the machining outcomes. The main effect plot and analysis of variance (ANOVA) framework to analyze machining characteristics. Moreover, a hybrid parametric optimization is selected with orthoANN-coupled with MOJayaalgorithm to predict the necessary machining parameters setting

to improve the machinability of Ti-3Al-2.5V. The most significant parameter observed is DC for Cs and CGD, which is determined to be 36.51% and 42.65%, respectively. However, the interaction term of DC and WT exhibited the highest contribution of 39.16% to the SA. Finally, the confirmation has been conducted and found the maximum absolute percentage errors are 9.2%, 12.5% and 10.6% for Cs, SA and CGD, respectively. This proposed optimum approach provides a promising solution for machining performance and significantly enhances the economic efficiency of production.
Keywords: Corner-Deviation; Surface-Roughness; WEDM; ANN; MOJaya.

Paper ID #246

Material Utilization Efficiency-Guided Laser-Direct Energy Deposition of Inconel 718 Alloy Powder for Aeroengine Components

Prasenjit Patra[1*], Saikat Nandi[1], Partha Saha[1], Pranab K Dan[1]
[1]Indian Institute of Technology Kharagpur, Kharagpur – 721302, India
*psaha@mech.iitkgp.ac.in

Abstract. Inconel 718 is the most widely used Ni-superalloy for aeroengine parts capable of withstanding high temperature. Laser-direct energy deposition process is gaining massive popularity in these industries due to its ability to produce near-net shape parts in less time compared to other laser-based additive manufacturing techniques. However, the primary concern for this type of process is lower material utilization efficiency or powder catchment efficiency (PCE). Therefore, this article aims to evaluate the effects of input processing conditions, i.e., laser power (LP) and scan speed (SS), on powder catchment efficiency (PCE), Dilution (D) and Aspect Ratio (AR) simultaneously for deposition of Inconel 718 to improve the powder utilization keeping all the other two parameters within the permissiblelimits. From the results, it can be inferred that PCE is improving with the increase of LP and the maximum PCE reached is 48.04 % at LP of 1000 W and SS of 400 mm/min. The thermal signature of the molten pool during deposition is recorded with an infrared pyrometer to calculate the solidification cooling rate (CR) during deposition. The effects of CR on the resultant grain size are studied, with the increasing scan speed, the CR is increasing significantly, which is the major reason for grain refinement. Microhardness of the deposited tracks increases with the increment in CR and reduction in grain size; minimum grain size and maximum hardness of 3.03 μm and 270.3±8.1 $HV_{0.2,}$ respectively, were achieved in this study.
Keywords: Inconel 718, Direct Energy Deposition, Powder Catchment Efficiency (PCE), Thermal Signature.

Paper ID #247

Prediction of Cup Height using Non-Associated Flow Rule during Square Deep Drawing of Anisotropic Sheets

Amit Kumar[1*], Shamik Basak[1]
[1]Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247667, India
*shamik.basak@me.iitr.ac.in

Abstract. Formability prediction in sheet metal forming industries has gained great attention as it has significantly reduced the cost of manufacturing. In this study, a deep drawing of extra deep drawing (EDD) steel sheet of 1.0 mm thickness was conducted using a square punch-die setup. A strong non-uniformity of the cup height was observed in the cup edge periphery. The average heights at the four edge corners and the middle of the four edge walls were found to be 39.29 mm and 33.90 mm, respectively. Subsequently, surface strain and thickness distribution were investigated along two major directions rolling and diagonal of the sheet. A maximum thinning of

0.81 mm and 0.94 mm were observed at the corner regions in the diagonal and rolling direction, respectively. Furthermore, a numerical study of the process was done using two different material models. Out of which one was based on the non-associated flow rule (NAFR) and the other was based on the associated flow rule (AFR) of metal plasticity. Both of these models were coupled with anisotropic quadratic Hill48 yield criteria. The predicted results from these two models were validated with the experimental data. The prediction accuracy of the NAFR model was more than the AFR model. A 5.08% and 10.95% prediction error in cup height was obtained when predicted through the NAFR and AFR approach, respectively.
Keywords: NAFR, FE simulation, Square cup drawing.

Paper ID #249

Improving Surface Quality of Wire-EDMed Tungsten Surfaces using Sequential Jet-ECM Operation: From Rough to Refined

Ramver Singh[1*], Naorem Ronaldo Singh[1], Pradeep Dixit[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology, Bombay, Mumbai, Maharashtra, 400076, India
*ramver@iitb.ac.in

Abstract. This research presents a two-step approach to improve Wire-Electrical Discharge Machined (Wire-EDMed) tungsten surfaces using sequential Jet-Electrochemical Machining (Jet-ECM). Wire-EDM is a widely used technique for machining tungsten, but it often leads to rough surfaces, thermal damage, microcracks, and recast layers, all of which can compromise material fatigue strength. In this study, we demonstrate the effectiveness of the sequential Jet ECM operation in enhancing surface integrity. By systematically exploring the effects of altering jet traverse speed, applied voltage, and nozzle stand-off distance through parametric investigation, we elucidated the process of material removal aimed at minimizing damage. Evaluations of the surfaces demonstrated a significant decrease in surface roughness following the implementation of JetECM, coinciding with the removal of distinctive surface patterns associated with Wire-EDM. The emergence of "flute casts" was attributed to the flow dynamics across the treated surface during material dissolution. This study provides valuable insights into machining methodologies, especially for the enhancement of tungsten surfaces, with potential implications for expanding their utilization in high-performance industries.
Keywords: Prost-processing, Jet ECM, EDM, Surface Integrity.

Paper ID #250

Laser Micro-Texturing of Titanium Surfaces for Enhanced Hydrophobicity for Biomedical Applications

Dinesh Kumar S[1*], Kishor Kumar Gajrani[1*]
[1]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram, Chennai, Tamilnadu, 600127, India
*g.kishor@iiitdm.ac.in

Abstract. This research work highlights the techniques to improve the hydrophobicity of the titanium alloy (Ti6Al4V) using laser surface texturing. Different micro-textures namely hatched, window pane, cross-hatched, dash-hatched, and striped were fabricated with different offset distances onthe titanium alloy surface to improvethe wettability. The process parameters considered in this are the scanning speed (1000 and 2000 mm/sec), and power (16 and 18 W) with a constant pulse frequency of 10 kHz. Further, the surface morphological features on the fabricated textures were analyzed by using an optical microscope and a digital USB microscope. The contact angle was significantly increased after laser microtexturing. Among all the texture types, window pane,

and cross-hatched texture have attained the maximum contact angle, which is categorized as hydrophobic in nature and is nearly doubled as compared to the contact angle of as-received titanium alloy. The results of the wettability test demonstrated that the contact angle increases following low-temperature annealing. From the overall wettability test results, the cross-hatched texture formed with the laser texturing parameters of 16 W power, 1000 and 2000 mm/sec scanning speed, and 10 kHz pulse frequency and an offset distance of 0.3 mm displayed extremely hydrophobic behavior with a 133° contact angle, which is considerably higher than the asreceived surface contact angle of 74.6°. Based on the values of the measured contact angles, it is shown that the surfaces can be tailored to improve the hydrophobicity for suited medical assistive devices and bio-implants.
Keywords: Contact angle; hydrophobic surfaces; micro-textures, medical assistive devices.

Paper ID #251

Finite Element Analysis to Predict Post Pelvic Stability Subjected with Triangular and Circular Pattern of Bone Harvesting in Bone Autograft Surgery

Syed Naveed ul Meiraj[1*], Ponnusamy Pandithevan[2]
[1]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai - 600127, Tamilnadu, INDIA.
[2]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai - 600127, Tamilnadu, INDIA.
*ppthevan@iiitdm.ac.in

Abstract. Bone grafting is a widely employed surgical procedure wherein the bone transplanted from a donor is used as a substitute for defect or damaged site. Bone for grafting can be harvested from various locations such as ribs, skull, pelvis, femur, tibia, etc. The pelvis is widely regarded as the golden standard for bone extraction owing to the abundance of corticocancellous bone. However, the process of bone extraction is often accompanied by various post graft complications and potential risks that cause pelvic instability. The present study aimed to develop a non-invasive finite element method by which the physician can determine the suitable location to extract the bone without compromising the mechanical integrity of the pelvis. As a measure, stress developed after harvesting the bone in four different patterns namely, rectangle, triangle, circle, and ellipse were compared to identify the most appropriate pattern that would result in lesser complications. As a procedure, a three-dimensional model of the pelvis was constructed using a computed tomography data sets and analyzed using Abaqus® software. The model was subjected to a body load of 600N considering single leg stance. The results revealed that stress developed was higher at iliac crest (4.32 MPa) when harvested in triangular window pattern. Circular pattern of bone harvesting was associated with lesser stress at iliac crest (2.05 MPa) followed by elliptical (2.49 MPa) and rectangular pattern (2.93 MPa). The outcomes of this study can be used to prevent post-harvest complications in pelvis without compromising the mechanical strength.
Keywords: Finite Element Analysis, Computed Tomography, Bone Grafting.

Paper ID #252

AFM Surface Morphology Investigation of Micro Holes on AISI 316 Stainless Steel by EDM Drilling

U. Ashok Kumar[1*], P. Laxminarayana[2], M. Prakash[3]
[1] Assistant Professor ©, Department of Mechanical Engineering, University College of Engineering, Osmania University, Telangana State 500007 India
[2] Sr. Professor, Department of Mechanical Engineering, University College of Engineering, Osmania University, Telangana State 500007 India
[3] Assistant Professor ©, Department of Mechanical Engineering, University College of Engineering, Osmania University, Telangana State 500007 India
*ashok.u@uceou.edu

Abstract. The study deals with the micro holes surface morphology, surface roughness and micro cracks of AISI 316 machined by EDM drilling process and were examined by Atomic force microscope (AFM) Technique. Experimental studies were conducted by considering the process parameters of Current, Pulse ON time, Pulse OFF time with copper electrode of 300µm diameter. The Experiments planned according to Taguchi L9 Orthogonal Array. The outcomes of experiments are surface texture, surface roughness after the machining process shown excellent with low pulse energy parameters. The average Surface roughness Ra was 5 to 20 nm for the 300µm diameter micro-holes, over the scanning area. Additionally, the AFM application generated information about the 3D Surface imagining, recast layer, micro-cracks on micro hole of AISI 316 stainless steel. These findings highlight the effectiveness of AFM as a superior tool for evaluating the surface characteristics of micro holes in AISI 316 stainless steel, offering potential advancements in precision EDM Drilling machining applications

Keywords: Atomic force microscopy (AFM), Die Sinker Electrical discharge machining (DS-EDM), Surface morphology, Surface roughness, micro holes, Micro Cracks

Paper ID #253

Numerical Investigations of Cold Extrusion Parameters an AA 2024 Alloy

Anupama Francy Kothasiri[1*], Srinivasa Rao Chalamalasetti[2], P. Gopalakrishnaiah[3]
[1]Vishnu Institute of Technology, Bhimavaram, West Godavari, Andhra Pradesh, India,
[2]Andhra University College of Engineering, Visakhapatnam, Andhra Pradesh, India,
[3]PVP Siddhartha Institute of Technology, Vijayawada, Andhra Pradesh, India.
*anupamafrancy.k@vishnu.edu.in

Abstract. The process parameter selection is a vigorous method for obtaining proper extrusion process in order to obtain good quality products. Extrusion is a metal forming process, in which the billet is converted in to the desired shape. The parameters which are effecting on the extrusion process are die geometry, extrusion ratio, die angle, ram speed, material properties etc. The flow of metal is greatly influenced these parameters and hence extrusion force is essential constraint which results on the quality of product. The aim of the present work is numerically investigates the influence of the extrusion input process parameters on the output responses. Die angle, ram speed and coefficient of friction are considered as output parameters and extrusion force, damage and work piece displacement considered as output responses. AA 2024 alloy is selected as a billet material. The three levels of the input put parameters are die angle (10°, 20°& 30°), ram speed 1.6mm/min, 3.2mm/min & 4.8mm/min) and coefficient of friction (0.06, 0.08 & 0.1). The experiments are designed according to L_{27} orthogonal array and simulations are performed with DEFORM-3D software. A multi objective optimization is carried out with Grey Relational Analysis (GRA) by giving equal weightage to three output responses. The optimum set of process parameters are 30°DA, 4.8 mm/min RS and 0.1 CoF, for extrusion force, damage and displacement.

Keywords: AA 2024 alloy, Die angle, ram speed, Grey relational analysis, Extrusion Force, DEFORM-3D.

Paper ID #254

Investigation of Variant Electrodesin Electrochemical Micromachining of Stainless Steel 904l

P. Hariharan[1*], E. Rajkeerthi[2], B. Mouli Prasanth[3], J. Deepak[4]
[1]Professor, Department of Manufacturing Engineering, College of Engineering Guindy, Anna University, Chennai, India
[2,4]Research Scholar, Department of Manufacturing Engineering, College of Engineering Guindy, Anna University, Chennai, India
[3]Assistant Professor, Humanitarian Technology Lab, Dept.of. Electronics and Communication Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India
*rajkeerthipsgtech@gmail.com

Abstract. Electrochemical Micromachining (micro-ECM) is a novel machining process capable of producing high aspect ratio micro-holes, micro-cavities, micro-channels, and micro-grooves on conductive and difficult-to-machine materials. The current research project goal is to conduct a parametric study on process parameters such as machining voltage, electrolyte concentration, and pulse time for machining SS904L in order to investigate their effects on response characteristics such as material removal rate, overcut, and taper angle. This study also attempts to establish the best electrode and electrolyte combination for machining Stainless Steel 904L, among two electrodes. A comparison of copper and polygraphite electrodes with NaCl electrolyte was reported. To study the impacts of input parameters on MRR, Overcut, and conicity, a Taguchi L_9 orthogonal array was used. Based on the results of the experiments, the polygraphite tool with NaCl has the highest MRR and the copper tool with NaCl has the lowest overcut. When comparing the Polygraphite tool to the Cu tool at 15 g/l Ec, 12V and 55 duty cycle, an overcut of up to 6% was observed. A similar trend in taper angle is seen, with a taper angle of 8.5^o in Polygraphite tool and 9^o in Cu tool. However, in terms of material removal rate, the PGT performed better than Cu tool and with an increase in MRR by 2.7 times. The polygraphite tool (PGT) was found to have better microhole precision.

Keywords: Electrochemical micromachining, electrode, electrolyte and overcut.

Paper ID #255

Temporal Feature Analysis of Audio Signal for Instability Identification in High-speed Micromilling of Thin-walled Ti6Al4V

Sethurao Gururaja[1*], Kundan K Singh[2]
[1,2]Department of Mechanical Engineering, Birla Institute of Technology and Science-Pilani, Hyderabad Campus, Telangana -500078, India
*ksingh@hyderabad.bits-pilani.ac.in

Abstract. Ti6Al4V is the preferred material for most aerospace and biomedical components due to its high strength, less weight, and biocompatibility. But, machining of Ti6Al4V is challenging due to its low heat dissipation capacity. In thin-walled micromilling, regenerative chatter is unavoidable. However, early detection of the chatter onset can be used as feedback to control process parameters, avoid chatter occurrence, and improve production rate. In the present work, audio signals recorded during micromilling of thin-walled Ti6Al4V have been analyzed in the time domain by segmenting them into equal parts. Euclidean distance (ECD) analysis has been carried out to analyze the change in the dynamics of the machining process with changes in machining time via signal segmentation. Principal component analysis (PCA) has also been applied to classify the signals into stable and chatter domains for instantaneous detection of chatter. Instability can be identified easily with the proposed methodology without solving the characteristic equation of motion. It has been found that 3% is the allowable limit of variation in ECD between segments for stable cutting, beyond which the cutting process becomes unstable. Analysis of the Eigen value contribution showed that a minimum of three principal components are necessary for accurate and

reliable classification. The results are validated with machined surface analysis, which are in agreement with each other.
Keywords: Audio signal, Micromilling, Segmentation, Ti6Al4V.

Paper ID #257

Micro Machinability Evaluation of Bottom Pouring Stir Cast Al6061/Gnps Nanocomposites

Sunil Rawal[1*], Mayank Kumar[1], Tharra Bhavani[1], Ajay M. Sidpara[1*], Jinu Paul[2]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kharagpur
Kharagpur, West Bengal-721302, India
[2]Department of Mechanical Engineering, National Institute of Technology Calicut, Karnataka-673601, India
*ajaymsidpara@mech.iitkgp.ac.in

Abstract. A novel class of materials called aluminum matrix composites has the potential to meet the requirements of advanced engineering applications. In the current study, Al6061-based GNP nanocomposites were fabricated using a bottom-pouring stir casting technique. Microstructural characterization techniques were used for analyzing the distribution of reinforcement particles and the presence of those particles in the nanocomposite. SEM micrographs showed the dendritic structure with a reduction of the casting defects due to the wetting agent. Intermetallic compounds were observed during the fabrication, which was confirmed by the XRD spectrum. The effect of GNPs on the matrix material was evaluated through mechanical characterization. The microhardness result showed a 25% increase in hardness compared to the base Al6061 alloy. The micromachinability of the fabricated nanocomposite was evaluated. Microchannels were machined using a two-fluted TiSiN-coated solid carbide end mill tool with a 500 µm diameter. The influence of micromachining parameters, including feed rate, spindle speed, and depth of cut, on surface roughness and cutting force was analyzed. The ANOVA result showed that the optimum parameter was observed at a spindle speed of 21000 RPM, a feed rate of 10 mm/min, and a 200 µm depth of cut, which showed lower surface roughness and cutting forces. The results showed that with an increase in spindle speed, F_y and F_z decreased by 35% and 13%, respectively, because of the thermal softening of the material. The optimum cutting parameter can generate a channel that is high in quality and dimensionally accurate with few little burrs.
Keywords: Bottom pouring stir casting, Aluminum matrix nanocomposite, Graphene nano platelets, Micromilling, Machinability.

Paper ID #258

Effect of Weld Zone and Forming Histories on Crushing Behaviour of Stretch-Formed Domes of Laser Welded Blanks

Bhupesh Singh Katiyar[1*], Sushanta Kumar Panda[1], Partha Saha[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, Kharagpur
West Bengal, 721302, India
*sushanta.panda@mech.iitkgp.ac.in

Abstract. In the present study, a 2 kW CNC controlled fiber laser facility was exploited to weld extra deep drawing (EDD) steel sheets of 1.2 mm thickness to fabricate similar material combination laser welded blanks (LWBs) with weld zone (WZ) lying at the center. The LWBs and monolithic EDD steels were subsequently deformed utilizing an indigenously developed stretch forming setup consisting of a hemispherical punch under both lubricated and un-lubricated conditions to achieve a similar dome height of approximately 14.10 mm. All these specimens were compressed between two parallel flat platens under a quasi-static crushing speed of 2 mm/min. The compression of the stretch-formed domes initiated with flattening of hemispherical portion. Later, inward dimpling of hemispherical portion followed by flattening of conical portion were witnessed. It was found that the load progression during crushing of the lubricated stretch-formed specimens

was better than that of the un-lubricated specimens. Overall, 4-5% increase in the energy absorption and mean crushing load was observed in all the lubricated EDD and LWB specimens in comparison to their respective un-lubricated specimens. Moreover, due to the presence of the WZ, the LWBs absorbed 4% more energy than the monolithic EDD steels. The FE model of crushing test was developed and it was validated that the prediction result was better with incorporation of anisotropy of the sheet metal, WZ properties and forming histories in terms of effective plastic strain and thickness distribution.

Keywords: Laser Welding, Tailor Welded Blanks, Forming Histories, Crushing.

Paper ID #259

Influence of Voltage and Scanning Rate on Surface Finish in Electrochemical Jet Machining (EJM) of Ti6Al4V

Arindam Maity[1*], S. Mitra[2], B. Bhattacharya.[3]
[1,2,3]Department of Production Engineering, Jadavpur University, Kolkata-32, India
*arindammaity1947@gmail.com

Abstract. Significant potential is demonstrated by electrochemical jet machining due to its versatility and wide-ranging applications in various manufacturing industries, particularly within the defense and biomedical sectors. In the forthcoming years, it is expected to be regarded as a highly proficient, successful, and widely adopted unconventional machining process within contemporary manufacturing. An adaptable in-house setup for electrochemical jet machining is the focus of this research, with the aim of investigating the influence of voltage and scanning rate on the surface finish of Ti6Al4V. Experiments were conducted on Ti6Al4V, a specialized titanium-based super-alloy (titaniumaluminum-vanadium) engineered for applications requiring exceptional strength and heat resistance. The primary process parameters, namely voltage and scanning rate, were varied to ascertain their effects on surface roughness. During the electrochemical jet machining of Ti6Al4V, excellent surface finishes ranging from 0.115 to 0.146 μm were achieved, utilizing a mixed electrolyte composed of NaBr (1 M) and NaNO3 (1 M). The flushing process was substantially improved by the incorporation of an inner jet tool, thereby leading to a remarkable enhancement in machining accuracy.

Keywords: Electrochemical jet machining, Ti6Al4V, surface finish.

Paper ID #260

A Method to Control an In-Situ Temperature in Micro End Milling of Ti6Al-4V

Jyotirmay Behera[1*], Syed Naveed ul Meiraj[2], Ponnusamy Pandithevan[3]
[1]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai - 600127, Tamilnadu, INDIA.
[2]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai - 600127, Tamilnadu, INDIA.
[3]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing Kancheepuram, Chennai - 600127, Tamilnadu, INDIA.
*ppthevan@iiitdm.ac.in

Abstract. Titanium and its alloys are the most preferred materials in aerospace and biomedical field because of the high strength-to-weight ratio, excellent corrosion resistance, and superior heat resistance. However, titanium alloys pose challenges in machining due to their poor thermal conductivity, varying shear strength, low modulus of elasticity, high chemical affinity, and high red-hot hardness. Elevated temperatures can result in thermal expansion, softening, and even chemical reactions, compromising the structural integrity and dimensional accuracy of the titanium component. Therefore, this study focused on temperature control in micro end-milling of Ti-6Al-4V alloy using linear and macro tile tool paths. The results revealed that when the spindle speed was chosen below 5000 rpm, the linear tool path generated lesser temperature compared to the

macrotile tool path. However, when the spindle speed was chosen above 5000 rpm, the macrotile tool path generated a lesser temperature than the linear tool path. These results indicated that the choice of tool path along with process parameters were crucial in controlling the temperature during machining of Ti6Al-4V alloy. From the study it was concluded the macrotile tool path was the best to mill the Ti-6Al-4V alloy at high spindle speeds.
Keywords: Micro Machining, End Milling, Fractal Geometry, Ti-6Al-4V.

Paper ID #262

Deformation Behaviour of Friction Stir Welded Cu-Cr-Zr- Ti Alloy Sheet during Single Point Incremental Forming

Dibya Ranjan Behera[1*], Bhupesh Singh Katiyar[1], Aniket Singh[1], Prasun Kundu[1], Sushanta Kumar Panda[1*], Sujoy Kumar Kar[2], S.V.S. Narayana Murty[3]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, 721302, India
[2]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal, 721302, India
[3]Vikram Sarabhai Space Centre, Indian Space Research Organisation, Thiruvanathapuram, Kerala, India
*sushanta.panda@mech.iitkgp.ac.in

Abstract. In the present work, Cu-Cr-Zr-Ti alloy sheets were joined through friction stir welding (FSW), and subsequently, the welded blank was deformed to obtain a truncated cone geometry using a single point incremental forming (SPIF) process. Through uniaxial tensile tests, performed to assess the integrity and evaluate tensile properties of welded specimens, it was found that the presence of weld zone decreased yield strength, ultimate tensile strength and total elongation by 21%, 13% and 8%, respectively, compared to the as-received specimen. The occurrence of final rupture in the base material away from the weld zone indicated sufficient weld integrity produced by the FSW process. Microstructure of the weld cross-section revealed very fine equiaxed grains in the stir zone (SZ) and coarser elongated grains in the thermo-mechanically affected zone (TMAZ), while the heat affected zone (HAZ) contained even coarser grains with annealing twins. Microhardness was found to be higher in SZ than TMAZ and HAZ due to the contribution of grain boundary strengthening. Further, the welded specimen failed during the forming process at a cup height of 37.32 mm with a wall angle of 75.88° through occurrence of fracture in the base material at the cone bottom resulting from maximum thinning. Based on these results, it was inferred that this alloy sheets fabricated by joining monolithic sheets through FSW technique can be potentially deformed into large depth parts of cryogenic engines employing the SPIF process.
Keywords: Cu-Cr-Zr-Ti alloy, Friction stir welding, Microstructure, Single point incremental forming.

Paper ID #263

Experimental Investigation on Milling Performance of TiAlN/TiN (PVD) Coated Tungsten Carbide Insert on SDSS 2507

Padala Sai Varaha Pradeep[1]*, Jayaram C Sasi[1], Jose Mathew[1]
[1]National Institute of Technology, Department of Mechanical Engineering, Calicut, India, 673601
*psvpradeep100@gmail.com

Abstract. Multi-layer coatings are widely used for conventional tools to reduce the wear of the cutting tools. In this study, a cutting insert coated with TiAlN/TiN multilayer coating with PVD deposition technique is used. To study the influence of various milling parameters, a full factorial design is employed. ANOVA is used to analyse the results and find the significant factors that affect the cutting force, tool wear and surface roughness. The surface morphology, elemental composition of the fresh-coated tool and worn out tool are characterised by SEM, EDS,

respectively. The inserts are used for end milling of Super duplex stainless steel under dry conditions. The characterization tests revealed several wear mechanisms like delamination, attrition, adhesion and diffusion wear took place. Dry milling tests are carried out with the coated inserts, they revealed that the diffusion of various elements from SDSS took place into the inserts.
Keywords: Super duplex stainless steels, ANOVA, SEM.

Paper ID #264

Fabrication of Hybrid Natural Fiber Reinforced Composite and Characterisation of Density and Void Volume Fraction

Pankaj Kumar Gupta[1*], Shubhender Singh Yadav[2], Anup Malik[3]
[1, 2, 3]Malaviya National Institute of Technology, Jaipur, (Raj.)-302017-INDIA
*pankaj.mech@mnit.ac.in

Abstract. Composites are a type of material utilized widely in different fields because of their superior mechanical and physical properties and the fact that they are designed for specific uses. Natural fibers have become a superior option for synthetic fibers over the last decade due to their advantages over synthetic fibers. However, animal fibers such as wool have not been used as a reinforcing phase very much [1]. Wool fiber has excellent thermal insulation properties, and it is due to the presence of nitrogen (15-18%) and water content that leads to interference of combustion. Its limiting oxygen index (LOI) is also very high (about 25) among other natural and synthetic fibers; this means that wool requires a high minimum oxygen concentration to maintain the combustion after the material is ignited [2]. Several researchers used the self-extinguishing property of wool and tried to form a composite. Flax fiber is a better choice for improving the mechanical properties of wool reinforced composite in present work. Fabrication of hybrid wool and flax reinforced polymer composite by HLU process and measuring the fraction void content in order to check the further physical and mechanical properties The strength of composites is determined by the matrix's quantity, void fraction, positioning, and nature of the reinforcement.
Keywords: Hybrid composite, natural fibers, density, void Volume Fraction.

Paper ID #265

Experimental Investigation on the Effects of Aluminate Coating on the Corrosion Behaviour of Additively Manufactured AlSi10Mg Alloy

Dr.V. Ezhilmaran[1], P. Suya Prem Anand[2], Pathalamuthu Pitchaimuthu[3], R. Damodaram[4]
J. Suresh kumar[5]
[1]Department of Manufacturing Engineering, College of Engineering, Anna University, Chennai
[2]School of Mechanical Engineering, VIT Vellore
[3]Department of Mechanical Engineering, Anand Institute of Higher Technology, Chennai
[4]Department of Manufacturing Engineering, SSN College of Engineering, Chennai
[5]Department of Mechanical Engineering, College of Engineering, Anna University, Chennai

Abstract. Selective laser melting (SLM), an additive manufacturing technique, enables the production of intricate metal components with superior mechanical qualities. Unfortunately, the surface corrosion that occurs on SLM-produced components limits their application. Sulfuric acid anodization has recently emerged as a viable method for improving the durability and corrosion resistance of AlSi10Mg alloy produced by SLM. This paper investigated the sulfuric acid anodization of an AlSi10Mg alloy produced by SLM. Several characterization techniques, including Energy Dispersive X-ray analysis (EDAX), Scanning Electron Microscopy (SEM) and Weight Loss Analysis by Acid Immersion Corrosion Test, were used to examine the effects of the anodizing period and electrolyte composition on the surface morphology and corrosion resistance of the anodized AlSi10Mg alloy. The results showed that the sulphuric acid anodization process effectively created a dense and uniform oxide layer on the surface of the AlSi10Mg alloy, which

improved its corrosion resistance property. The optimal anodizing conditions were found to be an anodizing time of 30 minutes, a temperature of 20°C, a current density of 0.5 A/dm^2 and an operating voltage of 40V. Overall, this study provides valuable insights into the sulphuric acid anodization process of SLM technique-made AlSi10Mg alloy, which has the potential to significantly improve the performance of corrosion behavior of these parts in various applications, such as aerospace and automotive industries.
Keywords: Additive manufacturing, SLM, AlSi10Mg, Aluminium alloy, Sulphuric acid Anodization, Corrosion behavior

Paper ID #266

Design and Analysis of Gradient Lattice Structure for Light Weighting Applications

Yadu Udayan[1*], A.K. Hemnath[1*]
[1]Department of Mechanical Engineering, Amrita School of Engineering Chennai Campus, Vengal, Tamil Nadu, 601103, India
*hemnathceg@gmail.com

Abstract. Additive manufacturing hasproven numerous advantages in many fields like aerospace, automobile, defence, etc. In these fields, a significant requirement is achieving a high strength-to-weight ratio by incorporating lattice structures. To achieve varied degrees of functionality and optimum strength-toweight ratio properties, gradient properties are acquired by adjusting design parameters such as cell size, strut length, and strut diameter of the unit cells in lattice systems. Comparing gradient lattice structures to non-gradient lattice structures, gradient lattice structures offer variable densification and porosities and the ability to combine many types of unit cells with various topologies. This work attempts to analyze and choose the suitable unit cell for generating gradient lattice structures. Different lattice structures are chosen and subjected to volume reduction and structural and distortion analyses. Based on the preliminary studies, the best lattice structures are chosen and incorporated as gradient lattice structures in aerospace applications.
Keywords: lattice structures, powder bed fusion, lightweight structure, metal additive manufacturing, distortion.

Paper ID #267

Experimental Investigations on Tool Wear Analysis in Dry Machining of SDSS 2507

Shafeeque T P[1*], Jayaram C Sasi[1], Allan George[1], Jose Mathew[1], Basil Kuriachen[1*]
[1]National Institute of Technology, Department of Mechanical Engineering, Calicut, India, 673601
*shafmangad@gmail.com

Abstract. Super Duplex Stainless Steels (SDSS) 2507 is a difficult-to-cut material that finds immense usage in different commercial uses owing to its excellent hardness, strength and wear resistance. Moreover, high work hardening, high built-up edge formation and low thermal conductivity make it difficult to machine which results in severe tool wear issues like chipping and catastrophic failures. Different studies have been seen on the machining of SDSS by using coated tools, but the use of MT CVD TiCN-Al_2O_3 is limited. Hence this study is an effort, in the orthographic turning process, to recognize the significance of different cutting parameters like speed, feed rate and depth of cut on the overall tool wear, cutting force and chip morphology using a full factorial (2^3) design using TiCN-Al_2O_3 coated tungsten carbide inserts. SEM and EDS analysis of tool rake face, flank face and chips are also carried out to study microstructural variations after machining. The lowest experimental levels recorded overall average flank wear and cutting force values of 0.118 mm and 46N and it was observed to be 0.163mm and 381N respectively at higher experimental levels.
Keywords: SDSS 2507, turning, wear progression, cutting force, surface roughness.

Paper ID #268

Modification of Engine Block Design for Modal Response Improvement: An FEA Based Case Study

Prince Pal Singh[1*], Jatinder Madan[2*], Rajat Tripathi[2], Pritpal Singh Virdi[3]
[1]3D Engineering Services, Chandigarh – 160036, India
[2]Chandigarh College of Engineering and Technology (Degree Wing), Chandigarh - 160019, India
[3]Research to Product Engineering Services, S.A.S Nagar, Punjab - 160055, India
*Jatinder.madan@gmail.com

Abstract. Engine blocks are fundamental components of automotive engines that experience various dynamic forces during operation. Modal analysis is a well-established technique in structural engineering that helps to identify natural frequencies, mode shapes and damping ratios of mechanical structures. This paper presents a case study to improve modal response of a four-cylinder engine block of a tractor by first identifying the regions of improvement using finite element analysis (FEA). Thereafter, the design modifications in the original design are made accounting for functional and manufacturability considerations. Lastly, the modified design of the engine block is analyzed for the modal performance to make comparison with the original design for making recommendations and decision support. The modified design showed improvements in modal frequencies across all the mode shapes with marginal increase in weight in mass of the engine block

Keywords: Modal Analysis, Finite Element Analysis, Manufacturability.

Paper ID #270

Residual Stress Analysis in an Infinite Plate with a Central Aperture under Thermal Loading

Mohit Rajput[1*], S.M. Kamal[2], R.U. Patil[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Jammu, India
[2]Department of Mechanical Engineering, Tezpur University, Tezpur-784028, Assam, India
*2020rme2068@iitjammu.ac.in

Abstract. This paper presents a comprehensive investigation into the reinforcement of lughole structures, widely employed across aerospace, automobile, and marine industries. The study focuses on augmenting the load carrying capacity and fatigue resistance of these structures by addressing the challenges posed by thermal loading and induced the compressive residual stresses surrounding the holes. In ABAQUS, using a thermo-mechanical couple temperature displacement approach is employed to capture the effects of temperature gradients on the mechanical response in the vicinity of hole. The plasticity is incorporated using von Mises yield to capture the yielding and plastic deformation behavior of the material in the vicinity of lughole structure under plane stress condition.

Keywords: Residual stress, Thermo-mechanical couple temperature displacement, von Mises yield criterion, Plane stress condition.

Paper ID #271

3D Printed Graded Metamaterial for Acoustic Applications

Prasenjit Sharma[1*], Janakarajan Ramkumar[1*]
[1]Dept. of Mechanical Engineering, IIT Kanpur, Kanpur, Uttar Pradesh, 208016
*prasenj@iitk.ac.in

Abstract. In order to create a model of acoustic diodes, functionally graded layers of a BCC unit cell are stacked. The samples are 3D printed using SLA technology. Due to their porous form, printing samples without support structures poses the greatest challenge. However, external supports are available to facilitate the removal of uncured resins. In the low-frequency region, the

unidirectional transmission of acoustic waves is identified (1-2000 Hz). Absorption coefficients with variable porosity and unit cell size is demonstrated in both directions (Forward and backward) with Finite Element Analysis. Experimental validation, numerical simulations, and analytical calculations based on the JCA model confirm the predictability and accuracy of graded metamaterials. Unidirectional transmission has numerous potentials uses in ultrasonic devices, such as acoustic rectifiers, acoustic one-way mirrors, acoustic diodes, and related domains.
Keywords: Graded Acoustic meta-material, SLA Printing, JCA model, Acoustic absorptivity

Paper ID #272

Comparative Thermal Analysis of Aluminum Welding using Friction Stir Welding (FSW), Plasma-FSW, and Tungsten Inert Gas (TIG)-FSW

Deepak Kumar Yaduwanshi[1*], Sandeep Karnwal[1], Sujeet Kumar[1], Subhash Chand[1], Praveen Kumar[1]
[1]Department of Mechanical Engineering, School of Engineering and Technology, IIMT University Meerut, U.P, India
*deepak.adigrat@gmail.com

Abstract. This research work presents the comparative analysis of heat input during aluminum welding focusing on Friction Stir Welding (FSW), PlasmaFSW, and Tungsten Inert Gas (TIG)-FSW. The objective of this study to study the thermal behavior and joint performance of these welding technique when applied to aluminum materials. To understand the heat transfer, temperature distribution and associated effect during the welding process plays a crucial role in thermal analysis. A comparison of the heat input, heat dissipation, and heat output of these three welding techniques is necessary for analyzing their weld characteristics. In this research work we used ABAQUS software to developed computational model and numerical simulation for analyses the thermal aspect of each welding technique. Welding parameters such as heat generation by tool, preheating by auxiliary heat source and welding speed are considered to understand heat distribution within the wed zone are evaluated and compared. The influence of auxiliary heat source by Plasma and TIG show major effect on thermal behavior of welding such as peak temperature, cooling rate and thermal gradients across the weldment. The thermal energy generated by the Plasma arc significantly contributes to elevating the peak temperature during Plasma-FSW. Due to the intense heat generated by the Plasma arc, the preheated zone has a higher peak temperature than the other two welding processes. A significant contribution of this study is the insight provided into the thermal behavior and performance of FSW, Plasma-FSW, and TIG-FSW in aluminum welding. Comparison of different techniques allows us to understand their advantages, limitations, and potential optimization strategies.
Keywords: Comparative analysis, Thermal analysis, Aluminum welding, Friction Stir Welding (FSW), Plasma-FSW, Tungsten Inert Gas (TIG)-FSW, Hybrid Friction Stir Welding.

Paper ID #273

Inclusive Application of Polymer 3D Printing and Metal Additive Manufacturing for The Development of Modular-Insert Type Wheels for Green Grinding

Thekkoot Surendran Sarath Babu[1*], V S Sooraj[2*]
[1,2]Department of Aerospace Engineering, Indian Institute of Space Science and Technology, Valiamala, Kerala, 695547, India
*sooraj@iist.ac.in

Abstract. Green and sustainable practices in machining that offer cost-effectiveness, reusability, reduction in energy, resources, and overflow are always encouraged to fulfill the vision of an environmentally friendly manufacturing sector. The present research marks its significance in this context, discussing the design and development of a custom-configurable and re-usable grinding wheel for surface grinding with the aid of additive manufacturing. A modular grinding wheel,

geometrically analogous to insert type tool and/or tyre-wheel unit of automobiles, with a re-usable base wheel and custom configurable abrasive segments attached on it, generated via Fused Deposition Modelling (FDM) and Laser-Powder Bed Fusion (LPBF), has been presented. Experiments using the proposed wheel, in comparison with traditional electroplated CBN wheel, showed superior grinding performance and surface topography. Application of the proposed wheel in segmented mode could effectively breakdown the boundary layer around the rotating wheel and shown a 31.58% reduction in grinding force, a 6.83% reduction in average roughness, and a 34.68% reduction in grinding temperature at selected cutting conditions. In addition to the re-usability of base wheel and reconfigurability of abrasive segments, the possibilities of internal passages in base wheel for coolant delivery have also been demonstrated, which showed a 56.31% reduction in grinding temperature as compared to flood cooling.
Keywords: Grinding Wheel, Modular, Re-usable, Additive Manufacturing, FDM, LPBF, Green Machining.

Paper ID #274

Functionalization of Additive Manufactured Ti alloy using Grinding Processes: Achieving Uniform Surface Roughness

M Ahmed[1*], N Arunachalam[2]
[1]Indian Institute of Technology Madras, Chennai, Tamil Nadu, 600036, India
[2]Indian Institute of Technology Madras, Chennai, Tamil Nadu, 600036, India
*chalam@iitm.ac.in

Abstract. Ti-6Al-4V alloy finds extensive use in medical contexts for bone replacement owing to its favorable mechanical characteristics and compatibility with biological systems. The Ti-6Al-4V alloy produced out of the electron beam melting (EBM) process cannot be used directly for any specific applications. The surface texture needs to be functionalized using various postprocessing techniques. In this paper Precision grinding operations is selected as a post processing technique to achieve required high degree of surface finish and tighter surface tolerance for the final component. The influence of processing conditions on the surface including wheel speed, depth of cut, and feed rate on the critical parameters such as grinding force, surface grinding energy, surface roughness, surface morphology, and chip morphology. The effect of these parameters was studied, and some key influencing parameters and their levels are identified for effective processing of this additive manufactured components. The paper specifically focuses on the uniformity of the surface and its influence on the overall surface finish.
Keywords: Electron beam melting Additive manufacturing, Grinding process.

Paper ID #275

Joining of Dissimilar AA6063-T6 and CRCA/IS-513 Alloys By FSSW-C and Conventional FSSW: A Comparative Study through Modelling and Simulations

Sukanta Das[1*], R. Ganesh Narayanan[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology, Guwahati, Assam, 781039, Assam
*sukan176103114@iitg.ac.in

Abstract. Friction Stir Spot Welding with a Consumable Sheet (FSSW-C) is an advanced, sustainable method for welding dissimilar alloys, effectively tackling tool wear. Here, the tool engages a consumable sheet above base sheets, separated by gap at the edges. A pinless tool stirs and softens the consumable sheet with frictional heat, and forging pressure pushes material into the gap, bonding with base sheet edges. Preventing tool wear is a key advantage. This study compares FSSW-C to conventional FSSW through finite element simulations using DEFORM 3D. Both methods are tested at rotational speeds: 612 rpm, 900 rpm, and 1200 rpm. FSSW-C shows an 18%

lower peak temperature. As rotational speed rises, both the processes show increased effective strain and strain rates. FSSW-C consistently reports higher effective strain and strain rates, signifying superior material flow behavior and enhanced material distribution.
Keywords: FSSW-C, FSSW, Effective Strain, Effective Strain Rate.

Paper ID #276

Microstructural and Tribological Property Investigation on SS316L-Cu Graded Bulk Deposit Prepared by Wire Arc Additive Manufacturing

Bunty Tomar[1*], S. Shiva[1]
[1]Laboratory for Advanced Manufacturing and Processing, Indian Institute of Technology Jammu, Jammu and Kashmir, 181221, India
*bunty.tomar@iitjammu.ac.in

Abstract. Fabricating steel and copper-based functionally graded material (FGM) via cold metal transfer-based wire arc additive manufacturing (CMT-WAAM) is an innovative investigation. Components combining Cu and steel show significant usage in many industrial applications as they combine high corrosion resistance, ductility, thermal conductivity, and wear resistance to excellent mechanical properties. Joining steel and copper is challenging due to the mismatch in their thermo-mechanical properties. In this experiment, a functionally graded material (FGM) bulk structure of pure copper (Cu) and 316L stainless steel (SS) was successfully developed using CMT-WAAM. The bulk fabricated samples were characterized under optical microscopy, and field emission scanning electron microscopy in as fabricated conditions. The tribological properties of the samples were analyzed using ball on disc tribometer. The wear track was investigated to reveal the wear mechanism. This works paves the way to use CMTWAAM to fabricate steel/copper bulk FGMs.
Keywords: WAAM; Cold metal transfer (CMT); Metals and alloys; Microstructure; Wear

Paper ID #277

A Comparative Study on Surface Roughness analysis during Turning of Additively Manufactured and Wrought Inconel-718

Mahesh Deshmukhe[1*], Yash Raut[1], Navneet Khanna[1], Kamlesh Joshi[1*]
[1]Department of Mechanical and Aerospace Engineering, Institute of Infrastructure, Technology, Research and Management, Ahmedabad, Gujarat, 380026, India
*kamleshjoshi@iitram.ac.in

Abstract. Inconel-718 (In-718) is a difficult to machine superalloy with unique properties which makes it one of the widely used material. Additive manufacturing processes, particularly Selective Laser Melting has ability to print metallic parts with decent surface integrity. However, the part printed from the process still required some post machining to achieve desired surface finish to make it functional during actual working conditions. This works explores the surface integrity of the machined surface of additively manufactured In-718 after turning operation under three different type of cutting environments: dry, flood, and cryogenic (using liquid CO_2). The machining operation was performed at three different cutting velocities of 60, 70, and 80 m/min. The roughness so obtained were compared with the roughness obtained by machining of wrought In-718. The surface roughness was observed to be deteriorating with an increase in cutting velocity for both wrought and AMed part due to excessive heat generation at higher cutting velocities during dry machining while the use of cryogenic environment significantly improves the surface quality at higher cutting velocity (80 m/min). The lowest surface roughness of 0.4 µm under cryogenic machining environment. Machining of wrought part at 80 m/min indicated an improvement in *Ra* by 18.1% and 17.77% in flood and cryogenic environment, respectively and an improvement by 13% in flood and 59% in the cryogenic environment for additively manufactured part. Overall, it

was observed that cryogenic machining environment supports better surface finish for the machining of additively manufactured In-718 even at higher values of cutting velocity.
Keywords: Cryogenic machining, Inconel, Additive Manufacturing, Surface roughness, Tool wear.

Paper ID #278

Thermomechanical Modeling and Analysis of Friction Stir Butt Welding of Aerospace Grade Aluminium-alloy (2219-T87) Plates

Ramana Murthy Bagadi[1*], Jeevan Jaidi[2], Karthik G M[3], Suresh D Meshram[4]
[1]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
[2]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
[3]Department of Mechanical Engineering, IIT BHU, Varanasi, Uttar Pradesh, 221005, India [4] [4]Metal Joining Group, DMRL, Hyderabad - 500058, Telangana, India
*ramanam757@gmail.com

Abstract: Friction Stir Welding (FSW) process is widely used for joining of similar and dissimilar, ferrous and non-ferrous metals in automobile, aerospace, and defence industries. The selection of optimum process and tool parameters for a given workpiece material and thickness is essential to generate adequate heat and material flow around the tool-pin and get a defectfree weld. The experimental approach in designing optimum parameters is a tedious, time-consuming, and expensive, and therefore, the simulation-based approach would be cost-effective and also provides a comprehensive data in real-time. A 3-D coupled thermomechanical model is developed in COMSOL Multiphysics software and studied the effect of welding speeds (200-600 mm/min) on thermal histories, workpiece material deformation, von Mises stresses, equivalent plastic strains, and weld zones in butt welding of Al-Cu binary alloy (2219-T87) plates at high welding (traverse) speeds. The yield stress-based frictional heat source model and temperature-dependent thermophysical and mechanical properties of AA2219-T87 are used. A conical tool-pin (8 and 5.5 mm as pin diameters, 5.5 mm pin height, 21 mm tool-shoulder diameter) with 750 rpm and 25 kN load is used for 6 mm thick plates. The authors proposed a range of temperatures for FSW zones of AA2219-T87, and found a good agreement between the predicted and experimental zones with material bulge at the tool shoulder edge, which decreases with an increase in welding speed.
Keywords: FSW, Thermomechanical model, Traverse speed, von Mises stress, Equivalent plastic strain.

Paper ID #279

Development and Quasi-Static Compressive Behaviour of Al-Cenosphere Composite Foam

Ashish Kumar Singh[1*], Anubhav Singh[1], Prosenjit Das[1]
[1]Advanced Manufacturing and Materials Processing Laboratory (AMMPL), Department of Materials Engineering, Indian Institute of Science (IISc), Bangalore, 560012, India
*prosenjitdas@iisc.ac.in

Abstract. In the present investigation, aluminium foams are fabricated via stir casting route using titanium hydride (TiH_2) as a foaming agent. Microstructural analysis of the foams has been carried out in terms of cell geometry and cell wall thickness. The compressive deformation behavior of these foams is examined under varying temperatures of test chamber i.e., at 25^{o}C, 100^{o}C, 175^{o}C, 250^{o}C, and 325^{o}C, at different low strain rates. The primary findings of the compression test include the stress value corresponding to the yield plateau as well as the amount of energy absorbed till the densification strain. The energy absorption ability of the foams increases as the strain rate increases. Furthermore, energy absorption initially increases with the increasing test temperature and thereby reaches a peak value at 175^{o}C. Whereas beyond the peak temperature, the amount of energy absorption decreases with the increasing test temperature. Microscopic analysis of the deformed foam samples has been conducted to gain insights into the predominant failure modes.

This analysis revealed that at lower temperature range, the prevalent deformation modes are cell wall cracking and crushing, whereas at higher temperature, cell wall bending and buckling are the dominant deformation mechanisms.
Keywords: Aluminium, Cenosphere, Composite foam, Plateau stress, Densification, Energy absorption.

Paper ID #280

A Numerical Study on KrF Excimer Laser Ablation of Unidirectional CFRP Using Simplified Geometric Models with Two Separate Strategies

Joydeep Kundu[1*], Santosh Mandal[2], Partha Saha[1*]
[1]Indian Institute of Technology Kharagpur, Kharagpur – 721302, India
[2]Aerospace Composites Division, Hindustan Aeronautics Limited, Bengaluru-560037, India
*psaha@mech.iitkgp.ac.in

Abstract. In this numerical study, two separate strategies were proposed for the development of the simple geometrical models of unidirectional carbon fibre reinforced polymer (UD CFRP) and numerical simulation of KrF excimer laser ablation treatment of UD CFRP was done with those proposed models. Matrix polymer lamina and carbon fibre laminas were considered in Strategy 1, whereas in Strategy 2, intermediate lamina was also considered along with those aforementioned laminas. The temperature ranges obtained at the topmost surface after numerical simulation with Strategy 1 and Strategy 2 were 710.22 K – 745.35 K and 709.60 K – 744.73 K, respectively. However, the temperature ranges which were obtained at the lowest position of matrix polymer lamina were 329.12 K – 330.45 K and 330.30 K – 332.67 K after numerical simulation with Strategy 1 and Strategy 2, respectively. Comparing the obtained temperature range at the lowest position of the matrix polymer lamina, it was suggested that the performance of Strategy 2 was marginally better than Strategy 1. The experimental validation of the KrF laser ablation of UD CFRP was also done. The carbon fibres were visible after efficacious ablation of the first layer matrix polymer during experiment.
Keywords: KrF Excimer Laser Ablation, Unidirectional CFRP, Numerical Modelling.

Paper ID #281

Unleashing the Mechanical Characteristics of PLAMWCNTs for Medical Advancements

Bobby Tyagi[1*], Abhishek Raj[1], Akash Jain[1], Tapish Raj[1], Ankit Sahai[1], Rahul Swarup Sharma[1]
[1]3D Printing and Additive Manufacturing Lab, Department of Mechanical Engineering, Dayalbagh Educational Institute, Dayalbagh, Agra, Uttar Pradesh-282005, India
*bobbytyagi079@gmail.com

Abstract. A prosthetic socket is a component of an artificial lower limb and can be characterized as the mechanism that connects the prosthetic limb to the amputated portion. The objective of this study is to investigate the impact of key control variables, namely nozzle hole diameter (NHD) at three levels (0.15mm, 0.25mm, and 0.40mm) and internal filling pattern (IFP) with three different configurations (grid, tri-hexagon (THN), honeycomb (HCB)), on the mechanical properties of PLA reinforced with multi-walled carbon nanotubes (PLAMWCNTs). These specimens were fabricated through the fused filament fabrication (FFF) process. The ensuing samples were subjected to both flexural and compressive testing. Following these tests, a detailed fractographic analysis was conducted. Subsequently, Taguchi's technique was applied to perform a statistical analysis of the experimental outcomes. The findings derived from this investigation are then utilized to design and produce an economically efficient transtibial prosthesis employing 3D contour acquisition and FFF technology. The objective is to create a prosthetic socket that exhibits superior flexural and compressive characteristics and enhanced overall strength.
Keywords: Fused filament fabrication, PLA-MWCNT, flexural behaviour, Taguchi, prosthesis.

Paper ID #282

A Comparative Study of Effects of Multiple Reinforcements Incorporated with Al-Si-Mg Alloy using Friction Stir Processing

Pratap Singh*, Akash Jain, Ankit Sahai*, Rahul Swarup Sharma
Department of Mechanical Engineering, Dayalbagh Educational Institute (Deemed University), Agra – 282005, India
*sahaiankit@dei.ac.in

Abstract. This study presents a comparative analysis of the effects of multiple reinforcements incorporated into an Al-Si-Mg alloy using friction stir processing (FSP). The study aims to investigate the microstructure and mechanical properties of the composites produced by incorporating various reinforcement materials, such as multiwalled carbon nanotubes (MWCNTs), aluminum oxide (Al_2O_3), and silicon dioxide (SiO_2). The results show that the addition of MWCNTs, Al_2O_3, and SiO_2 to the Al-Si-Mg alloy significantly improves its mechanical properties. The topmost tensile strength of 183.31 MPa is reported for Al-MWCNTs composite, representing an 18% compared to the base metal's strength (155.27 MPa). Similarly, nanocomposites reinforced with SiO_2 and Al_2O_3 exhibit strength enhancements of 11.18% and 7.33%, respectively. The Al alloy had an initial hardness of 68.45 Hv, while MWCNTs reached the highest value at 96.2 Hv, surpassing Al_2O_3 (94.6 Hv) and SiO_2 (85.8 Hv). Hardness increased 1.4 times for MWCNTs, 1.38 times for Al_2O_3, and 1.25 times for SiO_2 compared to the base samples. Fractured samples were analyzed using FESEM. The Al-MWCNTs composite displayed cracks and MWCNT clusters, potentially contributing to its strength. The Al-Al_2O_3 composite sample showed scratches, and an EDS analysis confirmed aluminum predominance. The Al- SiO_2 sample had holes, Si clusters, and a higher Si content than the base metal Al6061. Overall, this study provides insights into the effects of multiple reinforcements on the properties of Al-Si-Mg alloys, which can help in the development of advanced materials with improved performance characteristics for various industrial applications like automotive, aerospace, railway, shipbuilding, etc.

Keywords: Friction stir processing, Tensile strength, Hardness, Fractography.

Paper ID #283

Evaluating the Influence of Infill Density for Impact Behaviour of Virgin PLA and Its Composites

Tapish Raj[1*], Akash Jain[1], Bobby Tyagi[1], Ankit Sahai[1], Rahul Swarup Sharma[1]
[1]3D Printing and Additive Manufacturing Lab, Department of Mechanical Engineering, Dayalbagh Educational Institute, Dayalbagh, Agra, Uttar Pradesh-282005, India
*tapish194102@dei.ac.in

Abstract. The emergence of Fused Filament Fabrication (FFF) technology has opened new avenues for researchers to create intricate geometric structures, particularly for designing high-impact energy-absorbing structures across various applications. This study focused on conducting impact tests to quantify the energy absorption capabilities of two types of fused filament-fabricated polymer composites: carbon fibre-reinforced poly-lactic acid and graphene-reinforced poly-lactic acid. The investigation involved varying infill patterns and infill densities. Among the various infill patterns and densities tested, it was found that a concentric infill pattern with a 90% infill density demonstrated the highest energy absorption performance for carbon fibre-reinforced poly-lactic acid. The experimental data from the impact tests clearly indicated that the impact strength was directly correlated with both infill density and infill pattern. Specifically, adjusting the infill density resulted in a reduction in the impact strength of the printed specimens. To gain further insights into how the energy-absorbing behaviour depended on the chosen process parameters, an analysis of variance using Taguchi's method was applied to the impact test results. Additionally, the examination of fractured surfaces using scanning electron microscopy (SEM) revealed various types of voids and showed improved interlayer adhesion for different composite materials. This

research significantly contributes to our understanding of the mechanical properties of PLA (poly-lactic acid) and its composites. The knowledge gained from this study has the potential to drive advancements in the fields of material science and FFF technology, with broader implications for applications requiring high-impact energy absorption.
Keywords: Fused filament fabrication, infill pattern, infill density, mechanical characteristics, poly lactic acid.

Paper ID #284

Machine Vision Integrated Machine Learning Module for Predicting Abrasive Waterjet Milled Surface Quality

Chinmoyee Datta[1*], Hari Ranjan Meena[1], D.S. Srinivasu[1 *]
[1]Indian Institute of Technology Madras, Chennai, Tamilnadu, 600036, India
*devadula@iitm.ac.in

Abstract. Complex surfaces in advanced engineering materials (AEMs) can be generated using abrasive waterjet (AWJ) technology due to the high material removal rate, high surface quality and hence can be utilized in the healthcare, aerospace, and automotive industries. Although AWJ technology can machine AEMs without burr, long chips, and thermal deformation, unlike conventional machining, the process is stochastic aggressive, and producing highquality finish is challenging. Furthermore, due to process instability and material ductility, the surface has uneven depth and waviness. Hence, a characterization approach is needed to measure the quality of milled parts. Although the confocal laser scanning microscope and optical profilometer are used to measure texture characteristics, these have drawbacks, such as (i) the difficulty of incorporating into the production workflow and providing real-time feedback and (ii) the high cost and slow operational speed. Therefore, the present work proposes an in-situ approach for predicting the surface waviness (W_a) of the AWJ milled components. The proposed approach leverages machine learning (ML) techniques to analyze the image data during milling and extract valuable insights. Furthermore, the principal component analysis (PCA) is incorporated to determine the most influential characteristics in the data, allowing for a better understanding of the underlying variables influencing surface quality and reducing the multi-collinearity effect. Following this, the ML model is used to train the PCA features to predict surface waviness. Among all the prediction models considered in the study, Huber's regressor model provided the most accurate prediction, with an R^2 value of 0.92 for surface waviness.
Keywords: AWJ milling, PCA, Machine learning, Huber regressor.

Paper ID #285

Optimization of Abrasive Jet Drilling on Alumina Plate using Silicon Carbide Abrasive

Deb Kumar Adak[1,2*], Sourav Misra[2], Santanu Das[*2], Naser A. Alsaleh[3], Barun Haldar[3]
[1]Department of Mechanical Engineering, College of Engineering & Management, Kolaghat, KTPP Township, West Bengal- 721171, India.
[2]Department of Mechanical Engineering, Kalyani Government Engineering College, Kalyani, West Bengal-741235, India.
[3]Mechanical and Industrial Engineering Department, College of Engineering, Imam Mohammad Ibn Saud Islamic University, Riyadh 11432, Saudi Arabia
*debkumaradak1968@gmail.com

Abstract. Abrasive jet machining is a widely used machining process for hard and brittle materials which are quite difficult to machine by conventional machining processes. Drilling is done with high velocity stream of gas carrying fine abrasive particles which impact on the work surface to erode the material as required. Optimization of material removal rate (MRR) as well as nozzle wear rate (NWR) are possible by deciding appropriate range of process parameters such as abrasive flow

rate, abrasive grain size, system pressure and stand-off distance (SOD). Experiments have been designed with Box–Behnken design of response surface methodology (RSM) and the analysis is done using Minitab 2017. Drilling is carried out on 99.7% pure alumina plate of 4 mm thickness, using silicon carbide (SiC) abrasive. After performing analysis of variance (ANOVA), significance of individual parameter and their interactions are found out in terms of judging 'p' value with more than 95% confidence level. The working jet pressure contributes significantly on material removal rate through impact erosion. It has been noted that as system pressure increases, MRR and nozzle wear rate (NWR) show an increasing tendency.
Keywords: Abrasive jet drilling, alumina plate, material removal rate, nozzle wear rate, stand-off distance, response surface methodology.

Paper ID #286

Experimental Investigations and Development of a Welding Fixture for Friction Stir Welding of Titanium Alloys

Ramprasad Ganesan[1*], Hema Pothur[2]
[1]Research Scholar, Department of Mechanical Engineering, S V U College of Engineering, Sri Venkateswara University, Tirupati, Andhra Pradesh, 517502, India.
[2]Associate Professor, Department of Mechanical Engineering, S V U College of Engineering, Sri Venkateswara University, Tirupati, Andhra Pradesh, 517502, India.
*ramprasadofficial16@gmail.com

Abstract. Joining titanium alloys by Friction Stir Welding (FSW) is a multifarious process that involves thermal and mechanical phenomena at the weld interface. As such the literature shows there is a need for a welding fixture to constrain the workpieces firmly and to withstand the various forces, and temperatures developed during the joining process. Therefore, in this research, a solemn attempt is made to conduct a series of pilot experiments for FSW of titanium sheets in a conventional vice setup, and the various defects and failures that arose during the processes were established. The welding fixture was designed considering the 3-2-1 principle of location for constraining the corresponding degrees of freedom and based on the defects and failures encountered in the pilot experiments. The selection of suitable fixture material was analyzed for three different materials using Finite Element Analysis (FEA). After the selection of the suitable material from the analysis, the fixture was fabricated using various techniques and then heat-treated accordingly. The efficacy of the fabricated fixture was validated by experimental investigation by joining titanium alloy. The validation results confirmed that a superior weld joint was obtained in comparison to the pilot experiments.
Keywords: Titanium alloys, Static structural analysis, Steady-state thermal analysis.

Paper ID #287

Influence of Microtool's Shape and Size on Microchannel Fabrication through Micro-EDM

Biswesh Ranjan Acharya[1*], Abhijeet Sethi[1], Aher Sumeet Milind[1], Partha Saha[1*], Dilip Kumar Pratihar[1]
[1]Indian Institute of Technology Kharagpur, Kharagpur – 721302, India
*psaha@mech.iitkgp.ernet.in

Abstract. Micro-EDM is a versatile technique for fabricating various microfeatures, such as microholes, microchannels, and 3D features on any metallic surface. Microchannel fabrication remained one of the critical topics in micromachining due to its extensive application in microfluidics, bio-medical, etc. In general, cylindrical microtools are extensively opted by researchers for microchannel fabrication. The current paper investigated the effect of the size and shape of the microtools during microchannel fabrication on SS304. Four microchannels were fabricated using different microtools of varying shapes (cylindrical and cut-edge) and sizes (with approximate diameters of 200 μm and 100 μm). Fabricated microchannels were compared based on

their lateral overcut, frontal overcut, channel depth, and surface roughness (Ra). The lateral overcut was less than the frontal overcut. However, both could be improved by employing cut-edge microtools. Cylindrical microtools were used to fabricate microchannels with wide bottoms and parallel walls. A reduction in the microtool diameter decreased the microchannel depth due to increase in longitudinal tool wear. The cylindrical microtool with a larger diameter fabricated microchannels with the least surface roughness. Employing cut-edge microtools instead of cylindrical microtools, increased the tungsten deposition and decreased the carbon deposition on the microchannel surface. Reduction in the microtool diameter increased the tungsten deposition and decreased the carbon deposition due to the increased longitudinal tool wear and fall in the microchannel depth, respectively.
Keywords: Tungsten Microtool, Micro-EDM, SS304, Microchannel, Shaped Microtool, Overcut, Surface Roughness.

Paper ID #290

Low-Cost Fabric-Based Wearable Energy Storage Device

Soumili Sahoo[1*], Santosh K. Mishra[1], Animesh Pandey[1], Tribeni Roy[1*]
[1]Department of Mechanical Engineering, Birla Institute of Technology and Science Pilani, Rajasthan 333031, India
*tribeni.roy@pilani.bits-pilani.ac.in

Abstract. Wearable energy storage devices (ESDs) like batteries, supercapacitors, and hybrids, are currently being explored as possible energy storage solutions for flexible electronics. Textile-based composites show significant promise as the electrical device provides for the development of smart clothing. Graphite-based composite materials are establishing themselves as significant electrode materials in the devices that store energy. The customized structures of devices improved electrical and thermal conductivities, mechanical qualities, cost-effectiveness, and expansive surface area. In this work, the developed supercapacitors based on graphite are abortable as well as wearable. The performance of the fabricated supercapacitor was analyzed using electrochemical characterization and the results indicate that the device has an areal capacitance of 12.686 mF/cm^2, an energy density of 1.44 mWh/cm^2, and a power density of 52 mW/cm^2. The Nyquist curves of the device have also been investigated using electrochemical impedance spectroscopy that showed an equivalent series resistance is 44.2Ω.
Keywords: Wearable ESD, textile, graphite, electrochemical characterization.

Paper ID #292

Finite-Element Simulation Study of Electrode Configurations on Weld Quality Parameters of Resistance Spot Welding of Aluminium-Alloy/Steel Sheets

Prashanth Kumar Reddy Gillela[1*], Jeevan Jaidi[2], Karthik Gangaraju Manogna[3]
[1]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
[2]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India
[3]Department of Mechanical Engineering, IIT BHU, Varanasi, Uttar Pradesh, 221005, India
*gprashanth.s26@gmail.com

Abstract. Aluminium-alloys are becoming increasingly integrated into the conventional steel car body structures to achieve light weight, resulting in increased fuel efficiency and reduced exhaust emissions. Joining of aluminium-alloy and steel sheets by Resistance Spot Welding (RSW) process is challenging because of distinct electrical, thermal and mechanical properties. As a result, there will be a severe heat imbalance between the sheets during the RSW process. In the present study, simulations are performed for the RSW of Al-alloy/steel sheets with two different combinations of electrode caps (radius/radius - F/F, and radius/truncated – F/E), and the predicted results are analysed in terms of the current density and temperature distribution, nugget sizes as well as flow

and residual stresses. A finite-element (FE) based transient 2-D axisymmetric coupled electrothermomechanical model is developed (in COMSOL Multiphysics software) considering the elastoplastic behaviour of the sheets and temperature dependent thermophysical and electrical properties of the electrode and sheet materials. The contact conductance model for resistance to the transport phenomena across the interfaces, and the apparent heat capacity model for phase-change (melting/solidification) are used. It is found that the melting of Al-alloy sheet occurred along the faying surface, while in steel sheet, it occurred at the sheet center. The predicted nugget sizes are in good agreement with the measured data from the literature. Also, it is found that the residual stresses are significantly low with the F/E electrode combination than with that of F/F electrodes.
Keywords: RSW, Al alloy/steel, contact conductance, nugget size, residual stress.

Paper ID #293

A Review on Additively Manufactured Prosthetic Devices

Ajeet Manna[1*], Dayanidhi Krishana Pathak[1*], Anurag Dixit[1], Pawan Sharma[2]
[1]G.B. Pant DSEU Okhla-I Campus (formerly known as G.B. Pant Govt. Engineering College), Okhla-III, New Delhi-110020, India
[2]Indian Institute of Technology Banaras Hindu University, Varanasi, Uttar Pradesh-221005, India.
*dayanidhikrishana.pathak@dseu.ac.in

Abstract. There are numerous applications for additive manufacturing (AM, often recognized as 3D printing). In the non-technical world, AM, sometimes known as 3D printing, is a technique for creating tangible parts utilizing computer-aided design and building items layer by layer. With AM process, there is no restriction on complexity or customization. Though AM provides a significantly larger possibility for personalization and complicated geometries when compared to conventional production, these features are not unique to AM. Tailored implants, medical models, and saw guides are the most frequently used medicinal applications. Prosthetic and orthotic advancements have always been made possible by developments in related disciplines. The art of creating prosthetic limbs has allowed people who have lost a limb to be fitted with a prosthetic that performs so well and closely matches the original appearance that they can get back to their daily tasks. For the manufacturing of prosthesis, a variety of material such as wood, aluminum, aluminum alloys, plastic, leather, various metals, and their composites can be used. Artificially created organs that are implanted through surgery include hearing devices, prosthetic heart valves, cartilage, and ligaments. While prosthesis replaces a limb or other bodily component, an orthosis supports and improves them. The major aim of this paper is to showcase a quantitative examination of the available 3D printed prosthetic devices and the evolution of fabrication of prosthetics with the AM technologies.
Keywords: 3D Printing, Customized, Orthotics, Prosthetic.

Paper ID #294

A Simulation based Degradation Study of 3D Printed Ti6Al4V Screw and Plate Implant

Dayanidhi Krishana Pathak[1*], Pawan Sharma[2], Deepanshu Verma[3]
[1]G.B. Pant DSEU Okhla-I Campus (formerly known as G.B. Pant Govt. Engineering College), Okhla-III, New Delhi-110020, India
[2]Indian Institute of Technology Banaras Hindu University, Varanasi, Uttar Pradesh-221005, India
[3]Indian Institute of Technology Delhi, New Delhi-110016, India
*dayanidhikrishana.pathak@dseu.ac.in

Abstract. Titanium and its alloys are extensively used in different biomedical applications such as cardiovascular and orthopedic implants. Using additive manufacturing, user-specific implants can be easily fabricated. However, the chances for corrosion growth exist owing to the contact between metal and surrounding electrolytic environment such as bone and muscle. Hence, due to the

corrosion, biocompatibility and toxicity issues may exist, which can cause problems such as aseptic loosening, implant failure, and short life. Therefore, it is necessary to evaluate such biomaterials' toxicity and corrosion behavior to avoid the damage that may occur within the human body. Hence, in this study, a simulation of the corrosion behavior of Ti6Al4V has been performed using Multiphysics simulation-based platform known as COMSOL. A 2D model and 3D bone in a screw model have been developed and simulated. Electric current density and change in overall thickness with respect to time were computed. The current density of 1.51×10^{-7}A/cm^2 was obtained with a total reduction of 4.06 μm in 365 days. The corrosion rate was also evaluated and was found to be 1.327×10^{-4}mmpy. Furthermore, a comparison of corrosion behaviour between the simulated data and experimental data of Ti6Al4V from previous studies has been carried out. The simulation results were found to be within the permissible range of previously reported experimental studies with a maximum deviation of 3.56%.
Keywords: Additive Manufacturing, Bioimplants, Corrosion, Simulation.

Paper ID #295

Developed a Mathematical Model for a Sustainable Flow Shop Scheduling Problem

Suneet Singh[1*], Sneha Kushwaha[2], Santosh Kumar[1], Saurabh Pratap[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi, India
[2]Department of Information Technology, Shivajirao S. Jondhale College of Engineering Dombivli East, Maharashtra, India
*s.pratapiitkgp@gmail.com

Abstract. Manufacturing customized products makes scheduling difficult. Since machine work scheduling influences net productivity, most industries focus on it. The number of machines and jobs to schedule increases the complexity of the challenge, emphasizing the need for an appropriate scheduling technique. Superior scheduling improves customer satisfaction, productivity, cost reduction, and competitiveness. This study addresses a flow shop scheduling problem that reduces tardiness by processing work via a sequence of machines. We need LINGO, an optimization modelling software, to address this. This method is effective and efficient. To demonstrate the proposed flow shop scheduling solution's efficacy and efficiency, we must create 20 instances and solve with LINGO. For each instance, the result shows that optimum delay can be achieved from multiple job operation sequences. Additional research will include a sensitivity analysis to demonstrate the adaptability of the offered solutions and their results.
Keywords: Flow shop scheduling, optimization, LINGO.

Paper ID #296

Prediction of Wettability Characteristics of SMAW Electrode Coatings using Neural Network Modelling for Power Plant Welds

Vijay Kumar[1*], Rahul Chhibber[1]
[1]Indian Institute of Technology, Jodhpur, Rajasthan, 342030, India
vijay.4@iitj.ac.in

Abstract. Shielded metal arc welding is extensively used for fabrication, maintenance, and repair purposes of power plant welds. Flux's thermophysical, physicochemical, and high-temperature wetting behaviour significantly influence the weld pool's properties. The coating fluxes were formulated using an extreme-vertices design approach. The aim of this work is to conduct experiments and model the wettability properties, such as contact angle and work of adhesion, of the developed shielded metal arc welding (SMAW) coating flux using an artificial neural network (ANN) approach. Pellets were prepared to perform the experiments. The contact angle and work of adhesion were calculated using Image J software. The developed ANN model has been tested for its prediction capability and compared with regression analysis predictions. Results show that the

ANN model of contact angle and work adhesion has shown improvements in root mean square error of 45.25 % and 60.37 %, respectively. The ANN model has shown better prediction accuracy than regression analysis.
Keywords: ANN, contact angle, work adhesion, flux, wettability.

Paper ID #297

Tensile Properties of Polyether Ether Ketone Printed by Fused Deposition Modeling

Anil Babu[1,2*], N. Selvaraj[1], Manjaiah M[1]
[1]Department of Mechanical Engineering, National Institute of Technology Warangal, Hanamkonda-506004, Telangana, India
[2]Department of Mechanical Engineering, B V Raju Institute of Technology, Narsapur, Medak-502313, Telangana, India
*ap21merep20@student.nitw.ac.in

Abstract. Polyether ether ketone (PEEK) stands out as a high-temperature engineering polymer widely utilized in medical applications due to its exceptional mechanical properties, thermal stability, and chemical resistance. Fused deposition modeling (FDM) 3D printing offers a cost-effective and versatile manufacturing method with high material efficiency. This study aims to produce flawless PEEK samples via 3D printing, enhancing their mechanical properties to match those of injection molded parts. Tensile samples were printed in horizontal, vertical, and 45° inclined orientations under optimized process conditions. All orientations shared consistent printing conditions. The evaluation focused on deformability, print quality, and tensile properties. Results revealed that horizontally printed samples exhibited superior tensile strength and elongation compared to vertically or 45° inclined prints. Notably, a remarkable ultimate tensile strength of 76.7 MPa was attained in the horizontal build direction. This was achieved with specific parameters: nozzle temperature at 405°C, platform temperature of 180°C, printing speed set at 5 mm/s, and a layer thickness of 0.1 mm.
Keywords: PEEK, Fused Deposition Modelling, Tensile properties.

Paper ID #298

Surface Topographical Characterization of Zno Nanostructured CFRP Composite in High Speed Micro Drilling

Arnab Das[1,2*], Ravi Shankar Rai[3], Vivek Bajpai[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology (ISM) Dhanbad, Jharkhand, 826004, India
[2]Mechanical Engineering Department, Camellia Institute of Technology, Kolkata, 700128, India
[3]Department of Automation and Robotics, Sandip Institute of Technology and Research Center, Nashik, India

Abstract. This paper describes the surface characteristics of ZnO nanostructured CFRP composites in high speed micro drilling process. Two different nanostructured composites have been developed by varying the molar concentration of ZnO growth solution from 15 mM to 25 mM by hydrothermal method. Further, high speed micro drilling operations have been performed on those nanostructured CFRP composites alongwith unstructured one. Three different levels of spindle rotational speeds (25000, 37500, and 50000 rpm) and feed rates (1 *µm/rev*, 3 *µm/rev*, and 6 *µm/rev*) have been incorporated in the machining operation. The average surface roughness, delamination, circularity, and burr height have been measured. All those parameters have been improved significantly for nanostructured composites as compared to unstructured one. The best surface finish has been found on 15 mM ZnO nanostructured composite at spindle rotational speed of 50000 rpm and feed rate of 3 *µm/rev* with an average surface roughness of 1.88 *µm*. Favorable

machining conditions have been achieved at higher spindle rotational speed and higher feed rate during the micro drilling operation of CFRP composites.

Keywords: ZnO nanostructured CFRP composites, High speed micro drilling, Surface topography, Delamination.

Paper ID #299

Geometrical Analysis of Bead in Direct Current Electrode Positive-based Submerged Arc Additive Manufacturing (SAAM)

Suraj Goala*, Shrikrishna N. Joshi*

Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, 781039, India

*snj@iitg.ac.in

Abstract. In Submerged Arc Additive Manufacturing (SAAM), the metal deposition process requires high energy for melting and solidifying the material. Thus, obtaining the optimal process parameters for less energy consumption and generating geometrically accurate and uniform deposited structures is important. In this work, an algorithm is developed to optimize the energy input per unit length and the geometric parameters, such as bead penetration and penetration depth, to obtain the same shape and size of the initial bead so that the geometric structure will be uniform and the energy consumption will reduce significantly. The process parameters are optimized using the relations between the input process and geometric parameters proposed in the past for DCEP-based Submerged Arc Welding. Initially, the process parameters for penetration depth were optimized, and then, based on the optimal process parameters as input, the bead width was optimized. These outputs are scrutinized for the energy input per unit length, which is lower than the initial data. The algorithm was run for several iterations, and the optimal output was obtained. A case study was performed to verify the developed algorithm's output. A similar geometrical structure of the single bead was obtained, which reduced the requirement for post-processing operations and decreased the energy input per unit length by 7.82%.

Keywords: Submerged Arc Additive Manufacturing, Wire Arc Additive Manufacturing, Genetic Algorithm, Optimization, Additive Manufacturing, Submerged Arc Welding.

Paper ID #300

A Comparative Study of Die-sinking EDM and Electrical Discharge Drilling (EDD) Process for making small holes in Cemented Carbide

Pravendra Kumar[1*], S.K.S. Yadav[2], V.P Singh[3]

[1]JRF, DST Project, Department of Mechanical Engineering, Harcourt Butler Technical University, Kanpur, 208002, India

[2]Professor & PI, DST Project, Department of Mechanical Engineering, HBTU Kanpur, India

[3]Professor, Department of Mechanical Engineering, HBTU, Kanpur, India

Abstract. Conventional machining processes exhibit excessive prominence in manufacturing industries due to their high production rate along with good accuracy and acceptable tolerance limits. In conventional machining processes, material removal takes place by plastic deformation of work material due to direct contact between tool and workpiece followed by shearing action. Hence, the major limitation of conventional machining processes is that the tool material should be harder than the workpiece. Cemented carbide is one of the hardest known cutting tool materials used in conventional machining processes such as drilling, milling, turning etc. Conventional machining of cemented carbide is very difficult due to its extremely high hardness, excellent impact resistance, good toughness and very high melting point temperature (about 2800°C). Most commonly used machining processes for cemented carbide are grinding by diamond tools and electrical discharge machining (EDM). The present study is focused on comparing the results of

die-sinking EDM and electrical discharge drilling (EDD) process during machining of small holes (ø2 mm) in cemented carbide.

Keywords: EDM, EDD, Cemented carbide.

Paper ID #302

Numerical Study on Critical Wire Size for Titanium Melting Through Highfrequency Induction Heating System for Additive Manufacturing Process

Avadh Kishore Prasad[1*], Swarup Bag[1], Sajan Kapil[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Assam, India
*avadh_kishore@iitg.ac.in

Abstract. The high-frequency induction heating (HFIH) system is an environmentally friendly process and novel energy source that rapidly heats the electrically conductive wire to develop various deposition-based processes such as additive manufacturing (AM) and drip casting. This study discloses the critical diameter for the titanium wire melting under the optimized coil and process parameters. A 2D numerical model is formulated to investigate the time required for the titanium wire melting, both at its outer surface and within the core. The present study uses an optimized 3-turn circular cross-section helical coil with a coil current of 550 A and a current frequency of 353 kHz for titanium wire melting. The study suggests that the power transfer efficiency of induction heating (IH) is enhanced first and then decreases with an increase in the wire diameter. The critical diameter for melting the titanium wire is 3.6 mm under the optimized process parameters. The time needed to reach the wire melting temperature within the core of the wire decreases up to a diameter of 3.6 mm and then increases afterward. This study also suggests that the wire size is a critical factor or parameter for improving the IH system's efficiency.

Keywords: Additive manufacturing, titanium wire, critical diameter, induction heating.

Paper ID #303

Influence of Laser Texturing on Contact Separation and Sliding Mode Triboelectric Nanogenerator for Vibration Sensing

Diksha Jaurker[1*], Puneet Gupta[1], Tannu[1], Kaushik P. S[1], Ashwani S. Tripathi[1], Suhas S. Joshi[1], I. A. Palani[1]*
[1]Department of Mechanical Engineering, Indian Institute of Technology Indore, India
*palaniia@iiti.ac.in

Abstract. Triboelectric nanogenerators (TENGs) have advanced as versatile and efficient devices with applications expanding beyond harvesting electricity. TENGs provide electrical signal outputs corresponding to the amplitude and frequency of delivered vibrations or mechanical disturbances. In Literature, different surface modification techniques have been deployed to improve the performance of TENGs. Out of which Laser texturing is an advanced surface modification technique to enhance triboelectrification. This work aims to perform a comparative study on the influence of laser texturing on TENG's performance in contact separation TENG (CS-TENG) and sliding TENG (S-TENG). Laser textured lines were created using 532 nm wavelength Nd3+: YAG pulsed laser. In CS-TENG the electrical performance is observed to be improved by the laser texturing, whereas the laser texturing degraded the electrical performance of the S-TENG and decreased the sensitivity towards vibrations. Pristine S-TENG was able to detect the working condition of the air compressor. Hence the proposed S-TENG was found to be an effective and reliable vibration sensor.

Keywords: Triboelectric nanogenerator, vibration sensor, laser texturing.

Paper ID #304

Effect of Beveled Exit Edge on Burr Formation in Drilling

Debjit Misra[1,2*], Santanu Das[2*], Partha Pratim Saha[3]
[1]Dr. Sudhir Chandra Sur Institute of Technology & Sports Complex, Dum Dum, West Bengal-700074, India.
[2]Kalyani Govt. Engineering College, Kalyani- 741235, West Bengal, India.
[3]Kanchrapara Railway Workshop, Eastern Railway, West Bengal- 731345, India
*sdas.me@gmail.com

Abstract. The unwanted projections of material adhered to the machined surface of the work piece known as burr. The burr formation on the edges of machined surfaces is one of the inherent problems during machining. The burrs are formed both on the tool entry surface and exit surface that deteriorate the part quality and affects the assembly process negatively. The burr minimization is an important for manufacturing aspect which reduces cost and increases the life of the product. In the present work, an investigation has been carried out by varying various process parameters, including feed rate and the cutting environment, while considering different drill diameters and the exit edge bevel angle of the workpiece. Minimum burr height and width are attempted to be find out based on experimental observations produced by two sets of experiment with varied process parameters. From the experimental data it is observed that, by providing the exit edge bevel angle of the work material, burr height and width is reduced remarkably.
Keywords: Machining, Drilling, Entry burr, Exit burr, Burr height, Burr width.

Paper ID #305

Tool Condition Monitoring Techniques in Micromilling: A Review

Avinash H. Kamble[1,2*], R. S. Pawade[1], S. S. Metan[3]
[1]Dr. Babasaheb Ambedkar Technological University, Lonere, 402131 India
[2]NK Orchid College of Engineering and Technology, Solapur 413002, India
*ahkamble29@gmail.com

Abstract. Microscale manufacturing is growing rapidly, particularly in the biomedical, electronics and aerospace areas. Therefore, the ability of micro-cutting techniques, such as micromilling needs to be improved in order to produce complex features with good surface finish. It is essential to inspect the state of cutting tool while the operation is being performed to get high surface finish. Like in conventional milling process, it is difficult to utilize the sensors for this purpose in micromilling process. Hence, tool state monitoring in micromilling become difficult. This paper summarizes the approaches for indirect methods for tool state monitoring in micromilling that has been used and documented.
Keywords: Micromachining process, Micro milling process, Tool state monitoring, Acoustic emission.

Paper ID #307

Selective Laser Sintering of CNTs-PA12 Polymer Nanocomposites

Jairam Raigar[1*], Rajkumar Velu[2]
[1,2]Additive Manufacturing Research Laboratory, Indian Institute of Technology Jammu
Jammu and Kashmir – 181221, India
*jrmkhajotiya@gmail.com

Abstract. Selective laser sintering (SLS) is one of the most promising additive manufacturing technologies to produce functional end-use components using thermoplastic powders. This work proposes a design for selective laser sintering of multiwalled carbon nanotubes (MWCNTs) filled with polyamide 12 (PA12) polymer composites with enhanced thermophysical properties for

aerospace and automotive applications. The MWCNTs were mechanically mixed with PA12 powder in 0.5 and 1.0 weight percentages to formulate the nanocomposite powders. The single-layer samples of neat PA12 and new MWCNT-PA12 formulations were designed and fabricated using the SLS process. Thermogravimetry, Differential Scanning Calorimetry, Fourier Transform Infrared Spectroscopy, and Field Emission Scanning Microscopy were used to assess the thermophysical and physicochemical properties of the nanocomposites. The effect of laser processing parameters was experimentally evaluated for each composition for successful printing. The surface morphologies of the sintered samples were analysed to determine the optimal processing parameters for the SLS processing of composite powders. The results showed that the addition of carbon nanofillers in the PA12 matrix has significantly affected the thermal and viscoelastic properties of the nanocomposites. The inclusion of MWCNTs has significantly increased the thermal degradation onset temperatures and hence widened the SLS processing window. The density of 0.5 wt% of MWCNT-PA12 printed samples was observed to be 10.5% higher, whereas the density of the samples printed with 1.0 wt% MWCNT-PA12 was 18.46% lower than the samples printed with neat PA12. Therefore, the 0.5% CNT-PA12 composition resulted in an optimal composition.
Keywords: Selective Laser Sintering, SLS, Additive manufacturing, MWCNTPA12 polymer nanocomposite.

Paper ID #310

Predictive Model for Deposition Success in Wire Laser Additive Manufacturing

Anas Ullah Khan*, Yuvraj K Madhukar
Indian Institute of Technology Indore, Indore – 452020, India
*yuvrajmadhukar@iiti.ac.in

Abstract. Wire alignment is a consistent challenge in wire laser additive manufacturing (WLAM). The position of the wire before the start of deposition could decide the quality and deposition success. Convolutional neural network (CNN) is known for providing excellent results in image classification. The image dataset consisted of 1422 images, which were split into a ratio of 60:20:20, representing the training, validation, and testing data. The images were broadly categorised as *Success* or *Failure,* referring to the estimation of the possibility of a smooth and defect-free deposition. The proposed model was evaluated on various metrics and yielded an accuracy of 90.06%.
Keywords: Predictive model, additive manufacturing, convolutional neural network, laser.

Paper ID #311

High-Infeed Grinding of Aluminium Composite by Patterned Diamond Tool

Trilochan Prasad Nanda[1*], Amitava Ghosh[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Madras
Chennai, 600036, India
*amitava_g@iitm.ac.in

Abstract. In the present work, the feasibility of dry abrasive machining of $AlSiC_P$ composite has been investigated using an indigenously prepared singlelayer brazed diamond grinding tool having uniformly arranged abrasive grits. The experiments were carried out in reciprocating surface grinding mode in a vertical machining center. Dry grinding was performed with increasing order of infeed ranging from 20 μm to 100 μm in combination with a grinding velocity of 70 m/s and table feed values of 500 mm/min and 1000 mm/min. Grinding forces, specific grinding energy, and grinding chips collected at different cutting depths were studied to analyze the grindability of aluminium composite, which is, as such, known to be a sticky-abrasive material. There was no sign of wheel loading. However, a hint of chip adherence on grit tips was noted at higher infeed values,

which escalated the rate of increase in cutting force. Although such abrasive machining was realized without any trace of wheel loading, surface roughness was unfavorably high due to fewer overlapping cuts and non-participation of passive grits.
Keywords: High-speed grinding, Al-SIC composite, Single layer diamond grinding wheel, Patterned grain arrangement.

Paper ID #312

Laser-Based Drilling of Granite: Morphological and Microstructural Studies

Antash Kishore Sinha*, Shrikrishna N Joshi*
Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, 781039, India
*snj@iitg.ac.in

Abstract. Rock drilling is a process of rock pulverization and path creation through the use of drilling tools to pave the way for mineral exploration. The traditional drill bits used for this purpose are Tungsten Carbide bits and Polycrystalline Diamond compact bits. However, these are extremely complex in design and subjected to high wear and tear in hard rock formations. Hard rocks like Granite hold large shale reserves, a prominent natural gas resource. In the past decade, combined thermo-mechanical drilling technologies based on plasma, flame, and laser have emerged as effective potential solutions for hard rock drilling. They can resolve the limitations of conventional drilling technologies. Laser-based rock drilling utilizes beneficial laser characteristics to cause irregular thermal expansion and cracking in rocks. This work examines the prospect of drilling hard granite rock using a continuous wave CO_2 laser with a manual pulsing facility. Process parameter influential analysis has been carried out to examine the role of laser power and scanning speed. The range of laser power considered in this study is 70 to 90 W, and the scanning speed is 50 to 150 mm/s. The investigation also presents characterization results of X-ray diffraction and field emission scanning electron microscopy to analyze the role of phases and elements during laser interaction. Microstructural changes have been analyzed through stereo zoom and metallurgical optical microscopes. The notable response of granite has been highlighted and discussed separately.
Keywords: Characterization, Granite, Laser, Laser rock drilling, Microstructure, Optical microscopy, Striations.

Paper ID #313

Feasibility Study on Additive Manufacturing of Inconel 625 and Aluminum Bimetallic Parts

Manjunath BN[1*], Pranjal Shukla[2], Jayaprakash P[1], DV Kiran[2], N Venkaiah[2], N Balashanmugam[2], Dheemanth BA[1]
[1]Central Manufacturing Technology Institute, Bengaluru, India
[2]Department of Mechanical Engineering, Indian Institute of Technology, Tirupati, India
*manjunathbn@cmti.res.in

Abstract. Inconel 625, a renowned nickel superalloy, is highly regarded for its remarkable corrosion resistance at elevated temperatures. In contrast, Aluminum alloys are known for their lightweight attributes and superior thermal conductivity. Combining these materials in a bimetallic component offers the potential to harness the distinctive strengths of each. Conventional techniques for joining dissimilar metals, like friction stir welding and metal arc gas welding, come with inherent limitations. These methods often result in the formation of brittle intermetallic compounds (IMCs) and residual stresses due to the substantial heat input involved. The current research focuses on studying the deposition of Inconel 625 onto an Aluminum 6061 substrate using two advanced technologies—laser-based directed energy deposition (DED) and cold metal transfer (CMT)-based wire arc additive manufacturing (WAAM). For study purposes, single-track and multi-layer depositions of Inconel 625 onto Aluminum 6061, using a laser-based DED machine and Wire Arc

Additive Manufacturing processes with varying energy densities were carried out. The observations of the fabricated specimens unveiled several challenges which included the initiation of cracks and delamination during deposition at higher temperatures due to the difference in thermal conductivity between Inconel 625 and Aluminum 6061. Additionally, the high reflectivity of Aluminum to laser, its exceptional thermal conductivity, and the formation of intermetallic compounds between Aluminum and nickel at the deposition zone further aggravated the complexity of the process. In summary, the article aims to provide valuable insights on the feasibility and potential advantages of employing additive manufacturing to achieve bimetallic printing of Inconel 625 onto Aluminum 6061 which can potentially back innovations in larger industries such as aerospace and marine.
Keywords: Inconel 625, Aluminium 6061, Additive Manufacturing, Bimetallic, Directed Energy Deposition, Wire Arc Additive Manufacturing.

Paper ID #315

Dry and Near Dry Grinding with Patterned Brazed cBN Wheel

Bandana Priyadarshini*, Amitava Ghosh
Indian Institute of Technology, Madras, Tamil Nadu, 600036, India
*me21d001@smail.iitm.ac.in

Abstract. The present investigation aims to evaluate the advantages of employing minimum quantity lubrication (MQL) technique utilizing sunflower-based vegetable oil during grinding of AISI 52100 steel, using a patterned brazed microcrystalline cBN grinding wheel. Single-layer brazed cBN wheels have displayed considerable promise in grinding applications. The uniformly distributed patterned cBN wheels represent an enhancement over randomly distributed ones, as they can accommodate a larger volume of chips and effectively cut the material with a high material removal rate (MRR) while avoiding wheel loading issues. In dry grinding conditions, a significant amount of heat accumulates at the grinding interface, leading to a rapid increase in the temperature of the grinding zone. Furthermore, substantial friction forces arise due to the conversion of heat during sliding friction and the plowing process occurring between the cBN grits and the workpiece. This results in an elevated specific tangential and normal grinding force, increased specific energy consumption, and a rougher surface finish, especially at higher depths of cut. The utilization of MQL, specifically sunflower oil, proves to be an effective solution by providing satisfactory anti-friction and antiwear properties. Notably, applying sunflower oil induces a more significant shearing effect on the chips than dry grinding conditions.
Keywords: Microcrystalline cBN, MQL, Vegetable oil.

Paper ID #316

Artificial Neural Network-Based Prediction of Wire EDM Control Parameters during Machining of $Ni_{50.3}$-$Ti_{29.7}$-Hf_{20} SMA

Balaji V[1 *], Ranjeet Kumar Sahu[1], Narendranath S[1]
[1]National Institute of Technology Karnataka, Surathkal- 575025, India
*balajiv.207me003@nitk.edu.in

Abstract. Ni-Ti-Hf shape memory alloys (SMAs) have demonstrated significant potential in high-temperature applications in aviation, space, energy exploration, and actuators. However, conventional machining of these difficult-to-machine materials can lead to issues such as high tool wear, dimensional inaccuracy, and degradation of shape memory properties. As a result, non-conventional machining processes are preferred, with Wire Electric Discharge Machining (WEDM) showing better results than other methods. A recent study investigated the effect of WEDM process parameters on the machining of Ni-Ti-Hf SMAs by implementing an RSM-based Central Composite Design (CCD) technique. The pulse time was found to be the most influential parameter for cutting rate (MRR) and surface roughness (SR). The study also aimed to build a prediction

model using Artificial Neural Network (ANN) for the most critical WEDM control parameters, namely CR and SR, with an error below 5%. Additionally, the surface integrity of the machined samples was examined using SEM, EDS, and microhardness. The results revealed that surface defects like micro-cracks and micro-pores increased with an increase in discharge energy, and a harder surface was observed near the machined zone. The minimum and maximum Recast Layer Thickness (RLT) obtained were 9.27µm and 49.14µm, respectively.
Keywords: WEDM, ANN, Ni-Ti-Hf, SMA, Response surface Design.

Paper ID #317

Study on the Mechanical and Wear Properties of A 319-Sic Composite Produced by Stir Casting Process

Pranav Anand[1*], L. Sankara Rao [2], Uppu Srinivas Rao[3]
[1, 3]Department of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi, 221005, UP, India
[2]Department of Metallurgical Engineering, Indian Institute of Technology (BHU), Varanasi, 221005, UP, India
*lsrao.mwit@itbhu.ac.in

Abstract. Aluminum metal matrix composites (MMC) are meeting the requirements of the automotive and aerospace emerging industries by increasing the overall performance of components. Stir casting is the most economical process to produce metal matrix composites. A319-SiC composites were manufactured by adding different wt.% (12, 16, 20) SiC particles. The alloy was molten in the furnace and SiC particles were added to the periphery of the swirl metal pool formed due to stirring of the metal. The present study shows the effect of different wt.% of SiC on the mechanical and wear properties of the composites. Wear characteristics of dry sliding at room temperature were evaluated with the help of a pin-on-disc machine. Wear experiments were performed under 1 m/s sliding speed with varying load for total sliding distance of 3000 m and varying sliding speed with constant load of 3 kg for 3000 m sliding distance. Mechanical and Wear properties of as cast alloy are compared with the A319 composites. The A319 alloy with 12wt% SiC composite has shown enhanced hardness, strength and wear properties than the base alloy cast. A319-16%SiCp MMC, A319-18SiCpMMC. The uniform distribution of SiC particles in the A319 matrix improved the mechanical and wear properties of the A319-12SiCpMMC. The wear rate increased with increase in load and as well as raised in sliding velocity for the as cast and all other composites. As cast alloy and A319-12%SiC have shown severe and mild wear respectively at high load and sliding velocities.
Keywords: Stir Casting; A 319 alloy; Metal Matrix Composites; Wear.

Paper ID #318

Electrochemical Machining with Identical Polarity of Tool and Workpiece: A Feasibility Study

Maran Rajakumaran[1*], Akshay Dvivedi[2]
[1, 2]Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247667, India
*mr@me.iitr.ac.in

Abstract. Across the globe, there is a broad perception that the anodic dissolution in the case of electrochemical machining process occurs only when the tool and workpiece are connected to the negative and positive terminals of DC power supply, respectively. The present work deviates from the existing convention to substantiate other possibilities by which anodic dissolution can be achieved. Two new combinations are investigated, in which both the tool and the workpiece are connected to the same polarity, i.e., positive or negative. To support the claims, numerical and

experimental studies were conducted, and the effect of equal polarity in contrast to the existing convention was analyzed from the machined hole diameter.
Keywords: Identical Polarity, Electrochemical Machining, Potential Difference.

Paper ID #320

Deep Learning-Based Neural Network for Flank Wear Prediction using Acoustic Emission Signals on Inconel 617 Alloy

Pramod A[1*], Deepak Lawrence K[1], Jose Mathew[1]
[1]National Institute of Technology Calicut, Department of Mechanical Engineering, Kozhikode, Kerala, 673601, India
*pramodadishesha13@gmail.com

Abstract. Acoustic emission (AE) signals were acquired from machining experiments to develop deep learning based neural network models for predicting tool flank wear on Inconel 617 alloy. The milling experiments were conducted with different combinations of process parameters until the flank wear of the tool reached the predetermined failure limit. The raw data from the sensor signal was filtered to remove anomalies present in the dataset. The Local Outlier Factor (LOF) algorithm was applied to evaluate the anomaly detection performance on the sensor dataset and was found to be the most effective. Statistical features that correlated with tool flank wear were extracted from the filtered data using feature engineering. A deep neural network was developed and its performance was evaluated using a new set of milling conditions. The model's accuracy was evaluated by comparing the predicted tool wear to experimental results. The results showed that the acoustic emission data can explain 96% of the total variation in the predicted tool wear values.
Keywords: Tool wear prediction, Acoustic Emission sensor, Local Outlier Factor, Deep Neural Network.

Paper ID #321

An Experimental Analysis on Vertical Milling of Ti-6Al-4V under SQL based DBD Technique

Yatendra Kumar Yadav[1*], Debraj Shaw[1], Manish Mukhopadhyay[2], Pranab Kumar Kundu[1*]
[1]Department of Mechanical Engineering, Motilal Nehru National Institute of Technology, Allahabad, Prayagraj, Uttar Pradesh, 211004, India
[2]Department of Mechanical Engineering, Meghnad Saha Institute of Technology, Kolkata, West Bengal, 700150, India
*pranabkundu@gmail.com

Abstract. Manufacturing industry is increasingly emphasizing the use of advanced materials with enhanced physical and chemical properties. However, due to these superior properties, machining of these materials has become more challenging, as it requires high cutting forces and generates high temperatures at the machining zone. Ti-6Al-4V is one such material that is now extensively employed in industries such as aerospace and medical equipment. This experimental investigation is focused on improving machinability by employing a drop-bydrop (DBD) cutting fluid delivery method, and assessing the effects of flow rate and feed on various machinability parameters, such as cutting forces, surface roughness, and temperature during operation. The experimental results indicate an enhancement in the machinability of Ti-6Al-4V while using DBD method of coolant delivery technique. Additionally, it is observed that cutting forces, temperature, and surface roughness increase with an increase in the feed rate. The maximum heat transfer rate from the machining zone has been found at 0.099 ml/s flow rate.
Keywords: Titanium alloy, Machining, Drop-by-drop, MQL.

Paper ID #322

Design and Development of FSW Tool for Carbon-Manganese Steel

Sanjay Raj[1*], P jayant Kumar Reddy[2], Pankaj Biswas[3]
[1, 2, 3]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati 781039, Assam, India
*sanjayraj.me@gmail.com

Abstract. The use of friction stir welding techniques to join high-strength materials such as steel and tungsten alloys faces a major problem in terms of tool life and tool cost due to high wear. In the present work, a cost-efficient WC-11%Co tool and a novel composite of WC-11% Co + 1% Carbon Nano Tubes (CNT) tools are manufactured to achieve the tool wear solution. For this purpose, at first pre-sintering temperature and holding time were calculated. Sintering of various compacted tools are sintered at 850 ^{o}C to 1300 ^{o}C with holding times varying from 30 minutes to 1500 minutes, whereas four attempts were made to manufacture FSW tool at 850 ^{o}C,950 ^{o}C, 1050 ^{o}C and 1300 ^{o}C. A comparative study of 11% cobalt tools with added CNT particles was performed. Higher compaction density, higher holding time, more homogeneous mixture of raw materials, good proportionate of organic binder and temperature between 1050 ^{o}C -1300 ^{o}C, with cobalt percentage in between 11%, produces the finest tools. Joining of carbon manganese steel with high strength FSW tool performed very smoothly.
Keyword: FSW tool, Carbon Nano Tubes, Powder metallurgy, Sintering, Manufacturing.

Paper ID #323

Development of CNN Framework for Surface Defect Analysis in WAAM of Bio-Compatible Ti6Al4V

Alok Kumar[1*], Kundan K. Singh[2*], Suresh Kumar Reddy Narala[3]
[1, 2, 3]Department of Mechanical Engineering, Birla Institute of Technology and Science-Pilani Hyderabad Campus, Telangana -500078, India
*ksingh@hyderabad.bits-pilani.ac.in

Abstract. Wire arc based additive manufacturing (WAAM) process is one of the promising manufacturing methods for the manufacturing of large and complex metallic component. GTAW based deposition results in higher quality with almost no splash and it creates less pollution; hence, it is highly suitable for application in producing the more accurate components. The selection and optimization of WAAM process parameter is very critical to achieve the satisfactory geometrical and dimension dimensional accuracy of fabricated products. Consequently, present work uses the GTAW-based WAAM for deposition of Ti6Al4V wire on Ti6Al4V substrate. The WAAM of Ti6AL4V has been carried out at three levels of wire feed varying from 0.6 m/min to 1.8 m/min at an interval of 0.6 m/min and at the two levels of current of 80 A and 100 A. The torch travel speed has been kept constant at 50 mm/min. The analysis of bead formed at different parameters shows that minimum width of bead can be produced at lower feed of 0.6 m/min and at higher current of 100 A. However, higher height of bead has been produced at higher feed of 1.2 m/min and at lower current of 80 A. Optical parameters analysis of the images of bead along the deposited length have been found to be capturing the variation in surface topography of bead produced at different WAAM process conditions. The proposed CNN architecture has been found to be classifying the defect and defect-free deposition with good accuracy.
Keywords: WAAM, Image analysis, CNN.

Paper ID #324

An Iot-Embedded Smart Sustainable Reverse Logistics System towards the Circular Economy

Dhirendra Prajapati[1*], Praveer Agrawal[2]
[1,2]Shri G S Institute of Technology and Science, Indore, MP, India-452001
*pdhirendra15@gmail.com

Abstract. Reverse logistics has received more attention in recent years due to the significance of conserving natural resources and safeguarding the environment through recycling and safe disposal. This study focuses on proposing a framework of a smart sustainable reverse logistics system by implementing the novel IoT technology (SSRLSIoTT) for the collection of electronic products from the user locations and delivery at recycling centers towards a circular economy. Formulate an MIQPbased optimization model that helps to minimize the cost associated with the SSRLSIoTT by optimizing the number of vehicles assigned, routes for collection, and facility locations within the network, and by minimizing the carbon emission taxation cost. Implement the exact optimization approach to get better solutions for the proposed model for analysis and decision-making purposes. Obtained results and analysis helps government policymakers, and business organization to make some policies in favour of social, environmental, and economic aspects of sustainability for the development of the nation and world as well.

Keywords: IoT Technology, Reverse Logistics, Sustainability and Circularity, MIQP Approach, Exact optimization approach.

Paper ID #325

Fabrication of Tungsten Carbide Tools through ECM for UAECDM Process using Different Electrolytes

Monika Singh*, Anuj Vats, Akshay Dvivedi, Pradeep Kumar
IIT Roorkee, Uttarakhand, 247667, India
*m_singh@me.iitr.ac.in

Abstract. Tungsten carbide (WC) microtools are in great demand due to their high hardness, strength, and melting temperature. The electrochemical machining process works effectively in the fabrication of WC microtools. The WC tool encounters non-uniform dissolution during the electrochemical machining process, and micro pits form on the machined surface, which affects the tool's usability and thus requires further studies. The WC micro tools perform nicely in the ultrasonic-assisted electrochemical discharge machining process as they withstand high temperatures well. Thus, WC micro tools were fabricated in the present work through electrochemical machining, and the effects of four electrolytes, KOH, NaOH, NaCl, and $NaNO_3$, were studied on the machined tool surface morphology and material removal rate. The influence of the machining parameters, the electrolyte temperature, and the applied voltage on the dissolution rate was investigated. Micro tools of diameter 500μm were fabricated from 2mm diameter cylindrical rods to machine borosilicate glass via the Ultrasonic-assisted electrochemical discharge machining process.

Keywords: Electrochemical-machining, Tungsten carbide, Ultrasonic-assisted electrochemical discharge machining.

Paper ID #326

Simulation of Magnetic Field and Force with Varying Shapes of an Electromagnetic Forming Coil for the Development of the Wheelchair Structure using FEA

Tushar Tiwari[1*], Mohammed Rajik Khan[2], Pranab K Dan[3]
[1,3]Indian Institute of Technology Kharagpur, Kharagpur, India
[2]National Institute of Technology Rourkela, Odisha, India, 769008
*itstushar.tiwari23@kgpian.iitkgp.ac.in

Abstract. Electromagnetic Forming (EMF) is an effective technology for deforming metals and alloys utilizing a magnetic field using generated Lorentz' powers to the workpiece ideally made of electrically conductive material in a contactless manner. The process is perceived suitable to translate a design into a manufactured component; for tube diameter enlargement, besides other types of shape modifications, which here is for compliance of economic, ergonomic, light-weighting, and aesthetic considerations, involved in the design-for-manufacturing of the push rim tube of a wheelchair. EMF is safe and easy to operate because a single die is needed and the shaping is done at high speed. EMF process is applied on a tube and turned into a ring, for purposing as a Push-rim or Push-ring, configured ergonomically, which rather is a customary feature for a wheelchair and common in platform-based design context. The two components in this forming method are the EMF coil and core. The cylindrical shapes of the coil are considered in analyzing the variation of magnetic field and Lorentz force on the different coil and core materials like Cu-Be alloy, Aluminum, Stainless steel, and Tin (Cu-Be, Al, SS, Sn) and are performed on ANSYSMAXWELL. The capability assessment of the EMF process is merited through the comparison of analytical and simulation results of the magnetic field and force, to get optimum bulging in the push-rim tube surface with the maximum amount of force generated by the coil. This work aims to enlarge the push-rim diameter fulfilling ergonomic and aesthetic considerations.
Keywords: Electromagnetic forming (EMF), magnetic field, Lorentz force, wheelchair push rim design, design for manufacturing.

Paper ID #327

Analysis of Nonuniformity in the Material Removal and Surface Roughness in Abrasive Flow Finishing of Spur Gear Owing to Variation in the Media Flow Passage Cross Section

Irfan Ahmad Ansari[1*], Kamal K. Kar[1,2], J. Ramkumar[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur-208016, India
[2]Advanced Nanoengineering Materials Laboratory, Materials Science Programme, Indian Institute of Technology Kanpur, Kanpur-208016, India
*irfan@iitk.ac.in

Abstract. The objective of this study is to provide an extensive comprehension of the behavior of viscoelastic abrasive media in the context of abrasive flow finishing (AFF), with a focus on the effect of abrupt contraction and expansion of the media flow near the entry and exit region of a typical flow channel. In order to understand this behavior, the study uses both media flow simulation and abrasive flow finishing experiments of spur gear. The flow channel entry experiences a sudden compression of the media, leading to a flow with a high Deborah number (De). As a result, the media in the vicinity of the contraction zone exhibit predominantly elastic behavior, resulting in increased pressure and flow velocity closer to the edge of the tooth (at the entrance of the flow channel), which may lead to nonuniform and harsher abrasion near these locations. Since the material removal and surface roughness in AFF heavily depend on media flow pressure and velocity, results indicate that material removal height near the tooth flank center was found to be 21 and 31% less than at the entry and exit of the gear flow channel. Additionally, the improvement in surface roughness is much more significant near the tooth center than near the entrance and exit surface of the tooth flank.
Keywords: Spur gear, Deborah Number, Abrasive flow finishing.

Paper ID #328

Effects of hBN/SiO_2 Nano-sized Particles on the Performance of ZA-27 Composite

Anuj Kumar[1*], Gurinder Singh Brar[2]
[1, 2]Department of Mechanical Engineering, NIT Uttarakhand, Srinagar (Garhwal), Uttarakhand, 246174, India

Abstract. Metal matrix nano composite material is a promising material with improved mechanical and tribological properties. Zinc-based hybrid composites have seen growing acceptance in various sectors for many years, integrating different reinforcements to enhance their wear resistance. ZA-27 shows improved tribological properties at room temperature. In present work, ZA-27 based hybrid nano composites was produced with average particle size 65nm of hBN (0 and 3 wt.%) and SiO_2 (0 and 5 wt%). Four specimens were fabricated using L4 Taguchi orthogonal array. Stir casting followed with ultrasonic vibration was used to fabricate metal matrix hybrid nano composites. X-ray diffraction (XRD) was conducted to study elemental analysis, hardness test was conducted to confirm the hardness of nano composite material. The wear characteristics of ZA-27 alloy and ZA-27 + hBN/ SiO_2 were investigated using a pin-on-disc tribometer, under load 20N, distance of 1000 m, and at a velocity of 1 m/s. The study revealed that nanocomposites exhibited superior hardness and wear resistance properties compared to monolithic alloys.

Keywords: ZA-27, Nanocomposites, Synthesis, Hardness, Wear.

Paper ID #329

Assembly Sequence Planning by Modified Particle Swarm Optimization

Gobinda Chandra Behera[1*], Vadher Hitesh Ajitbhai[2], Anil Rajagopal K P[3], Sankha Deb[4]
[1,2,3,4]Indian Institute of Technology, Kharagpur – 721302, India

Abstract. The assembly sequence planning plays a pivotal role in manufacturing, directly affecting the quality, cost, and product assembly time. It is often considered an NP-hard problem due to the large-scale combinatorial factors involved. This work reports a Modified Particle Swarm Optimization (MPSO) approach developed to create an assembly sequence optimizing the cost and time elements. It has been achieved by minimizing the number of tool and orientation changes in the assembly. The risk of premature convergence has been evaded by including one linear and two non-linear functions (concave and exponential) in the social and cognitive learning parameters. The performance of the proposed MPSO has been compared with GA and basic PSO and found to be superior in terms of average fitness function value and convergence rate. Case studies have demonstrated the efficacy of the method developed. The proposed algorithm has also provided multi-modal solutions for the described case studies.

Keywords: Assembly Sequence Planning, Particle Swarm Optimization, Cognitive Learning Parameters in PSO.

Paper ID #330

The Relationship Between Deformation Parameters and Corrosion Parameters of The Al-5.6Zn-2Mg Powder Metallurgy Alloy during Hot Upsetting

Katika Harikrishn[1*], M. J. Davidson[1], K.S Rajmohan[2], Kasagani Veera Venkata Nagaraju[1]
[1]Department of Mechanical Engineering, National Institute of Technology-Warangal-506004
[2]Department of Chemical Engineering, National Institute of Technology-Warangal-506004
*kharikrishna@student.nitw.ac.in

Abstract. In this comprehensive study, we investigated the pivotal role of corrosion-related parameters in various electrochemical tests: Potentiodynamic Polarization (PDP), Open Circuit Potential (OCP), Pitting Potential, and Electrochemical Impedance Spectroscopy (EIS). These tests are essential for assessing materials' susceptibility to corrosion and guiding corrosion control strategies across diverse industries. The research highlights the intricate relationship between

corrosion current density, axial strain, and temperature. As axial strain increases, corrosion current density decreases, with the lowest value observed at 500°C and high strain. Temperature elevation consistently leads to lower corrosion current density values. Similarly, the OCP test reveals that axial strain and temperature directly influence OCP values, with higher strain and temperature resulting in higher OCP values. These findings underscore the significance of these factors in assessing corrosion potential. In the context of pitting potential, we observe a positive correlation with axial strain and temperature. Higher strain and temperature lead to increased pitting potential values, emphasizing their combined effect on localized corrosion susceptibility. Lastly, the study delves into contact resistance in EIS, showing that as axial strain and temperature rise, contact resistance values also increase. This highlights the need to mitigate contact resistance for accurate corrosion assessment.
Keywords: Axial strain, Pitting potential, Electrochemical impedance spectroscopy, Open circuit potential, Corrosion current density

Paper ID #331

Experimental Investigation on Abrasive Flow Finishing of Spiral Bevel Gears

Vivek Rana[1*] Anand Petare[2*], Neelesh Kumar Jain[3]
[1,3]Department of Mechanical Engineering, Indian Institute of Technology Indore, India, 453 552
[2]Central Workshop, Indian Institute of Technology Indore, India, 453 552
*acpetare@iiti.ac.in

Abstract. The Abrasive flow finishing (AFF) process is a nontraditional finishing process that allows the use of a semi-solid viscoelastic polymeric mixture containing abrasive particles for the removal of burrs, deposition, geometry optimization, and stress relieving of complex shaped components, internal cavities, dies, and difficult to reach surfaces. This article employed a one-way AFF process to improve the surface quality of spiral bevel gear (SBG) made up of 20MnCr5 alloy steel. A unique fixture was prepared for holding the spiral bevel gear, and restrictions were created inside the fixture to guide the flow of the finishing abrasive medium over the curved flank surfaces. The SBG was finished using previously optimized AFF process parameters (i.e., extrusion pressure, size and volumetric concentration of the abrasive particles, and volumetric concentration of blending oil), and the finishing time varied at two levels. The surface roughness profile and surface morphology of the finished gears were studied. The results showed considerable surface roughness reduction that will help enhance microhardness and improve motion transfer characteristics. This investigation proves that AFF is a simple, versatile, cost-effective, reliable, accurate, and general-purpose alternative gear finishing solution.
Keywords: Abrasive, AFF, Finishing, Grinding, Spiral, Surface.

Paper ID #333

Controlled Environment Sintering of Si_3N_4-Sio_2- BN System and Calculations of Density and Porosity

P. Dutta[1*], P. P. Dey[2], R. Manivannan[3]
[1]Dept. of Mechanical Engineering, Indian Institute of Engineering Science and Technology, Shibpur
[2]Dept. of Mechanical Engineering, Indian Institute of Engineering Science and Technology, Shibpur
[3]Research Centre Imarat (DRDO), Hyderabad
*prosenjitdutta.me@gmail.com

Abstract. Engineering ceramics are widely used in different field of applications like aerospace, missile guidance, wave propagation etc. Therefore, electromagnetically transparent engineering ceramics like- Silica, Si_3N_4, Alumina etc. and their composites are rapidly developed by using different routes of processing's.

In this article, the Si_3N_4-SiO_2-BN system is sintered in a controlled N_2 environment at 1300°C for a dwell time of 12 hours, varying the BN content from 0-10% of the total weight. The study predicted the potential nitridation of the samples by weight gain and also measured the density and porosity of the materials.
Keywords: Silicon Nitride, Sintering, Dwell time, Nitridation.

Paper ID #334

Exploring Machining Capabilities of Al-Mg_2Si-Si Rod with Coated Carbide Insert

Dipanwita Biswas[1,2*], Ananya Banerjee[2], Santanu Das[2], Prosenjit Das[3]
[1]Department of Mechanical Engineering, Hooghly Engineering Technology College, Hooghly-712103, West Bengal, India
[2]Department of Mechanical Engineering, Kalyani Govt. Engineering College, Kalyani, Nadia-741235, West Bengal, India
[3]Department of Materials Engineering, Indian Institute of Science, Bangalore-560012, India
*dipanwita7.biswas@gmail.com

Abstract. Al-Mg_2Si-Si composite material has been selected in this work for its unique properties which need an experimental investigation to find out suitable machining parameters. This is a newly developed composite material having low density and can be applied in aerospace and other automobile industries. To make a product out of this composite material using machining operation, appropriate cutting tool, process parameters and environment are to be employed to obtain desired machinability. Dry as well as wet turning have been carried out on Al-Mg_2Si-Si composite using a narrow groove type carbide insert under different conditions. During turning tests, this composite material is subjected to different cutting velocity and feed at a constant depth of cut of 1.5 mm. Castrol Alusol is applied as the cutting fluid. By examining the effects of these cutting conditions on the AlMg_2-Si-Si composite, valuable insights can be gained regarding its machinability and suitability for specific applications. In this experiment, effects of machining parameters on cutting forces, chip formation and surface quality have been investigated in dry and wet environment. It is found that feed is the most significant factor affecting surface quality in both conditions as expected followed by cutting velocity. In wet condition, good surface quality without any built-up edge formation has been obtained unlike that in dry condition. Therefore, wet machining using Castrol Alusol as the cutting fluid may be recommended for use in the industry along with suitable machining conditions at 160 m/min cutting velocity and feed 0.06 mm/rev. It has been found that wet conditions provide good tool performance under a variety of cutting conditions.
Keywords: Turning, Coated Carbide, Forces, Surface Quality.

Paper ID #335

Study of Aspect Ratio of Laser Directed Energy Deposition of Inconel 718 Alloy

Ajay Kumar Maurya[1*], Amit Kumar[1], Surendra Kumar Saini[2], C.P. Paul[3]
[1]Department of Mechanical Engineering National Institute of Technology Patna, Bihar, India
[2]Department of Mechanical Engineering Poornima College of Engineering, Jaipur, Rajasthan, India
[3]Laser Additive Manufacturing Lab, RRCAT Indore, Madhya Pradesh, India
*surendra1feb@gmail.com

Abstract. Laser directed energy deposition is an advanced manufacturing process that has the ability to reduce the manufacturing costs associated with machining and fabrication of Inconel 718 make parts. This part fabrication technique can add details to pre-existing components and can repair the broken surface and surface defects. This technique uses high-power laser which make melt pool on a substrate material and then the powder material is deposited into the melt pool that further melted and solidify into a layer. The Inconel 718 is high demanding material in aerospace

and nuclear power sector for making parts for high temperature applications. However, processing of Inconel parts with traditional manufacturing is costly so the industries are seeking alternate part fabrication techniques. Laser directed energy deposition (LDED) is suited part fabrication method but geometric inaccuracy in built part is major challenge. Therefore, it is necessary to study the aspect ratio of synthesis Inconel 718. The aim of present research paper is to determine optimum value of design factors for the aspect ratio.
Keywords: Laser directed energy deposition, Inconel 718, Additive manufacturing, optimization.

Paper ID #336

Analysis and Fabrication of Functionally Graded Prosthetic Socket using Fused Filament Fabrication

Mohit Teacher[1*], Shabir Hussain Mir[2], Rajkumar Velu[3]
[1,3]Additive Manufacturing Research Laboratory (AMRL), Indian Institute of Technology Jammu, Jagti, PO-Nagrota, NH-44, Jammu, Jammu and Kashmir-181221, India
[2]Department of Mechanical Engineering, National Institute of Technology Surathkal, NH-66, Srinivasnagar, Surathkal, Mangaluru, Karnataka-575025, India
*mohitphd21@gmail.com

Abstract. Prosthetics are standard assistive devices that enable the partial movement of body parts lost due to dysvascular disorder or locomotive dysfunction. Conventionally fabricated prosthetics are stiff and lead to wounds and ulcers. As these devices require customization due to variations in the patient limb sizes, additive manufacturing (AM) provides an advantage in their fabrication. Therefore, it is necessary to design and develop a prosthetic socket from functional aspects. These aspects may be considered in two ways: graded from lattice structures and graded from polymer composites based on properties such as deformation and elastic modulus. Simulation and analytical models optimize the modulus of elasticity and deformation corresponding to the material uses based on stiffness and flexibility. The gyroid-type lattice structures are used to provide lightweight and thermo-regulatory prosthetic sockets. However, the models become distorted due to the large size of STL files. Fused filament fabrication (FFF) of the AM technique fabricates the graded prosthetic socket based on the geometrical aspects.
Keywords: Additive manufacturing, functionally graded polymers, prosthetic sockets, lattice structures, and simulation.

Paper ID #337

Influence of Surface Textures and Tribological Process Parameters on Frictional Characteristics of Al Alloy

Vikas Kumar Sahu[1*], Pravesh Chandra Shukla[2], Soumya Gangopadhyay[3]
[123]Indian Institute of Technology Bhilai, Raipur – 492015, India
*vikas.sahu@iitbhilai.ac.in

Abstract. The implementation of a regular micro-surface texture, namely in the form of micro-dimples on metal surfaces, may provide substantial enhancements in reducing friction for lubricated mechanical components. The objective of this study was to examine the influence of surface texture geometry and tribological process parameters on aluminium alloy (Al alloy). Three variety of plate samples having different surface textures were produced using conventional micro machining techniques. These samples were prepared for dimple diameters of 90 µm, 120 µm, and 240 µm, by maintaining the depth/diameter ratio as 0.16. Subsequently, these samples were subjected to reciprocating pin on plate tribological testing under six conditions, which were determined based on the load and speed parameters of a typical single-cylinder compression ignition (CI) generator engine. It has been reported that the coefficient of friction reduced in a range of 2.3 to 84%,

depending on different texture configurations and test conditions. Moreover, superior outcomes were observed under situations of elevated speed and increased load.
Keywords: Al alloy, Surface roughness, Textured surface, Tribology test, Frictional resistance

Paper ID #338

Influence of Grain-Size on Formability in Micro- Incremental Sheet Forming of Ultra-Thin Titanium Grade 2 Foils

Mainak Pal[1*], Anupam Agrawal[1*], Chandrakant K Nirala[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Ropar, Rupnagar 140001, Punjab, India
*anupam@iitrpr.ac.in

Abstract. Micro-incremental sheet forming (µISF) is a flexible manufacturing process and has advantages over existing micro-forming processes, due to its die-less nature of material deformation. In µISF, an ultra-thin foil is plastically deformed into a complex 3D geometry. It is precisely governed by the predefined toolpath of the forming tool on the surface of the foil. Due to sizeeffect, achieving high formability of the foils in micro-forming is difficult. This work investigates the deformation behavior of 100 µm thick CP-Ti Gr2 foils. The received foil is heat-treated at two different temperatures to obtain the foils with altered grain sizes. It was witnessed that the changes in annealing temperature and grain size enhanced the formability of the micro-parts. The foil with a higher grain size helped in increasing the fracture limit of the formed components.
Keywords: Micro-incremental sheet forming (µISF), CP-Ti Gr2 foils, Annealing, Grain size, Formability.

Paper ID #339

Stacked Ensemble Learning Based Bearing Fault Diagnosis

Subhendu Ghorai[1*], D. S Srinivasu[1], Piyush Shakya[1]
[1]IIT Madras, Chennai, Tamil Nadu, 600036, India
*devadula@iitm.ac.in

Abstract. Bearings are at the heart of all rotating equipment. The condition of the bearings often reflects the health of the machine. In particular, spindles, which are important components in various machining operations, are highly dependent on the reliability of their bearings. Therefore, diagnosing bearing defects is critical for managing bearing health. Towards this, the present work explores a methodology for classifying bearing faults using the stacked ensemble technique (SET). The SET leverages the strength of several underlying models (*e.g.*, logistic regression, decision trees etc.) chosen due to their unique properties. The base models are trained on bearing vibration data to make predictions, and then a meta-learner is trained to combine these predictions. The proposed methodology is implemented on vibration data generated from seeded bearing defect experimentation. The ensemble stacking approach not only improves predictive accuracy, but also mitigates the limitations inherent in individual models. The methodology classifies different bearing faults with 100% accuracy.
Keywords: Stacking ensemble, bearing fault diagnosis, fault classification.

Paper ID #341

Multipass Friction Stir Welding of Age Harden Aluminum Alloy

Sunil Kumar Yadav[1*], Padiri Murali[2], D K Singh[1], Zaheer Khan Yusufzai[3]
[1]Department of Mechanical Engineering, Madan Mohan Malaviya University of Technology Gorakhpur, Uttar Pradesh, 273010, India
[2]Department of Metallurgical Engineering, Indian Institute of Technology (BHU) Varanasi, Uttar Pradesh, 221005, India
[3]Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi, Uttar Pradesh, 221005, India
*skyme@mmmut.ac.in

Abstract. Joining of Age harden aluminum alloy is challenging. In this experimental work, the Age-harden aluminum alloy AA2024 has been joined using multipass friction stir welding (FSW). The impact of numerous friction stir welding passes on mechanical characteristics was examined using tensile and microhardness tests. It has been observed that as the number of passes increases, the ultimate tensile strength and % elongation decrease but the yield strength increases. The microhardness result shows that the average hardness of the nugget zone is higher than the parent metal, and the hardness value of the heat affected zone reduces as the number of passes increases.
Keywords: Multi pass FSW, AA2024, Tensile strength, Microhardness.

Paper ID #342

Optimizing Machining Processes with Digital Twin Technology: A Review of Recent Developments

Rajat Jain[1*], P. Subhash Chandra Bose[2]
[1]Research Scholar, Mechanical Engineering Department National Institute of Technology, Warangal, Telangana, 506004, India
[2]Professor, Mechanical Engineering Department, National Institute of Technology, Warangal, Telangana, 506004, India
*rj712074@student.nitw.ac.in

Abstract. Digital twin-driven machining and optimizing process parameters is a promising approach for improving the efficiency and quality of machining processes. This approach leverages digital twins (DTs), virtual models of physical systems that enable real-time monitoring and simulation of system behavior. Manufacturers can reduce waste, improve productivity, and enhance product quality by using digital twins to monitor and optimize machining processes. This article reviews recent studies on digital twin-driven machining and process parameter optimization, highlighting this approach’s benefits, challenges, and limitations. The future research directions in this field include developing more advanced digital twin models and algorithms, integrating with other technologies such as artificial intelligence and machine learning, and applications in emerging fields such as additive manufacturing and smart factories.
Gradually becoming a contested area in smart machining, digital twin (DT) technology enables the quality control of the dynamic cutting process by constructing the allegiance DT models. There is a shortage of detailed and systematic studies of DT-driven machining despite certain review publications focusing on digital twins (DTs). This study begins by introducing the Digital Twin technology for machining systems. Then, the DT-driven machining system’s essential features, procedures, and services are analyzed. Future study areas are also suggested based on the analysis of DT-driven machining. The article discusses the potential of digital twin-driven machining and process parameter optimization in improving manufacturing efficiency and quality, emphasizes its significance, and highlights the need for further comprehensive research.
Keywords: Digital Twins, DT-driven machining, Hybrid Machining Processes, Electromechanical Products.

Paper ID #343

3D- Printed Graphene Supercapacitors for Flexible and Wearable Electronics

Sudhansu Sekhar Nath*, Poonam Sundriyal*
Department of Mechanical Engineering, Indian Institute of Technology Kharagpur
West Bengal, India, 721302
*psundriyal@mech.iitkgp.ac.in

Abstract. Digital manufacturing techniques assisted by computer-aided design (CAD) can revolutionize the rapidly growing field of wearable electronics. Smart electronics have recently emerged as a potential solution for next-generation wearable and flexible electronics due to their applications in healthcare, sports, transport, military, soft robotics, artificial intelligence, the Internet of Things, etc. Direct Ink Writing (DIW) is a highly efficient 3D printing technique to fabricate flexible electronics and high-performance supercapacitors due to its processing capability to print a wide range of materials. Here we report DIW-printed graphene supercapacitors using a 3D bioprinter. The morphology and element composition of the used materials was performed by scanning electron micrography (SEM) and energy dispersive spectroscopy (EDS). The flexible structures were printed using a 3D bioprinter (Hyrel). The device also performed well under mechanical deformation conditions (stretching, folding, and bending), depicting high flexibility. The discussed technique is highly efficient for the digital manufacturing of supercapacitors and other electronics.
Keywords: DIW, Supercapacitor, Flexible electronics.

Paper ID #346

Mechanical and Metallurgical Characterization of Heat Treated Wire Arc Additively Manufactured Carbon Steel

Adarsh Prakash[1*], Ritesh Singh[1], Sachin D Kore[1]
[1]School of Mechanical Sciences, Indian Institute of Technology Goa, Ponda, Goa, 403401, India

Abstract. Wire Arc Additive Manufacturing (WAAM) is an advanced manufacturing tech- nique, especially known for its ability to produce large sized components with a high deposition rate. The high deposition rate with multiple thermal cycle exposure, introduces differences in the microstructure and mechanical properties of the component at different layers. It is studied that this disparity in the properties of the component can be reduced through appropriate post-printing heat treatment. This research investigates the impact of three heat treatment cycles, annealing, hardening, and normalizing, on a WAAM-produced low-carbon low-alloy steel (ER70S-6). The effects of these treatments on the microstructure and mechanical properties of the samples were studied. The examination of the microstructure in the as-printed sample revealed the presence of a small amount of lamellar pearlite formed along the grain boundaries of polygonal ferrite, which constituted the main micro-constituents. The WAAM deposited samples when subjected to all three heat treatments and the microstructure evolution was observed depending upon the different cooling rates. This microstructure evolution altered the mechanical properties. The metallurgical characterization of the heat treated samples was carried out using optical microscopy, scanning electron microscopy, and energy dispersive spectroscopy. The microhardness was studied using Vickers microhardness tester. The study provides valuable insights into heat treatment strategies for WAAM-deposited carbon steel, contributing to the optimization of final products with desired properties for industrial applications. These findings can aid in enhancing the manufacturing process and ensuring the quality and performance of WAAM-fabricated components in various industrial sectors.
Keywords: Wire arc additive manufacturing, ER70S6, post deposition heat treatment,
SEM, EDS, microhardness.

Paper ID #347

Process Modeling of Additive Friction Stir Deposition

Harish Ladi[*], Ram Rapaka, BuchibabuVicharapu*
Indian Institute of Technology Palakkad
*buchibabu@iitpkd.ac.in

Abstract. Additive friction stir deposition (AFSD), a potential solid state metal additive manufacturing technique that is used printing bulk metallic parts with simple shapes. The existing literature on additive friction stir deposition till date has been focused on to reveal the structure and properties under the given process conditions. The temperature distribution and the repeated thermal cycling responsible for the evolution of the final properties is important, but rarely reported in literature. Therefore, a numerical model is proposed in this study for the accurate computation of temperature distribution in three-dimensional domain. AFSD of a typical AA6061-T6 is modeled and validated with the corresponding experimental results available from independent published literature. The predicted peak temperature are at various locations found to be in good agreement with the corresponding experimental results. Further, the microhardness of the printed layers is analyzed for the range of process conditions using Johnson-Mehl-Avrami model (JMA). The JMA model accurately estimated the microhardness of the printed specimens.

Keywords: Additive friction stir deposition, Friction stir additive manufacturing, Numerical model.

Paper ID #348

Staircase Effect in Laser Decal Transfer Based µ-3D Printing for Curved structure.

Anshu Sahu[1*], Mohd. Washique Ahemad[1], Vipul Singh[2], I A Palani[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Indore, India. [2]Department of Electrical Engineering Indian Institute of Technology Indore, India.
*phd1901203002@iiti.ac.in

Abstract. Laser-induced forward transfer/Laser Decal transfer has shown its potential for the selective printing of material for different sensor fabrication for MEMS devices. With the continuous implementation of laser decal transfer, Laser µ-3D printing process is a novel approach for the printing of micro-scale structures and sensor fabrications. It provides high material freedom, design freedom, and high-resolution capability for producing complex multilayer three-dimensional structures. The layer thickness of the printed structure is nearly equal to the donor material thickness and the entire structure will be printed by the accumulation of pixels and selective location for the micro-scale three-dimensional structure. Since the materials are printed in pixel-by-pixel and layer-by-layer fashion for threedimensional structure, hence staircase effect is visible predominantly in most of the 3D printing process. In this work, an attempt is made to evaluate the staircase effect by three different displacement conditions for next-layer printing.

Keywords: Laser µ-3D printing, laser-induced forward transfer, Laser decal transfer, Microfabrication.

Paper ID #349

Printability of AlSi10Mg and Ti6Al4V in LPBF using Machine Learning

Md Tabraiz Imam[*], Simson D., Kanmani Subbu S.
Department of Mechanical Engineering, Indian Institute of Technology Palakkad, Palakkad, Kerala 678623,
*131914002 @smail.iitpkd.ac.in

Abstract. In recent decades, metal additive manufacturing has evolved as a niche manufacturing process to fabricate complex shapes and a wide range of feature sizes without any unique tool. The printing quality and reliability of the part depend on the single-track characteristics of laser powder bed fusion (LPBF). The experimental quantitative prediction of single-track characteristics and

influence of process parameters is a timeconsuming and costly process. Machine learning methods hold great potential in addressing the obstacles encountered in the realm of LPBF. This study, proposed a common supervised machine learning method to predict the printability of metal alloy. The single track characteristics say the track width measured which is used as a basic dataset for training the prediction model. The results show that predicted single track characteristics for the corresponding process parameters achieve accuracy greater than 80%. The proposed machine learning methodology can help in reducing the real-time consumption of predicting the printability of the metal alloy.
Keywords: LPBF, machine learning, material printability, AlSi10Mg, Ti6Al4V, single track.

Paper ID #350

Experimental Study on the Feasibility of Friction Stir Lap Welding of Polycarbonate to Al6061 Sheets

Nisith Ku. Goswami[1*], Raj Ku. Bisoyi[1], Kamal Pal[1]
[1]Department of Production Engineering, Veer Surendra Sai University of Technology, Burla, Sambalpur, Odisha 768018, India
*nisithgoswami82@gmail.

Abstract. Lightweight materials such as aluminium and thermoplastics have gained increasing popularity in various manufacturing industries because of their advantageous characteristics, including high strength-to-weight ratios, corrosion resistance, and self-insulating properties. In recent years, friction stir welding has emerged as a solid-state joining process that is well-suited for joining thermoplastics and aluminium. This is in contrast to fusion heat-assisted welding methods, which may not be suitable for lightweight materials due to their unfavourable thermal properties. Friction stir welding is a solid-state process that does not rely on melting the materials. In the present study, we explore the feasibility of using friction stir welding to join dissimilar materials, specifically polycarbonate (PC) and aluminium alloy Al6061. The thermoplastic polycarbonate is overlaid onto the metallic aluminium (Al6061) for lap welding. Our main goal was to investigate the influence of these parameters on the weld bead profile and subsequently on the tensile shear strength of the joints. The tensile shear load was analysed in conjunction with elongation. It has been found that the joint's tensile shear strength was maximized (24.1 MPa, equivalent to 51.27% of the polycarbonate's strength) at a medium tool turning speed (1100 rpm) and medium welding speed (55 mm/min), which resulted from effective mixing at the joint interface. However, it's important to note that the weld bead profiles exhibited a blackish appearance at all rotational speeds. Non-uniform weld beads were particularly evident at higher rotational speeds and lower to medium traverse speeds, notably at 50 mm/min and 55 mm/min, respectively.
Keywords: Lap welding, Al6061, PC, weld bead contour, joint tensile shear strength, Elongation at fracture.

Paper ID #351

High Strain Rate Electromagnetic Crimping on a Variation of Impact Target Geometry

Ummed Singh*, Ashish Rajak
Department of Mechanical Engineering, Indian Institute of Technology, Indore, 453552, India
*phd2201103006@iiti.ac.in

Abstract. Electromagnetic crimping (EMC) is a high-strain rate material joining process. EMC is the most suitable for conductive materials like Cu, Al, Ni, Mg, etc. In this process, the material near the electromagnetic field impacts the target materials, providing a rigid, air-tight joint in a fraction of a second. In this study, the AA6061 tube is crimped over the AA6061 rod at 6.34 kJ of energy using the electromagnetic forming (EMF) machine. Work is done to change the rod's surface profile geometry to improve crimped strength. Variations over the target rod surface, such as threads, knurls, grooves, and plain surfaces are made to understand the effect of target surface

geometry at the same discharge energy on the EMC process. The effect of the variables is analysed using a pull-out test, compressive shear test, cross-section analysis, and microhardness analysis.
Keywords: High strain rate process, Plastic deformation, Electromagnetic crimping process, Aluminum alloys Introduction.

Paper ID #352

Remaining Useful Life Prediction using Physics-Based Approach and Machine Learning Techniques

Venkata Krishna Manohar Bulusu[1*], Chethana R Gowda[2] ,Akashjyoti Barman[3] , Rahul Kumar[4] , Sudha Radhika[5], Sabareesh Geetha Rajasekharan[6]
[2,3,4,6]Department of Mechanical Engineering, BITS-Pilani Hyderabad Campus, Secunderabad, India
[1,5]Department of Electrical and Electronics Engg, BITS-Pilani Hyderabad Campus, Secunderabad, India [3]
*sradhika@hyderabad.bits-pilani.ac.in

Abstract. An aircraft and many mechanical machineries have multiple components which are crucial for its proper functioning, out of which, Printed Circuit Boards (PCB) play a pivotal role. A PCB has several components mounted on it, each playing an essential role in the overall functioning. Predicting the remaining useful life (RUL) of Printed Circuit Boards (PCBs) is one of the most important things. In the present study, the RUL prediction on a PCB without any components and a PCB with a capacitor fixed is performed, varying the input acceleration values sinusoidally and randomly. The RUL of PCB is estimated by combining a physics-based approach - Koopman operator, which is a mathematical tool to transform non-linear dynamic systems into linear ones, and a data-driven approach to enhance RUL prediction accuracy. Performance of various models using LSTM network with sigmoid as activation function, tanh as activation function, and different types of Koopman operators were performed and compared. A hybrid approach combining Koopman operators and LSTM networks was found to predict the RUL of PCBs providing a robust and accurate method for addressing the complexities of RUL estimation in electronic components.
Keywords: Remaining Useful Life, Long Short-Term Method, Printed Circuit Board, Koopman Operator.

Paper ID #353

Process Monitoring and Numerical Analysis of Mechanism of Laser Forming in Open-Cell Aluminium Foam

Mohammad Shahid Raza[1*] , Partha Saha[1]
[1]Indian Institute of Technology Kharagpur, West Bengal, 721302, India
*psaha@mech.iitkgp.ac.in

Abstract. Forming metal foam is always a challenge for providing the final shape to any component. The present work explores the behaviour of a 70% porous aluminium alloy foam. The mechanical deformation of such foams showed their brittle fracture behaviour for quasistatic loading conditions. The laser forming of the foam was carried out with process parameter variations in order to minimize surface damage to thin cell walls. The high conductivity of aluminium, along with high porosity, makes the material also challenging for thermal deformation. So, the monitoring of the surface condition of the material becomes an important task for its practical application. The monitoring of thermal and deformation was carried out to understand the bending mechanism of such noble materials. In the present material, all the process parameters showed a thermal gradient mechanism with local surface temperature reaching near the melting point. A significant difference between the TGM in solid sheets with respect to TGM in foam was observed. It was inferred that the role of material thickness is very prominent in the foam for obtaining different bending mechanisms like thermal gradient, buckling coupling and upsetting. Different characterizations

related to microstructure, pore deformation and densification were used to analyze the bending of the foam.

Keywords: Laser Forming, Monitoring, Metal Foam, Numerical Analysis.

Paper ID #354

Effect of Moisture Diffusion on Mode I/II Fracture Toughness of Banana-Sisal Fiber Reinforced Epoxy Composites

Suganth V[1*], N. Rino Nelson[1]

[1]Department of Mechanical Engineering, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram, Chennai-600127, Tamil Nadu, India

*rino@iiitdm.ac.in

Abstract. Natural fiber composite materials have attracted researchers, to drive towards sustainable development. The primary function of natural composites have a better strength-to-weight ratio and are light weight with degradable characteristics. Long term exposure of moisture affects the performance of composite. The primary objective of the study is to determine the fracture toughness for Mode I, and Mode II of Banana Sisal (BS) composites under moisture diffusion. In this study, the effect of moisture diffusion is studied on banana-sisal fiber reinforced epoxy composite for understanding the failure modes. The composite is exposed to moisture diffusion under ambient conditions. The failure modes of the composite laminates are prepared by compression moulding with predefined notch to height ratio. The experiments are conducted on both dry and wet specimens. The wet specimens composite laminates are subjected to water immersion for predefined time duration to reach the saturated mass equilibrium. The experiments are carried out using arcan fixtures indicating the mode I/II crack initiation and propagation for both dry and wet samples. Gravimetric analysis proved that natural composites have significant moisture uptake and stored in the interface region. The effect of moisture in composites decrease the critical value of K_{IC} compared to dry one; fiber matrix degradation occurs in this stage.

Keywords: Critical energy strain release rate, Delamination, Mixed mode I/II, Moisture diffusion, Natural composite, Sustainability.

Paper ID #355

A New Method for Part Consolidation and Functional Integration

Jayakrishnan Jayapal[1*], Hemnath Anandan Kumar[2], Sudhir Varadarajan[3], Senthilkumaran Kumaraguru[1*]

[1]Department of Mechanical Engineering, Indian Institute of Information Technology Design and Manufacturing, Kancheepuram, Chennai – 600127, India.

[2]Department of Mechanical Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Chennai, India.

[3]School of Interdisciplinary Design and Innovation, Indian Institute of Information Technology Design and Manufacturing, Kancheepuram, Chennai – 600127, India.

*skumaran@iiitdm.ac.in

Abstract. Product design and development are processes that require careful integration of various components to achieve the desired functional output. To improve the efficiency and effectiveness of these processes, this study examines the strategies of Part Consolidation (PC) and Functional Integration (FI). PC involves combining multiple functions into a single component, reducing the number of individual components. In the context of Additive Manufacturing (AM), these strategies offer significant potential for producing complex and customized products at a lower cost and with greater efficiency. This paper presents a novel methodology for optimizing the functional integration and part consolidation of AM products using a Design Structure Matrix (DSM) and Weighted Degree Centrality Score (WDCS). Specifically, the composite-DSM (CDSM), an advanced variation of the traditional DSM, is employed to identify potential candidates for PC and

FI. CDSM captures both hierarchical and non-hierarchical relationships between components in a system or project, making it a valuable tool for enhancing the design and manufacturability of AM products. This study contributes to the body of knowledge in product design and development, particularly in the context of AM, by offering a structured approach to harness the benefits of functional integration and part consolidation.
Keywords: Part Consolidation, Functional Integration, Centrality score, Weighted degree centrality, Additive Manufacturing, Design for Additive Manufacturing.

Paper ID #356

Microstructural Characterization of AZ31B Deposit made by Novel PBFS process

Prabhakar Kr Singh[1], Akash Mukhopadhyay[1], Probir Saha[1*]
[1]Indian Institute of Technology Patna, Bihta, Patna – 801106, Bihar, India
*psaha@iitp.ac.in

Abstract. Current investigation is the study of microstructural evolution in AZ31B deposit produced using AZ31B powder employing the novel Powder Bed Friction Stir (PBFS) technique. The fabrication of the deposit using AZ31B powder involved the implementation of a suitable process parameter, specifically a rotational speed of 1200 rpm and traverse speed of 360 mm/min. Additionally, a tool design with a triple-circular protruded feature was utilized. The microstructure analysis was done using electron back-scatter diffraction (EBSD). The examination focused on the resulting grain refinement, amount of recrystallization, and texture evolution.
Keywords: Solid state additive manufacturing, AZ31B magnesium powder, severe pastic deformation, grain refiement, texture evolution.

Paper ID #357

Influence of ALCLAD Layer on the Process Responses During Dissimilar Micro-Friction Stir Welding (μfsw) of Aluminum Alloy Sheets

Mayank Verma[1*], Probir Saha[1*]
[1]Advanced Manufacturing Lab., Department of Mechanical Engineering, Indian Institute of Technology Patna, Bihta, Patna – 801106, Bihar, India
*psaha@iitp.ac.in

Abstract. The presence of aluminum cladding on the surface of any material can affect the formation of the weld when joined with itself as well as with another material. It affects the process responses as well as the performance of the weld. Moreover, the analysis of the process responses can give useful information concerning the tool-workpiece interaction conditions. Hence, in the present work, welding forces and welding temperature were assessed during the dissimilar micro-friction stir welding (μFSW) of 0.5 mm thick ALCLAD AA 2024-T3 and AA 6061-T6. For the comparison purpose, dissimilar μFSW of unclad AA 2024T3 and AA 6061-T6 of the same thickness were carried out at the same process parameters. It was observed that a soft ALCLAD layer between the tool and the alloy beneath the ALCLAD alters the interaction conditions and influences the weld formation. This results in different process responses in both cases. The fluctuation in the welding forces obtained with ALCLAD (= 633.7 N) was lower compared to that with the UNCLAD (= 856.6 N). Additionally, the average temperature obtained with ALCLAD (= 342 ᴼC) was comparatively lower. This was because of the less deformation of the material due to more tool slippage caused by the soft ALCLAD layer. This further affects the intensity of material intermixing and deteriorates the performance of the weld. As a result, the highest weld efficiency (= 76.1 %) was achieved in the case of UNCLAD due to better material mixing as an effect of the absence of a soft layer.
Keywords: Dissimilar micro-friction stir welding, Welding forces, Welding temperature, ALCLAD, Ultra-thin sheets.

Paper ID #358

Pair-wise Comparison of Crucial Barriers to Circular Supply Chain Adoption towards Sustainable Manufacturing Prospects: An ISM-based Approach

Rita Nagwal[1*], Kumar Rohit[2], Ravindra Pathak[3]
[1,3]Medicaps University, Indore (MP, India)
[2]Shri G.S. Institute of Technology and Science, Indore (MP, India)
*rohitkumar.mechy@gmail.com

Abstract. This study profoundly determined and analyzed the core linkages between the barriers to circular supply chain (CSC) deployment and their impact on CSC performance in order to address the knowledge gap in the literature. In this study, the prime focus is to determine and classify the key barriers based on how they would affect the deployment of CSC practices in SMEs. There are in all a total of eighteen (18) barriers that have been identified as impeding the successful adoption of CSC practices in manufacturing sectors. The pair-wise comparison employing interpretive structural modelling (ISM) and MICMAC analysis was used to categorize these eighteen obstructions to CSC deployment. The pair-wise comparison and scores for these barriers to CSC deployment were generated based on rigorous discussions and brainstorming sessions. The key outcomes of this research were drafted in the matrix frame keeping the note of these scores so as to classify the key barriers to CSC adoption. The end results of this research emphasize on identification and categorization of significant barriers to CSC deployment based on pair-wise comparison and scores and the assessment of their impact on CSC performance metrics. This study will determine a set of crucial barriers required for the successful implementation of CSC practices targeting the overall sustainability in manufacturing enterprises not only in India but also on a global basis.
Keywords: Circular Supply Chain, Industry 4.0, Circular Economy, Barriers, ISM, MICMAC Analysis.

Paper ID #359

CO_2 Laser Surface Modification of Green Si_3N_4 - SiO_2 Ceramic for Enhanced Texture and Quality

Rajaram Kr Gupta[1*], Vijay Kr Pal[2*]
[1,2]Department of Mechanical Engineering, Indian Institute of Technology, Jammu - 181221, Jammu & Kashmir, India;
*vijay.pal@iitjammu.ac.in

Abstract. Si_3N_4 - SiO_2 - based wave transparent functional materials serve to safeguard the communication and guidance systems of space shuttles in harsh environments. However, machining or adding macro textures to the final sintered ceramic pellets, which are composed of Si3N4 and SiO2, proves challenging due to the extreme hardness and brittleness of these materials. To address this, the objective was to create micro-textured surface channels on green ceramic pellets formed through compression molding, followed by CO2 laser treatment (wavelength: 10.6 µm). This research delved into the influence of CO2 laser parameters on surface characteristics, including the heat-affected zone and surface morphology. The results demonstrated the successful formation of textured channels, featuring depths ranging from 7 to 47 µm and widths spanning 145 to 290 µm, achieved through CO2 laser ablation. Laser parameters significantly affected surface quality, yet X-ray Diffraction (XRD) analysis revealed no observable phase changes. Field Emission Scanning Electron Microscopy (FESEM) uncovered sintering layers within the laser-textured grooves, suggesting the melting and resolidification of Si3N4 + SiO2 particles, particularly at power levels of 10 W or higher and scanning speeds of 15 mm/s.
Keywords: Laser treatment; green ceramics compact; characterization; surface quality; Morphology of laser ablation.

Paper ID #360

Computational Analysis of Additively-Manufactured Tablets with Hybrid Infill Pattern

R Durga Prasad Reddy[1*], Varun Sharma[2*]
[1]Additive and Subtractive Manufacturing (ASM) Laboratory, Dept. of Mechanical and Industrial Engineering, IIT Roorkee, INDIA - 247667
[2]Dept. of Mechanical and Industrial Engineering, IIT Roorkee, INDIA
*varun.sharma@me.iitr.ac.in

Abstract. Additive manufacturing has been one of the most tremendously growing technologies in the manufacturing paradigm. Its advantages have propelled this technology as the most sought-after in various fields of industries. This technology has also been utilised to fabricate oral tablets and they have shown personalized release behavior that act as per the metabolic needs of patients. The aim of this research work was to analyse the degradation behaviour of 3D printed tablets, loaded with drug, in body fluid conditions. Computer-aided designs of tablets having hybrid infill structures were created and loaded into COMSOL software for analysis. The degradation of the loaded models of tablets have been carried out using modelling governing equations of previous literatures. Then, the results obtained using the computational analysis were analysed with the experimental in-vitro studies conducted for the Fused Deposition Modelling (FDM) fabricated polyvinyl alcohol (PVA) tablets loaded with myo-inositol drug in the previous study of the authors. It was found that the results obtained from the computational analysis were in agreement with that of the experimental data. There were slight errors found between the two plots for all the tablet formulations. This can be attributed to the values of the diffusivity constants used during the simulation of differential equations in the software. The present work can be essential contribution towards the assessment of feasibility of additively manufactured tablets as a means of achieving the goal of personalized medication.
Keywords: Additive manufacturing, drug dissolution, hybrid infill.

Paper ID #362

Development of Tool Wear Monitoring System using Data-Driven Approach

K.A. Swathi, Nitish Bhinde[*], Shrey Singhal, Sreejith. S, Amrita Priyadarshini, Sabareesh Geetha Rajasekharan[*]
Department of Mechanical Engineering, BITS-Pilani, Hyderabad Campus, Telangana-500078, India
*sabareesh@hyderabad.bits-pilani.ac.in

Abstract. Tool wear is a major factor in the cutting process, which directly affects the machining precision and part quality. Thus, a tool wear monitoring system is crucial in the machining process to determine the stages of tool wear and to enable replacement of tool before catastrophic failure. In this paper, a data-driven based approach is employed to classify the tool wear stages in a CNC machine using feature vectors derived from vibration and force measurements. Three different data-driven algorithms are used namely- J-48, Random Forest and Logistic Model Tree to classify the tool wear stages. The prediction accuracy obtained using these approaches proves the ability of machine learning methods to identify the inherent features embedded in the sensor signals to classify the stages of tool wear. Further, t-SNE plots obtained from feature vectors of vibration and force measurements individually and combinedly prove the effectiveness of the multi-sensor approach in tool wear estimation.
Keywords: Tool wear monitoring, data-driven methods, feature vectors.

Paper ID #363

Preliminary Investigation of Development and Tribological Behavior of Bilayer Electroless Ni –B Coating with Copper Inclusion Tin Stabilized Bath

Abhinandan Kumar*, Amod Surin, Vivek Gari, Arpit Nischal, Arkadeb Mukhopadhyay
Department of Mechanical Engineering, Birla Institute of Technology, Mesra, Ranchi – 835215, India
*kumarabhi.dtg@gmail.com

Abstract. Electroless nickel-boron coatings were created using a new, tin stabilized deposition bath. For single layer deposition the substrate dipped in composed bath for two hour, another next two hour substrate dipped into the solution for deposition of another layer. The surface of Bi-layer coated sample was characterized by Field emission scanning electron microscopy (FESEM), which shows the columnar growth at surface. The wear rate (0.63×10^{-6} g.N^{-1} .m^{-1}) and COF (0.43) was obtained through tricological test done on Pin-On-disc (POD). The corrosion test was done with 3.5% NaCl solution to evaluate E corr (131mV). The Bi-layered coating are also subjected ICP-OES to assure the boron wt. % (6.3). The immediate layer following the substrate may serve as an adhesion layer, which may be layered with an anti-wear and anti-corrosion top layer. Because of the variance in corrosion potential across different layers, bi-layer structures provide superior corrosion resistance than monolayer coatings. Inclusion of copper in electroless Ni-B coating provides enhanced crystallinity and more compact surface morphology. The scratch hardness is observed to be 12 Gpa at 10 N constant load. The average COF is seems to be minimum 0.43 at 0.5m/s sliding speed. The porosity test was also done to affiliate the absence of micro pores. The microhardness of Bi-layered as- deposited coating is found 816 at HV_{50}.
Keywords: Bi-layer, electroless Ni-B coating, wear, COF.

Paper ID #364

Application of Used Cooking Oil (UCO) FOR MQL Machining - A Feasibility Study

Pradeep Krishnan G[1*], D Samuel Raj [2]
[1, 2]Department of Mechanical Engineering, College of Engineering Guindy, Anna University
Chennai – 600 025.
*pradeepkrishnan.g@gmail.com

Abstract. Despite significant research in MQL during the last two decades, its ability to replace flood cooling in small and medium scale machining industries is limited in spite of its benefits over the flood cooling system. The performance of MQL in comparison with flood cooling is superior in terms of surface finish, tool life, and geometrical accuracy of the machined components. One major cause for this slow reach is the high recurring cost of the MQL oil. Commercial MQL oil from reputed brands costs from $8 to $18 per liter, while the cost of flood coolant oil is INR $2 to $3 per liter only. The high recurring cost of MQL oil makes it almost impossible for small and medium-scale industries to use MQL. With the high cost of MQL oil, use of MQL will be ~21.6 times higher than the flood coolant cost and therefore, it is impossible to use MQL as an alternative to flood cooling system. Therefore, it is imperative to reduce the cost of MQL oil. The waste oil from cooking is available at a lower cost and can used as a potential alternative to commercial oil. Used cooking oil (UCO) has very limited application despite its huge generation. Drilling studies are conducted at two different speeds on AISI 304 plates. The stainless steel 304 drilling studies with UCO have proved to be better than the commercial oil in terms of surface roughness and tool life at a medium cutting speed of 2390 rpm while at a high cutting speed of 4777 rpm, the performance of UCO is not satisfactory.
Keywords: Low-cost MQL oil, Used cooking oil, Stainless steel 304, Drilling.

Paper ID #365

A Review on the Application of Magnesium Metal Matrix Composites in the Biomedical Field

Rawad Yaqoub Aljabr[1*], Gondipalli Sai Mahesh Kumar Reddy[2], P.S.C Bose[3]
[1]Research Scholar, NIT Warangal, Telangana - 506004, India
[2]M. Tech, NIT Warangal, Telangana - 506004, India
[3]Professor, NIT Warangal, Telangana - 506004
*ra712191@student.nitw.ac.in

Abstract. A prominent area of medical science research and development has been the use of biodegradable materials for implants. Due to their unique properties, including as biodegradability, mechanical strength, and biocompatibility, magnesium (Mg)-based composites have attracted a lot of attention. The development and use of mg composite materials for implants are thoroughly reviewed in this research. According to the research, mg composites are a promising the future of implant material and an alternative to traditional implant materials. To overcome the current limitations and fully realize the promise of mg composites in the medical industry, more study and technological advancements are required.
Keywords: Magnesium composites, Powder metallurgy, Stir casting.

Paper ID #367

Effect of Carbon-Vacancy on Microwave Heating Characteristics of 3C-SiC

T L Dora[1*], Radha Raman Mishra[1*]
[1]Department of Mechanical Engineering, Birla Institute of Technology and Science Pilani, Rajasthan, Pilani-333031, India.
*rraman.mishra@pilani.bits-pilani.ac.in

Abstract. Understanding the thermal response of materials with defects under microwave irradiation is critical for various applications, including electronics, materials science, and energy conversion. To gain insights into the molecular level heating of 3C-SiC with carbon defects, this study employed classical molecular dynamics to explore the effects of microwave irradiation at varying electric field strengths and frequencies. The findings indicated that the inclusion of vacancies in the 3C-SiC system resulted in a significant temperature rise, leading to a much quicker attainment of its melting point when compared to the pristine 3C-SiC system. Carbon vacancies, as well as variations in E_n and *f*, had a substantial impact on the particle mobility and diffusivity within the microwave-irradiated 3C-SiC system. Notably, at high frequencies, approximately 90% increase in the diffusion coefficient was observed when E_n was increased from 0.1 to 0.5 V/Å.
Keywords: Microwave irradiation, 3C-SiC, vacancy defect, molecular dynamics, particle mobility.

Paper ID #368

Characterization of Al- 5% TiB_2 functionally graded composites developed via Centrifugal Casting Method

Basudeb Rajak[1*], Uppu Srinivas Rao[1*,] Rakesh Kumar Gautam[1], L. Sankara Rao[2]
[1]Department of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi, 221005, UP, India
[2]Department of Metallurgical Engineering, Indian Institute of Technology (BHU), Varanasi, 221005, UP, India
*sruppu.mec@iitbhu.ac.in
Abstract. This study aims to investigate the mechanical characterization and synthesis of Al- TiB_2 functionally graded materials (FGMs). The properties of FGM, such as density, hardness, tensile, and compressive strength have been studied. The FGMs are obtained with the centrifugal casting technique under the influence of mechanical stirring. To achieve the performance of Al-TiB_2 FGM, the horizontal centrifugal casting machine has been designed. Three different mold speeds are

considered for various parametric studies. Metallurgical & mechanical testing was performed subsequently of the product developed by this machine to evaluate the performance. The micro-hardness test was conducted over four samples with different mould speed. The effect of friction on the pin's surface was examined using SEM. Al-5%TiB_2 composite produced at 1100 rpm, exhibited less wear compared to the composites produced at 1000 and 1200 rpm.
Keywords: Centrifugal Casting; Functionally Graded Material; Fabrication; TiB_2; Aluminum.

Paper ID #369

Effects of Mesoporous Structure on Corrosion Behavior of Metal Fused Filament Fabricated 316L Stainless Steel

Vijaya Kumar P[1*], Velmurugan C[2*]
[1,2]Indian Institute of Information Technology Tiruchirappalli, Tamil Nadu – 620012, India
*velmuruganc@iiitt.ac.in

Abstract. Additive manufacturing technology is being employed in the medical industry to create complex shape of specimens composed by polymer, metal, and ceramic materials. The effects of post processes such as heat treatment and mesoporous structure formation are not investigated in detail on the 3D printed degradable materials. In this work, the stainless steel 316L components have been fabricated using metal fused filament fabrication process. The printed components were involved in post-processes such as debinding (at 427°C) and sintering (at 1350°C) in a high-temperature furnace. Thereafter, the mesoporous structure has been formed over the sintered specimens. The specimen surface was created to resemble a mesoporous structure in the range from 2 to 50 nm using anodization process. The corrosion behavior of the heat treated as well as mesoporous formed specimens was analyzed using potentiodynamic polarization test with simulated body fluid. Results of the research suggest that the mesoporous surface could obtain a better corrosion resistance and an extensive surface area when treated at 1123 K for 1.5 hours to meet biomedical application.
Keywords: Stainless steel; metal fused filament fabrication, post-processes; mesoporous; corrosion resistance.

Paper ID #370

Laser Polishing of Additive manufactured Cobalt Chrome Alloy by Continuous Wave Line Focused Beam: A Response Surface Methodology Based Approach for Improving Surface finish

Abhishek Kumar[1*], Cheruvu Siva Kumar[1], Ashish Kumar Nath[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology, Kharagpur- 721302, West Bengal, India
*abhishek.kumar.mec11@iitkgp.ac.in

Abstract. Direct Metal Laser Sintering (DMLS) is an additive manufacturing process where a laser selectively sinters metal powder particles, fusing them to create a solid part. Post-processing techniques are essential for additive manufacturing (AM) to achieve printed parts' desired final properties, functionality, and aesthetics. A highintensity laser beam is used in laser polishing to heat and melt the item's surface. Because the molten material reflows and hardens, the surface becomes smoother. Surface flaws such as burrs or roughness can be removed selectively using laser polishing without altering the overall dimensions of the part. Cobalt-chromium alloy is used as a substrate for fabricating surgical and dental implants due to its high weight-to-strength, biocompatibility, and toxicity. The study aimed to improve the surface finish of the lateral or side surfaces of an additively manufactured cobalt chrome alloy by changing process parameters such as laser power and scan speed. A contact-type surface roughness tester was used to measure the laser-polished specimen's average surface roughness (Sa). The 3-point method of surface leveling

produced the leveled surface. The form of the surface was extracted from the leveled surface by a polynomial of degree 2, resulting in form error and a surface without deviation. The experiment was designed and analyzed using a central composite design. Surface roughness improved from an average initial range of 15±2.2 µm to a final average of 6.44 µm and 2.74 µm (average 57.06% reduction with maximum 81.73% reduction), representing better improvement. High laser energy density was associated with higher form error and waviness components. In conclusion, laser polishing with a line-focused beam is an effective method for cost-effectively polishing larger areas.

Keywords: Direct Metal Laser Sintering (DMLS), Laser Polishing, Central Composite Design, Cobalt Chrome, Surface roughness.

Paper ID #371

Modification of Surface Topography of Inconel 625 By Fabricating Ordered Microtextures Using Micro Milling

Surya Prakash Singh[1*], Karali Patra[1], Vikash Kumar Sahu[2], Soumya Gangopadhyay[2]
[1]Indian Institute Technology Patna, Patna, Bihar, 801106, India
[2]Indian Institute Technology Bhilai, Bhilai, Chhattisgarh, 491001, India
*surya_2121me18@iitp.ac.in

Abstract. The surface texturing of micro/nano features is the most inventive and durable method of addressing various functional challenges, such as surface wettability and bio-tribological performances. Mechanical micro-fabrication is one of the most popular methods for creating highly precise micro-textures in a single step at a reasonable scale.

The current work describes the simple one-step fabrication of micro dimple patterns on the flat surface of Inconel 625 (IN625) to alter the topography and surface roughness. Parallel micro-dimpled surfaces with various end shapes have been successfully created utilizing mechanical micro-fabrication processes using three different cutting tool geometries. The choice of tool shape and micro-dimple depth affects the size of the micro-dimples.The impact of important parameters on surface topography, such as texture shape, size, and pitch was carefully examined. Digital microscopy and a 3D profilometer were used to examine the surface topography and roughness. The preliminary results indicated that ordered dimples created by micro-milling significantly changed the surface topography and roughness compared to untextured surfaces.

The study shows that the pitch, diameter, and depth of dimples of machined surfaces are closely matched with desired values. However, flat-end milled surfaces produce the maximum area surface roughness (Sa), which is almost three times rougher than that obtained with ballend mills.

Keywords: Micro-texture, Inconel 625, Milling, Roughness.

Paper ID #372

Experimental Investigations on Plasma Cutting of Medium Carbon Steel

Anand Petare[1*], Yuvraj Kumar Madhukar[2], Anas Ullah Khan[3]
[1]Central Workshop, Indian Institute of Technology Indore, India, 453 552
[2,3]Department of Mechanical Engineering, Indian Institute of Technology Indore, India, 453 552
*yuvrajmadhukar@iiti.ac.in

Abstract. Air plasma cutting technology is widely used for cutting complex profiles, geometrics, shapes, and sections in electrically conducting materials at high speed. It has the flexibility to change the cutting current, gas pressure, cutting speed and standoff distance to maintain the desired quality of the surface to be cut. In this experimental work, 10 mm thick, EN8 steel plates were cut using plasma cutting and their effect on cut surface quality was studied. Total sixteen experiments with compressed air were conducted using a full-factorial design of experiments to identify the optimum ranges of process parameters. The cut surface quality was analysed in terms of kerf width,

dross height, bevel angle and average surface roughness. The microstructure study of the cut surfaces reveals that the melting and blasting action mechanism of material removal in the plasma cutting. The microhardness study suggest more microhardness over the top region of samples than that of the bottom region. The outcome of this study would be beneficial for the researcher and engineers working in the area of plasma-assisted cutting of metals.

Keywords: Plasma Cutting, Dross, Kerf, Heat Affected Zone, Surface Roughness.

Paper ID #373

Validation of Class of Nonlinear Controllers on lab Scale Batch Reactor: Sliding Mode Controllers

Krupa Narwekar[1*], Prajwal Shettigar J[2], Thirunavukkarasu Indiran[3*]
[1]Instrumentation Manager
[2]Department of Mechatronics, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal – 576 104, Karnataka, India
[3]Department of Instrumentation and Control Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal – 576 104, Karnataka, India.
*it.arasu@manipal.edu

Abstract. Batch reactors are highly nonlinear due to its exothermic reaction with chemical feed along with its non-steady state. The uncertainty in this batch reactor experimental study is considered as the change in input cold water. Which is circulated in the reactor jacket to carry away the additional heat. Sliding Mode Controllers are more robust and sensitive to additional uncertainty added into the system dynamics. In this paper authors considered the nonlinear model equations developed for the experimental batch reactor by Prajwal et al. The optimal temperature profile is developed for acrylamide polymerization reaction and used as a reference trajectory for the closed loop simulation and validation. The coolant flow rate is the manipulated variable circulated via circular coil and the reactor temperature is the process variable. In this paper authors have presented four types of Sliding Mode Controller (SMC) to arrest the reactor temperature oscillations with the reference trajectory. The experimental results depicts that the SMC with PI sliding surface gives minimum control signal and reactor temperature tracks the trajectory over a period of time than other types of SMC.

Keywords: SMC, Exothermic Reactions.

Paper ID #374

Sustainable Manufacturing of Metal Additive Powders from Machining Scrap

Karan A. Baramate[1*], Franck Lacan[1], Michael Ryan[1], Soumya Gangopadhyay[2], Debajyoti Bhaduri[1]
[1]High-Value Manufacturing Research Group, School of Engineering, Cardiff University, Queen's Buildings, Cardiff, CF24 3AA, UK
[2]Department of Mechanical Engineering, Indian Institute of Technology Bhilai, Durg, Chhattisgarh, 491001 India
*BaramateKA1@cardiff.ac.uk

Abstract. The paper reports a study on the generation of viable metal additive manufacturing (AM) powders from AA5083 aluminium alloy scrap obtained from conventional milling process. This material recycling route involves multistage ball milling (BM) of raw chips using a planetary ball miller with varying ball-to-powder ratio (BPR: 10:1 and 15:1), ball diameter (5, 10, and 20 mm), RPM (150, 300, and 500), jar volume (100 and 250 ml) and BM time (30 and 60 mins). The BM powders were characterised in terms of the particle size distribution, morphology, and phase analysis. Single-track melting of the produced BM powder was subsequently carried out using an in-house laser powder bed fusion (LPBF) system by varying energy density (E_d) (15-134 J/mm^3). Quite expectedly, the height and width of the melted tracks increased with the increase in E_d. The

study demonstrates that it is possible to produce BM powders that can be utilised for fabricating AM parts, however further research is imperative in order to achieve the desired size, shape and flowability of the BM powders that can be suitable for LPBF process.
Keywords: Sustainable manufacturing, Additive manufacturing, Ball milling.

Paper ID #375

Development of Friction Stir Incremental Forming Process for Hard-to-Form Metal Sheets

D. Rajenthirakumar[1*], R. Sridhar[2] , T. Karthick[3]
[1, 2, 3]Department of Mechanical Engineering, PSG College of Technology, Coimbatore - 641 004, Tamilnadu, India
*drk.mech@psgtech.ac.in

Abstract. In this work, the behavior of titanium (hard-to-form material) formability is investigated using friction stir incremental forming process in which forming is done under localized friction heating caused by high tool rotation (without the use of dedicated dies).This work focuses on improving the mechanical properties (like hardness, yield strength and tensile strength) through process optimization. Series of experiments are carried out in a vertical machining centre with grade 5–Ti-6Al-4V alloy sheets of size 300 mm x 300 mm x 1.2 mm with hemispherical end forming tool. The effect of key process parameters, namely the rotation speed, the feed rate and the step depth is investigated. This work addressed the key issues encountered by researchers worldwide on friction stir incremental forming and it will provide useful guidance in improving the product quality formed by friction stir incremental sheet forming.
Keywords: Friction stir; Forming; Sheet; Thickness; Formability.

Paper ID #376

Investigation on Influence of Various Operating Parameters in Wire Arc Additive Manufacturing using ER4043 Aluminium Alloy

K. Venkateswarlu[1*], G. Ravi Kiran Sastry[2], K. Ashok[1], K. Santhosh Kumar[1], CH Ramachandra Reddy, CH R. Vikram Kumar[1*]
[1]N B K R Institute of Science & Technology, Vidyanagar, AP - 524 413, India
[2]National Institute of Technology, Tadepalligudem, AP – 534102, India
*cvikramkumar@gmail.com

Abstract. Wire and Arc Additive manufacturing (WAAM) is the most advanced technique used to fabricate parts by depositing material in layer-bylayer sequence using inert gas welding. Mechanical and metallurgical properties of WAAM products are much better and suited for aerospace engineering applications. The robotic MIG welding process is most suited for producing WAAM products of complex structures. This study investigated the influence of wire arc additive manufacturing (WAAM) parameters on the properties of welded layers of ER4043 aluminium alloy. The morphology and mechanical properties of the layered beads were analysed. The results showed that the hardness of the deposited layers decreased with increase of the specific energy consumption during welding. The cooling rate and formation of oxides on the weld bead during cooling caused the formation of air gap between two layers and results in delamination. The deposition of multi-layer welded bead changes the width and thickness of the previous deposited layers. The variation in thickness, width and hardness of the deposited material with variation in the welded parameters are presented and discussed in this paper.
Keywords: Wire Arc Additive Manufacturing, ER4043 Aluminium Alloy, MIG welding.

Paper ID #377

Characterization of Poly (Methyl Methacrylate)/ SilverDoped Hydroxyapatite Dip Coating on Ti6Al4V

Gagan Bansal[1,2*], Rakesh Kumar Gautam[1], Joy Prakash Misra[1], Abhilasha Mishra[2]
[1]Indian Institute of Technology, Banaras Hindu University, Varanasi, UP, 221005, India
[2]Graphic Era (deemed to be University), Dehradun, Uttarakhand, 248001, India
*gaganbansal12345@gmail.com

Abstract. This study aims to investigate the development and characterization of a biocompatible coating for Ti6Al4V substrates through the utilization of a dip coating process. The usage of titanium and its alloys in orthopedic and dentistry applications owns to their remarkable mechanical characteristics. The present study investigates the utilization of polymethyl methacrylate (PMMA) as a medium for the deliberate application of 20 wt% silver-doped eggshell-derived Hydroxyapatite (HAPAg20) onto Ti6Al4V substrates. The experimental methodology encompasses the synthesis of a composite material consisting of PMMA/HAPAg20, followed by a comprehensive analysis using scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FTIR). The analysis of surface wettability involved the contact angle measurements and the assessment of surface free energy (SFE). A hydrophilicity change of 7.03% was detected when comparing the PMMA ($75.27^0 \pm 1.69^0$) and PMMA/HAPAg20 ($70^0 \pm 1.44^0$) coated samples. The Atomic Force Microscope (AFM) is utilized for the characterization of surface topography, average surface roughness (Ra and Sa) and root mean square roughness (Rq and Sq) in both 2D and 3D. The incorporation of HAPAg20 into PMMA leads to a marginal elevation in surface roughness. Finally, the findings of this study provide a foundation for future examinations of the biocompatibility of these coated substrates in both in vitro and in vivo settings. These investigations will ultimately aid in the advancement of implant materials within the realms of orthopedics and dentistry.

Keywords: Poly (methyl methacrylate), Dip Coating, Titanium Alloy, Hydroxyapatite, Biomedical Characterization.

Paper ID #378

Grinding of Titanium Grade 5: A Review

Ashish Kumar Sharma*, Yatendra Kumar Yadav, Pranab Kumar Kundu*
Department of Mechanical Engineering, Motilal Nehru National Institute of Technology Allahabad, Prayagraj, Uttar Pradesh, 211004, India
*pranabkundu@gmail.com

Abstract. Grinding is a widely employed high-speed precision machining technique in industries to enhance surface quality. It involves abrasive grits adhered to a metallic disc or bonded together, producing tiny material chips during the operation. Its unique properties allow for simultaneous engagement of multiple fine abrasive grits, enabling the machining of difficult to cut materials. However, high-speed grinding generates substantial heat, potentially causing surface burns and chip re-deposition on the machined surface. Wheel loading and rapid wheel wear are also concerns. Despite challenges, grinding remains inevitable for high-demand materials like titanium. This paper provides a comprehensive review of a widely employed titanium alloy, Ti-6Al-4V grinding methods, emphasizing the importance of optimizing process parameters, abrasive wheels, and environmental conditions. The exhaustive review has been completed considering horizontal-spindle reciprocating table surface grinding of Ti-6Al-4V.

Keywords: Titanium alloy, Machining, Drop-by-drop, MQL.

Paper ID #379

A New Way of Estimation of Feedrate in Centreless Grinding Process using Video Analysis

Amal Dev B S[1*], N. Arunachalam[2], K. Hariharan[2]
[1]Department of Mechanical Engineering, IIT Madras, Chennai
[2]Associate Professor, Department of Mechanical Engineering, IIT Madras, Chennai
*chalam@iitm.ac.in

Abstract. The estimation of feedrate in throughfeed centreless grinding is important to assess the productivity of the process by deciding the machine setup configurations, which result in maximum throughput and minimum form errors. In various engineering disciplines, the estimation of object velocity from recorded video has been widely used. This work is aimed to estimate the feedrate of throughfeed centreless grinding process for different setup configurations using video analysis software by tracking the workpiece motion. The new proposed methodology involves feedrate estimation by analysing the recorded video of workpiece motion, comparison with theoretical feedrate for assessing the accuracy and a regression model to predict feedrate for new set up configurations. A mean percentage error of 11.50 % was obtained between theoretical and estimated feedrate, which shows the discrepancy between them. A linear regression model was able to fit the estimated feedrate with a standard deviation of 1.00 and an R^2 value of 98.41%. The regression model could predict feedrate of configurations well with a predicted R^2 value of 96.82%. It was observed that the estimated feedrate deviated from theoretical feedrate due to the factors such as regulating wheel friction characteristics, contact loss and regulating wheel form errors. The method serves as a quick way to analyse the workpiece motion, while the model built using the video analysis data could estimate the feedrate of the process with a good prediction accuracy. The method can also help in deciding the setup configurations for a pre-decided feedrate and for implementing computer-vision techniques for in-process feedrate measurement.

Keywords: Through feed, Feedrate, Video Analysis.

Paper ID #380

Development of Electroless Ni-B Coating with Enhanced Hardness using ANN-GA Methodology

Subhash kumar[1*], Arkadeb Mukhopadhyay[1], Arun Kumar Kadian[1], Anil Chandra Mahato[1]
[1]Department of Mechanical Engineering, Birla Institute of Technology, Mesra, Ranchi 835215 India
*phdme10001.23@bitmesra.ac.in

Abstract. The Electroless Nickel-Boron (ENi-B) coating finds extensive use in a variety of applications because of its superior hardness and exceptional wear resistance. The primary objective of the current research is to utilize artificial neural networks and genetic algorithms (ANN-GA) to improve the hardness through the development of an electroless Ni-B (ENi-B) coating. A model for an electroless bath, stabilized with lead nitrate, was developed using ANN. The parameters namely, nickel chloride, sodium hydroxide, ethylenediamine, sodium borohydride, lead nitrate, temperature, plating time and pH are considered and fitted into ANN model to obtain the optimized condition to get an enhanced hardness of electroless Ni-B (ENi-B) coating.The importance of developed electroless Ni-B bath parameters and its effect on the hardness of the coating was studied through GA and it revealed the optimized hardness value of 999 HV_{50}. The optimized value obtained from GA was validated with experiment carried out and found to be closer. The elemental composition was examined using X-ray diffraction (XRD), while scanning electron microscopy was employed to analyze the surface morphology.

Keywords: Electroless Ni-B Coating, ANN-GA, Microhardness.

Paper ID #381

Microstructural and Mechanical Studies of Maraging Steel Fabricated by Laser-Powder Bed Fusion and Conventional Processes: A Comparative Study

Manoj Kumar[1,2*], Santosh Kumar[1], Pankaj Kumar Singh[1], Bipin Kumar Srivastava[2]
[1]Department of Mechanical Engineering, IIT (BHU), Varanasi, U.P., India-221105
[2]Banaras Locomotive Works (BLW), Varanasi, U.P., India-221004
*manojkumar.rs.mec21@itbhu.ac.in

Abstract. Additive Manufacturing (AM) is a method for the fabrication of threedimensional complex parts for different industrial applications. In this study, maraging steel samples have been fabricated by laser-powder bed fusion (L-PBF) process using metal powder of maraging steel-300 (X3NiCoMoTi-18-9-5), and conventional maraging steel was used for comparison purposes. The as-built AM and conventionally fabricated samples have also been solution-treated at 900°C for 1 h and cooled in air. In solution-treated samples, better mechanical properties were observed in this low-carbon (<0.02%) Fe-Ni martensitic steel samples due to the precipitation of fine intermetallic structures. The density, microhardness, and microstructural examinations have been evaluated to compare the mechanical properties and also to validate the feasibility of the AM process for the fabrication of maraging steel components, applicable for industrial applications. The microhardness of L-PBF-produced samples is higher in comparison to conventionally produced samples because of precipitation and the fine grain structure formed due to the high solidification rate. After solution treatment, the microhardness of the L-PBF and conventional maraging steel samples was 51.0 and 48.6 HRC respectively. The density of maraging steel produced by both processes is almost similar. The fine grain structure was obtained in as-built L-PBF samples in comparison to conventionally fabricated samples. After heat treatment, the grain size of L-PBF-produced samples was reduced in comparison to that of as-built samples. From the result, it can be concluded that the AM process can be used to fabricate complex structures of maraging steel.
Keywords: Maraging steel, Laser-powder bed fusion (L-PBF), Density, Microstructure, Energy dispersive spectroscopy (EDS).

Paper ID #382

Numerical and Experimental Investigation of Freeform Fabricated Auxetic Structure-based Planar Mechanical Metamaterial

Shubhangee Singhal*, Rakesh Kumar, Sanyukta Marandi, Anu Agrawal, Anupam Agrawal*
Advanced Manufacturing Technology Lab, Department of Mechanical Engineering Indian Institute of Technology Ropar, Rupnagar, Punjab-140001, India
*anupam@iitrpr.ac.in

Abstract. The aerospace and automotive industries are working on lightweight structural materials with energy-absorbing properties and good mechanical properties to improve their functional parts' efficiency and fuel consumption. Using different foams and porous structure-based parts inevitably reduces the overall mass of carrier vehicles and parts. Due to its peculiar mechanical behaviour (i.e., negative modulus and Poisson’s ratio), specifically designed auxetic structure-based mechanical metamaterials have gained more research interest in recent years. It has resulted in the development of several new structural and hybridized unit cell-based auxetic structures with primitive, star, re-entrant, and origami-based structures. In the present work, an attempt has been made to design, simulate, and perform experimental characterization of re-entrant and star-based auxetic planar metamaterials for energy-absorbing applications. The designed structures are simulated using ABAQUS® with the ductile damage criterion to determine the failure modes under different loading conditions. The structures have been fabricated by Acrylonitrile Butadiene Styrene (ABS) using the Fused Deposition Modelling (FDM) process and further tested experimentally under compressive and tensile loading conditions. The Digital Image Correlation

(DIC) technique analyzes the strain field and calculates the Poisson's ratio of the designed structures.

Keywords: Mechanical Metamaterial; Additive Manufacturing; Re-entrant; Energy Asorption; Digital Image Correlation.

Paper ID #383

Prediction of Tensile Strength of Additively Manufactured Continuous Carbon Fiber Reinforced Polymer Composites through Machine Learning approach

Dhiliepan.R[1*], S.Nazeer[1], Muthukannan Duraiselvam[1*], J.John Rozario Jegaraj[2], K.Mohamed Hussain[1], Ramakrishnan Muthusamy[1], R.Jayaganthan[3]
[1]Department of Production Engineering, National Institute of Technology, Tiruchirappalli, Tamil Nadu, 620015, India
[2]Defence Research and Development Laboratory, Kanchanbagh, Hyderabad, Telangana, 500058 India
[3]Department of Engineering Design, Indian Institute of Technology Madras, Chennai, 600036 India
*durai@nitt.edu

Abstract. Continuous Fiber Reinforced Polymer (CFRP) composites are widely used in industries to utilize its superior mechanical properties, specifically their high specific stiffnesses and specific strengths. However, access to composite materials is currently limited in a number of applications due to production restrictions, which differ widely depending on the technology used. Comparing and assessing the mechanical characteristics of composites made using these different processes will help further knowledge on the potential of emerging additive manufacturing techniques for use in large-scale manufacturing and industrial applications. Composites made of CFRPs consist of combinations of short or continuous fibers bound by polymer matrix. Machine learning (ML) algorithms that are based on numerical and statistical procedures are utilized repeatedly to imitate human decision. The tensile strength of CFRP thermoplastic composites is projected in the present work using five different machine learning procedures, which are sourced and equated. Decision Tree (DT), Support Vector Regression (SVR), Linear Regression (LR), Random Forest Regression (RF) and Lasso Regression (LASSO) are those five algorithms. The ML model predicted the tensile strength of the composites using the python - jupyter notebook tool. The models were compared using the error analysis of Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Mean Square Error (MSE) and Coefficient of Determination (R^2). LASSO method found to be the best suit since it had highest R^2 value of 0.99 and the least errors of all the algorithms. The predicted tensile strength of 234 MPa obtained using LASSO model was validated and found closer to the experimental value.

Keywords: Continuous Fiber Reinforced Polymer (CFRP) composites, tensile strength, Machine Learning, decision tree, linear regression (LR), support vector regression (SVR), random forest regression (RF), and lasso regression (LASSO).

Paper ID #384

Predicting Weld Interface Profile of Laser Wobble Welding using an Analytical Approach at Early Design Stage

Naeem Siddique[1*], Indranil Manna[1], Nikhil Kumar[2], Abhishek Das[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, 110016, India
[2]WMG, The University of Warwick, Coventry, CV4 7AL, United Kingdom
*abhi@mech.iitd.ac.in

Abstract. Laser welding with beam oscillation has become popular to enhance the weld quality, which not only does the homogeneous mixing in the weld zone but also improves the joint strength. In addition, laser beam oscillation/laser wobble welding can help in controlling the penetration

depth/interface width. An analytical approach can help in understanding the effect of laser wobble parameters at early design stage. In this paper, an analytical model has been developed using mathematical understanding of the laser material interaction with the wobbling parameter. This model can be used for predicting the weld depth profile for a given set of process parameters. This model is used to determine the heat distribution, weld morphology and the depth of penetration. Increasing the wobble amplitude and frequency, interaction time gets reduced, which enhances the weld bead size but the energy density per unit cross-section reduces. Due to this, the depth of penetration of the weld bead reduces. This model will act as a guiding tool in selecting important process parameters to obtain a particular depth of penetration and it will also narrow down the number of experimental trials.
Keywords: Laser welding, Beam oscillation, weld-depth prediction.

Paper ID #385

Comparative Study on Induction Heating assisted Hybrid Friction Stir Welding With Friction Stir Welding of Nitinol in Lap Welding Configuration

Susmita Datta[1*], Shaket Khare[1], Pankaj Biswas[1]
[1]Indian institute of Technology Guwahati, Guwahati, Assam -781039, India

Abstract. Friction stir welding of Titanium and Nickel-based alloys are challenging because of the extreme tool wear and inadequate quality of the weld. Different secondary sources of energies have already been used by the previous researchers to assist the traditional FSW process. NiTinol, equiatomic Ni-Ti shape memory alloy with shape memory effect and pseudoelasticity, are widely utilized in the fields of aerospace, automotive, civil-structural and hydrospace application. To multiply the usage of the alloy, it necessitates the assembly of the alloy to further intricate shape, size and structure. Generation of intricate shape of NiTinol are complex and expensive as the alloy has low machinability and formability property. The solid-state welding process is gaining interest because it can impart better mechanical properties. In this current work, a comparison of conventional friction stir welding (FSW) and induction heating assisted FSW (IFSW) of NiTinol in lap joint configuration would be done using 1 mm thick NiTinol sheet. A cylindrical tool made of WC-10 % Co with taper pin was used. The experimentations were carried at tool rotational speed of 450 rpm. The welding speed was fixed at 40 mm/min for conventional FSW and at 70 mm/min for IFSW. The preheating temperature was fixed at 400 ˚C. Refined grain structures for both the cases were observed. As a result of this, mechanical properties were enhanced. The microhardness value of the stir zone was increased considerably from that of the parent material. The tensile properties were enhanced in comparison with fusion welding of NiTinol.
Keywords: NiTinol, Friction stir welding, Induction heating, Microstructure, Metallurgical property.

Paper ID #386

Feasibility Analysis of Aluminium Alloy Welding using Cold Metal Transfer (CMT) for Electric Vehicle battery tray fabrication

Rukaiya Azma[1*], Aviral Rastogi[1], Shewtank Rai[1], Naveen Kumar[1], Abhishek Das[1*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Delhi, Delhi-110016, India
*abhi@mech.iitd.ac.in

Abstract. One of the most promising solutions for the reduction of greenhouse gases caused by conventional fossil fuel-based vehicles is the use of electric battery-driven vehicles. The battery pack is the driving unit for electric vehicles, which consists of multiple battery unit cells. These cells are stored in the battery box or tray which is attached to the vehicles. High-quality weld with less heat input to the intricate battery parts is required for battery tray preparation. Cold Metal Transfer (CMT) is one of the effective joining methods for these battery packs due to its lower heat

input. In the present work, the sheets of aluminium alloy AA6061-T6 having a thickness of 1.5 mm were welded using a robotic CMT process by utilising the filler wire of 1.2 mm diameter of ER4046 at different weld speeds, currents and arc lengths. It has been observed that quality joint with good strength, hardness and optimum bead geometry was achieved at preferred welding parameters (current of 65A, weld speed 7 mm/sec and arc length 3.5mm). This paper reported the feasibility of welding lightweight aluminium alloy using the CMT process as low heat input is advantageous for thin sheets. Low welding speed and high welding current resulted in coarser grains. Lower arc length led to the formation of the improper weld bead and unequal heat distribution having lower tensile strength.
Keywords: Cold metal transfer, aluminium alloy, electric vehicle, battery tray.

Paper ID #387

Quantifying Energy vs Time Mode Variations obtained from Ultrasonic Metal Welded Busbar-to-Busbar Joints

Vijay Sharma[1*], Suman Bag[1], Naveen Kumar[1], Abhishek Das[1*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, 110016, India
*abhi@mech.iitd.ac.in

Abstract. Aluminium-to-aluminium and copper-to-copper joints are widely used combinations of materials for the busbar joints (due to their high conductivity) for electric vehicles. Ultrasonic welding has emerged as a most promising solid-state joining process due to its ability to avoid intermetallic formation, less porosity formation, and larger weld area than fusion-type welding. The key parameters affecting an ultrasonic joint's quality are clamp pressure, vibrational amplitude, weld time, and weld energy. In general, ultrasonic welding is done by varying either time or energy. Although USMW holds such suitability for the busbar joining process, very few studies have been conducted to determine the consistency of weld quality between these two modes. In this study, two types of joints of Al-Al and Cu-Cu were made under both time and energy modes while keeping the welding pressure and amplitude constant. Microstructural characterisations were carried out to understand the joining mechanism during both welding modes. Further, the mechanical behaviour of the joints (lap configuration) was investigated using the lap shear test. The lap shear strength for the busbar joints obtained under both modes unveiled high deviation in the strength for the sample welded under the time mode, while the samples welded with energy mode showed relatively consistent results. This study found that the energy mode was preferred for welding to reduce variation.
Keywords: Ultrasonic welding, Weld Microstructure, Joint Strength, Lap Shear Strength.

Paper ID #388

Numerical and Experimental Analysis of the Effect of Sheet Thickness Ratio on Clinching of AA6061-T6 Sheets

Priyabrata Nath[1*], R. Ganesh Narayanan[1]
[1]Department of Mechanical Engineering, IIT Guwahati, Assam, 781039, India
*nath176103112@iitg.ac.in

Abstract. The influence of the sheet thickness ratio on the joint quality of clinched joints was investigated experimentally and numerically. With three sheet thickness ratios, 0.8, 1, and 1.25, and four different sheet thickness combinations, 1.2:1.5, 1.2:1.2, 1.5:1.5, 1.5:1.2, clinched joints were produced using AA6061-T6 sheets of 1.2 mm and 1.5 mm thickness. The cross-sections of the joints were investigated to study the joint geometry parameter such as neck thickness and undercut. Single lap shear tests were conducted to analyze the static strength, energy absorption, and failure mode. In addition, a three-dimensional numerical model was developed using commercial FE software DEFORM-3D to conduct simulations. The results showed that with increase in sheet

thickness ratio the neck thickness of the joints increases, while there was no clear trend observed in case of the undercut. All the joints failed with neck fracture failure mode. Joints with larger sheet thickness ratio produced stronger joints with greater energy absorption. The numerical simulations had good correlation with the experimental results.
Keywords: Clinching, Sheet Thickness Ratio, FE Simulation, DEFORM-3D.

Paper ID #389

Optimisation of Process Parameters to Fabricate Tubular Components of AA 5083-O Alloy Using Friction Stir Welding for Crashworthiness Applications

Debolina Sen[1*], Surjya Kanta Pal[1*], Sushanta Kumar Panda[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, West Bengal, India-721302
*skpal@mech.iitkgp.ac.in

Abstract. Thin-walled tubular components of aluminium alloys, fabricated by friction stir welding (FSW) can be utilized in automobiles as energy absorbers due to its cost-effectiveness and no dimensional restrictions. However, FSW of tubes is challenging due to the presence of curvature in the tubes. Thus, an attempt was made in the present study to fabricate tubes of AA 5083-O through longitudinal friction stir welding process. Critical process parameters for welding the tube were optimised for the longitudinal direction using Response Surface Methodology so as to get a good quality welded joint. Furthermore, post welding properties of the tube such as roughness value of the weld zone and tensile properties were evaluated. It was found that with optimized parameters the weld region had low surface roughness and excellent tensile strength which was due to proper heat generation during welding. Moreover, the crushing performance of the welded tube was also performed and the weld zone showed no failure during crushing along with good energy absorption.
Keywords: Tubular structure, FSW, Optimisation, Mechanical properties, Crushing performance.

Paper ID #390

Laser Micromachining of PDMS-Water Based Transparent Microwave Metamaterial Absorber

Raj kumar[1], Kajal Chaudhary[2], Gaganpreet Singh[3], J. Ramkumar[1*], Raghvendra K. Chaudhary[4]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur, U.P, 208016, India.
[2]Department of Electrical Engineering, Indian Institute of Technology Kanpur, Kanpur, U.P, 208016, India.
[3]The Oskar Klein Centre, Department of Physics, Stockholm University, AlbaNova, SE-10691, Stockholm, Sweden
[4]Departemnt of Electrical Engineering, Indian Institute of Technology Kanpur, Kanpur, U.P, 208016, India.
*jrkumar@iitk.ac.in

Abstract. In the present study, initially the absorber is designed that comprised of optically transparent PDMS as the top layer, machined PDMS layer with the designed pattern as the middle layer, and the bottom-most layer comprised of the conductive ITO-PET layer. Subsequently, the PDMS sheet is fabricated, and the KrF excimer laser is employed for the micromachining. The parametric analysis is carried out by varying energy levels (500 – 550 mJ) and number of pulses (100 – 300) at a pulse frequency of 30 Hz to achieve the desired depth of machining in each layer of the sheet structure. Additionally, conducting a numerical simulation using COMSOL Multiphysics, where CFD analysis is performed to understand the pressure variation and wall stress within the structure.
Furthermore, the structure was simulated using HFSS software, and it was found that the reflection coefficient (S_{11}) lies below -10 dB for the frequency range of 15.1 GHz to 27.3 GHz. Similarly, the

transmission coefficient (S_{21}) also stayed below -10 dB for the same frequency band. Notably, it has been observed that EM absorption exceeds 90% within this frequency band that indicates the effectiveness of the metamaterial absorber in achieving broad absorption.
Keywords: Metamaterial Absorbers, PDMS Fabrication, Excimer Laser Micromachining.

Paper ID #391

Extrusion of Non-Symmetric shapes: Simulation and Experiment

Pratik Kumar Singh[1*], Santosh Kumar[2] , Navin Chaurasiya[1] , Md. Meraz[2]
[1]Department of Mechanical Engineering, UNSIET, V. B. S. Purvanchal University, Jaunpur-222003, India
[2]Deparment of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi-221005, India

Abstract. This paper presents the simulation model and experiment for the development of a symmetric and non-symmetric shape component using hot extrusion die design technique. Extrusion is the process by which metal is made to flow through a small opening, resulting in the creation of an exceptionally long strip with a uniform cross-section. A tough and complex problem in process modelling is the simulation of the hot extrusion process. This is a result of the process's extremely massive deformations, high strain rates, and significant temperature fluctuations. A computer programme is created to investigate the ideal form of the designed extrusion dies, which results in the lowest power consumption for a certain decrease in area, die length, off-centric location, and frictional conditions. The findings of some computations are contrasted with experimental and simulation verifications for a variety of circumstances. HyperXtrude and DEFORM 3D v11.0 have been used to simulate the work.
Keywords: Hot Extrusion, Non-Symmetric, Computation, Off-centric positioning.

Paper ID #392

Effect of Inter-track Offset on the Dimensional Accuracy of Thick Wall Produced by Wire Arc Additive Manufacturing Process

Soumyadip Das[1*], Varun Sharma[1,2 *]
[1]Department of Design, Indian Institute of Technology, Roorkee-247667, Uttarakhand, India
[2]Department of Mechanical and Industrial Engineering, Indian Institute of Technology, Roorkee-247667, Uttarakhand, India
*varun.sharma@me.iitr.ac.in

Abstract. Wire Arc Additive Manufacturing (WAAM) is an updated version of Gas Metal Arc Welding (GMAW) process that is used to fabricate threedimensional parts by melting and depositing material in a layer-by-layer manner. In this study, an attempt has been made to fabricate a thick wall through WAAM process using optimum inter-track or inter-pass offset to achieve dimensional accuracy of the fabricated part. Additionally, surface texture analysis has been performed for the experimental validation of the theoretical model of optimum inter-track offset. The experimental validation confirms that the use of optimum inter-track offset produces smooth and flat surfaces through a reduction in surface roughness and waviness. The average roughness at the overlapped region of two adjacent beads is found to be 1.14 microns. The improvement in surface quality is accounted for by selecting the value of intertrack offset equal to two-thirds of bead width.
Keywords: Wire arc additive manufacturing, Gas metal arc welding, Offset.

Paper ID #393

A Comparative Assessment to Evaluate Force and Stress of Nimonic 80A for Different Grinding Schemes

Aswani Kumar Singh[1*], Saurabh Singh Rathore[2], Varun Sharma[3]
[1,2]Additive and Subtractive Manufacturing Lab, Department of Mechanical and Industrial Engineering, Indian Institute of Technology, Roorkee, India
[3]Department of Mechanical and Industrial Engineering, Indian Institute of Technology, Roorkee-247667, Uttarakhand, India
*varun.sharma@me.iitr.ac.in

Abstract. Due to their undesirable properties at higher temperatures, machining nickel-based super-alloys presents substantial challenges. Additionally, environmental concerns arise due to the generation of temperature during the process. In order to address these issues related to traditional grinding, this work focuses on enhancing sustainability and performance by modifying the grinding process. This is attained with addition of ultrasonic vibration into the conventional Grinding (CG). The study examines various grinding approaches, analyzing cutting forces, temperature, and simulated value of stress. In the results section, the addition of high frequency and low amplitude of ultrasonic vibration showed positive upshots in grinding forces and temperature as compared to CG. Notably, UAG yields significant reductions in both normal and tangential cutting forces as well as a reduction in grinding temperature compared to CG. Based on the material removal process, forces were calculated experimentally for the UAG and CG. Afterward, these forces have been applied to the grinding zone to estimate the resulting stresses. This study provides the path to predict stress values after incorporating ultrasonic vibration onto the workpiece materials.
Keywords: Conventional Grinding; Ultrasonic Assisted Grinding; Nimonic; ABAQUS; Simulation.

Paper ID#394

Effect of Print Direction on Tribological Behavior of DMLS Manufactured Ti6Al4V Alloy for Knee Implant Application

Vipin Goyal*, Girish C. Verma
Department of Mechanical Engineering, Indian Institute of Technology, Indore 453552
*vipingoyal.raj@gmail.com

Abstract. In the present work, a study on the microstructure and tribological behavior of Ti6Al4V produced by direct metal laser sintering (DMLS) technique has been performed. All the samples were fabricated by the DMLS technique and then annealed (for stress relief) in a controlled atmosphere. In order to characterize tribological responses for orthopedicapplication, coefficient of friction (COF), and specific wear rate (SWR) were measured in a simulated body fluid (SBF) environment. Further, to understand the reason behind the obtained results, micro-hardness was measured along the study of microstructure. It has been found that the build direction (BD) possesses a lower SWR and COF as compared to the scan direction (SD). Moreover, the minimum COF and SWR are obtained at load 10N than the 5N and 20N. From the field emission scanning electron microscopy (FESEM) and Energy-dispersive X-ray spectroscopy (EDS) images of the worn surface, it was found that the most dominant wear mechanisms were adhesion, abrasion, and delamination.
Keywords: Additive manufacturing, Ti6Al4V, simulated body fluid, tribology, knee implant.

Paper ID #396

Evaluation of Microstructural, Mechanical, and Tribological Properties of Laser-Treated Electroless Ni-B Coatings

Vaibhav Nemane[1*], Mahesh Malviy[1], Satyajit Chatterjee[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Indore, Simrol, Indore 453552, India
*phd1701203005@iiti.ac.in

Abstract. Improvement in mechanical and wear properties of a material surface can enhance the service life of a component and thus have significant savings in energy and other resources. Electroless Ni-B coatings deposited using sodium borohydride as a reducing agent are well-known to alter the mechanical and tribological characteristics of material surface favorable for various industrial applications [1-3]. In the present investigation, to analyze beneficial advancement in the properties of electroless binary Ni-B alloy coating within a smaller area, a 2kW CW fiber laser is utilized for the laser treatment of coatings' surface. Variable laser power levels (100W, 150W, 200W, and 250W) are selected for this laser surface treatment in order to analyze the effects on coating's structural, mechanical, and tribological behavior and compare them with the as-deposited Ni-B coatings. All as deposited and laser treated coatings are thoroughly characterized using several techniques, namely XRD, FESEM, microhardness tester, scratch tester, and linear reciprocating sliding wear tester to study effects of the laser intensity on the coatings' properties. Ni-B coatings reveal short-range order characteristics and nodular top surface morphology in their asdeposited state. Significant changes in these characteristics are observed with the variation in laser power, which governs the degree of crystallization, and types of development of new phases within the coatings' matrices. Formation of intermetallic phases, such as nickel borides (Ni_3B and Ni_2B), iron borides (Fe_2B, Fe_8B, and Fe_7B) and $Fe_{0.64}Ni_{0.36}$ within coatings' matrices as a function of laser power governs the properties of coatings. Among all, samples treated at 150W evolved superior in terms of hardness, mechanical and tribological properties due to the precipitation strengthening achieved with the intermetallic phases developed within the crystalline coatings' matrices. Beyond 150W, either degradation in coatings characteristics owing to the coalescence and coarsening of intermetallic phases within matrix happens or a large-scale melting is observed.
Keywords: Electroless coating, Laser-treatment, Microstructure, Mechanical properties, Tribological properties.

Paper ID #398

Influence of Selective Microwave Hybrid Heating Process Parameters on Mechanical Characteristics of Inconel 625/SS 304 Dissimilar Weldment

Devendra L Kamble[1*], Ranjeet Kumar Sahu[1*], Narendranath S[1], Ravindra I. Badiger[2]
[1]National Institute of Technology Karnataka, Surathkal- 575025, India
[2]KarmaveerBhaurao Patil College of Engineering, Satara-415001, India
*ranjeetsahu.j@nitk.edu.in

Abstract. The utilization of a microwave hybrid heat source for the fabrication of dissimilar joints is now experiencing significant growth in the domain of advanced welding. This is because the said heat source could provide volumetric, uniform, and selective heating in a cost-effective way with negligible impact on the environment which would be beneficial to various industries. Till-date, researchers have used microwave hybrid heating to join various types of similar as well as dissimilar engineering materials. However, attention has not been paid on the joining and characterization of dissimilar Inconel 625-SS 304 materials using the afore-mentioned heat source as well as the promising applications of the weldments. Therefore, the current paper focuses on the influence of interfacial gap, type of susceptor and separator thickness on the joining of dissimilar materials – Inconel 625 and SS 304 alloys using selective microwave hybrid heating (SMHH). In SMHH, Nickel based powder is used as a filler material, and the process parameters used are

interfacial gap (0.25, 0.5, 1mm), susceptor (SiC powder, stone charcoal, Charcoal) to elevate the initial temperature and graphite sheet of thickness (0.5, 0.75, 1 mm) to avoid the intermixing of filler and susceptor respectively. The experimental results show that the combination of 0.25 mm interfacial gap, SiC as susceptor, and 0.5 mm graphite sheet provide the optimal tensile strength 422 MPa of the developed joint. The interfacial gap between the specimen found to be the influenced significantly on the UTS of the joint specimen followed by using SiC susceptor. The SiC susceptor owing to its high loss tangent absorbed the microwave rapidly and thus, increased the temperature at the joint interface which resulted in the favorable tensile strength. Further, the XRD results of the joints reveal that the joint zone contains carbides and intermetallic like Ni_8Nb, NbC, $Cr_{23}C_6$, Ni_3Cr_2, Cr_7C_3, $Fe_{2.50}Ti_{0.5}O_4$ and Fe_3Ni_2. Due to the presence of various hard carbide and intermetallic, the joint zone was found to fracture i.e. combined mode of fracture occur which is ascertained by SEM.
Keywords: Dissimilar material, Selective microwave hybrid heating, Characterization, UTS, Fractography.

Paper ID #399

Consequences of Addition of Nanoparticles on Tribological Behaviour of Coconut Oil Grease

Tanmoy Medhi[1*], Pranav Dev Srivyas[1], Pankaj Biswas[1]
[1]Indian Institute of Technology, Guwahati, Assam - 781039, India
*tanmoymedhi@gmail.com

Abstract. In the current study, coconut oil-based nano grease doped with 2 wt.% of hexagonal boron nitride (h-BN) and copper oxide (CuO) nanoparticles as additives have been investigated to observe its influence on the tribological properties. CuO and h-BN are used as additives because they possess special characteristics that signifies its uses, such as chemically inactive, resistance to oxidation, non-toxicity, high thermal conductivity, environment friendly and exceptional lubricity. The coconut oil-based nano grease was formulated by adding lithium stearate and was synthesized by sonochemical homogenization technique. In order to perform the tribological analysis, experiments were performed in configurations of ball on discs with a reciprocating test rig at different loading speeds from 10N-50N, 2mm stroke length and 50 Hz frequency under varying load conditions. Upon comparison with virgin coconut oil grease, the addition of nanoparticles has led to significant reduction in the friction coefficient and wear. On adding h-BN and CuO in coconut oil grease, friction coefficient was reduced by 17 % and 28 % respectively. As compared to h-BN, CuO reported a better wear reduction. It was observed that capability of the nanoparticles to create protective film especially by CuO is the main cause of enhanced tribological behaviour. Further analysis by 3D profilometer reported lower roughness values of worn samples doped with the nanoparticles.
Keywords: Coconut oil grease, Tribology, Lubrication.

Paper ID #401

Thermal Error Compensation for CNC Turning Machine using Regression Analysis

Shashank. P[1*], Dr. Deepak A.S[2], Aslam Taj Pasha[3]
[1,3]Ace Designers Limited, Bengaluru, Karnataka, 560058, India.
[2]M S Ramaiah University of Applied Science, Bengaluru, Karnataka, 560058, India.

Abstract. In the contemporary era of machinery, the demand for highly precise machines exhibiting enhanced accuracy experiences a continuous upsurge in tandem with technological advancements. This has ignited fierce competition within the manufacturing sectors, driving their efforts towards the development of CNC machines with superior accuracy. The predominant factor adversely impacting machine precision is thermal induced deformation. Multiple manufacturing sectors are actively engaged in research endeavors aimed at mitigating thermal distortion errors by

formulating compensation models through the utilization of diverse machine learning and statistical techniques. This study focuses on a Twin-spindle CNC turning machine, wherein real-time compensation methods are employed. Notably, machine learning methodologies, such as Regression analysis, have been meticulously selected for implementation in this research. The resultant parameters are derived from the Regression model and subsequently subjected to regularization techniques, enhancing the model's accuracy. These refined parameters are then integrated into the CNC machine in the form of equations. The outcomes of the regularized regression exhibit significantly improved accuracy compared to conventional Linear regression. Consequently, overall machine accuracy is markedly enhanced, leading to a 90% reduction in growth when compared to uncompensated results.
Keywords: CNC machine, Thermal errors, Regression analysis, Ridge regression, Normalization.

Paper ID #403

Slurry Erosion Behavior of Bead-On-Plate Welds Made on Nitrogen Containing Steel Using Gas Tungsten Arc Welding (GTAW)

Naveen Kumar[1*], Abhishek Das[1], Sagar Sarkar[1], Navneet Arora[2]
[1]Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, India 110016
[2]Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Uttarakhand, India 247667
*nkumar@iitd.ac.in

Abstract. The present study was focused on the slurry erosion study of nitrogen alloyed austenitic stainless steel (21-4N) base and bead-on-plate (BOP) welds. BOP welds were deposited on the base metal using gas tungsten arc welding (GTAW) process and characterized for their mechanical, metallurgical, and erosive wear properties. Nitrogen-containing duplex stainless steel filler wire ER2209 (0.18% N) was used to weld with pure Ar (100%) and Ar (95%) + N2 (5%) as shielding gas. The addition of nitrogen to shielding enhanced the weld nitrogen content and increased the austenite phase fraction [1], [2]. Microhardness of weld bead without nitrogen in shielding gas was observed to be lower as compared to nitrogen addition. Slurry erosion study on base metal and weld beads was carried out at 30º and 90º impingement angles, and it was observed that base metal with higher microhardness has higher erosion resistance. The erosive wear study was conducted by silica sand particles of size varying from 100 μm to 500 μm. The results show that minimum loss of material has occurred on the base metal surface followed by weld bead with and without nitrogen in the shielding gas. Increased nitrogen content in the shielding gas enhanced the properties of the weld bead and resulted in higher erosion resistance of the weld surfaces.
Keywords: 21-4N Nitronic Steel; Microstructure; GTAW; ER2209 filler; Erosion; Carbides.

Paper ID #404

Finite Element Simulation of Chip Formation and Experimental Characterization during Dry Machining of Inconel 617

Chandramani Upadhyay[1*], Sumit Singh Rajput[2], Soumya Gangopadhyay[2*], Susanta Kumar Sahoo[1]
[1]Department of Mechanical Engineering, National Institute of Technology, Rourkela, Odisha, 769008, India
[2]Department of Mechanical Engineering, Indian Institute of Technology Bhilai, Durg, Chhattisgarh, 491001, India
*soumya@iitbhilai.ac.in

Abstract. This study presents a comprehensive investigation into chip characterization during the turning of Inconel 617, employing three different cutting tool materials: WC, SiAlON, and SiC_w+Al_2O_3, while maintaining a constant feed rate and depth of cut at 0.15 mm/rev and 0.5 mm, respectively. The research encompasses three distinct cutting speeds, namely 50, 150, and 250

m/min. Notably, finite element (FE) simulations exhibit good agreement with experimental results at a 50 m/min cutting speed, revealing significant insights. It is observed that WC tools outperform SiAlON inserts in terms of lower main cutting forces and cutting temperatures, effective stress, effective strain, and superior chip reduction coefficient at lower cutting speed, while $SiC_w+Al_2O_3$ tools consistently yield lower chip reduction coefficients. Interestingly, at the other two cutting speeds (150 and 250 m/min), SiAlON tools exhibit superior chip reduction coefficients compared to WC tools. $SiC_w+Al_2O_3$ emerges as the most effective tool insert for the present machining conditions. These findings contribute valuable knowledge for optimizing machining processes in high-temperature alloy applications, making it possible to enhance performance and efficiency across varying cutting speeds.
Keywords: Inconel 617, WC, SiAlON, $SiC_w+Al_2O_3$, FE simulation, Dry machining.

Paper ID #405

Quality Assessment of Fabricated Micro-Holes on Microsliced Ti-6Al-4V Alloy Sheet using Maglev EDM

Anand Kumar*, Vivek Bajpai, Nirmal Kumar Singh*
Indian Institute of Technology (ISM) Dhanbad, 826004, Jharkhand, India
*nirmal@iitism.ac.in

Abstract. The current research implements in-house built Maglev EDM with pure DC power supply to fabricate micro-holes on Ti-6Al-4V alloy using copper cylindrical rod (ø = 530 μm). Initially, a Ti-6Al-4V alloy plate of thickness 5mm has been sliced into micro-sheets (thickness = 200 μm) using wire-EDM process. The micro-slicing operation was performed using 250 μm cutting wire electrode at feed rate of 1.12 mm/min and peak current of 12 A. The micro-sliced sheets are used as workpiece for micro-hole fabrication in Maglev EDM at a discharge voltage of 25V and discharge current of 0.5 A using distilled water as a dielectric. The experiments are repeated thrice with discharge pulse inspection using cathode ray oscilloscope (CRO) throughout the machining time registered using stopwatch. The machining operations were performed at a duty cycle of 95% for every experimental repetition. The performance outcomes such as average hole overcut (OC), circularity error (CE), and taper angle (TA) have been acquired at a stagnant dielectric flow rate. The experimental values of specific energy, overcut, taper angle, and circularity error at the optimal parameter have been obtained as 6.20 J/μg, 12.40 μm, 3.091 deg., and 38.40 μm respectively. The maglev EDM produces a micro-hole on conductive material, from the experiment the average machining rate of 53.16 μg/min. The machined surface has been inspected using a metallurgical microscope to acquire the EFI (extended focal imaging) image of machining conditions. Furthermore, the analysis of voltage-current characteristics waveforms depicts stable and consistent pulses with negligible irregularities. It also illustrates there is stable and uniform discharge occurs leading to better energy utilization as compared to conventional systems.
Keywords: Maglev EDM, Specific Energy, MRR, Copper, Titanium.

Paper ID #406

A State-of-the-Art Review on Laser Welding of Polymers- Recent Progress, Limitations and Research Gap

N. Banerjee[1*], A. Sen[1*], S.R. Maity[2], A. R. Biwas[1], A. Samanta[1]
[1]Department of Mechanical Engineering, Calcutta Institute of Technology, Howrah, West Bengal, 711316, India
[2]Department of Mechanical Engineering, NIT Silchar, Assam, 788010, India Abhishek Sen,
*abhishek.sen1986@gmail.com

Abstract. The utilization of lasers in polymer welding facilitates the production of intricate and lightweight structures. Despite the significant advancements in laser welding technology, broad

adoption and use of this technique continue to encounter many problems and limitations. There is a need for hybrid constructions that use the welding of thermoplastics and their combination with polymer surface welding techniques. The industrial demand for lightweight and high-performance materials resulted in concerns regarding the worldwide energy problem and carbon emissions. This comprehensive study provides an overview of the latest advancements, limitations, and areas of research that need further exploration in the field of laser welding of polymers with transparent materials. This study also investigates the impact of surface pre-treatment on the process of laser welding in polymers, including the corresponding requirements and potential applications. Moreover, this study has highlighted the potential to mitigate thermal and mechanical stress, which remains unattained despite modifications made in previous investigations.

Keywords: polymers, laser welding, review, challenges, laser quality.

Paper ID #407

Fabrication of Low Friction Al-Based Metal Matrix Composites and its Machinability Study

Yugabrat Gogoi*, Rishi Raj Bhattacharjee, Debarka Chattopadhyay, Mrinmoi Borah, Pallab Sarmah, Promod Kumar Patowari*

Department of Mechanical Engineering, National Institute of Technology Silchar, Silchar, Assam, 788010, India

*ppatowari@mech.nits.ac.in

Abstract. Metal Matrix Composites (MMCs) have established themselves as a bright, intriguing, and significant group of materials that have captured the interest of numerous researchers and scientists worldwide. The most recommended structural materials for automotive, electrical, and aerospace applications are aluminum-based metal matrix composites due to their superior corrosion and wear resistance, high specific modulus, thermal stability, and low weight. An attempt has been made to study the various effects of different reinforcement particles on Aluminum Alloy 6063 (Al6063). Al6063 is a significant member of the 6000 series, known for its better formability, wettability, and high strength-to-weight ratio, owing to the presence of magnesium (Mg) and silicon (Si) as the primary constituents. The reinforcement is an essential part of MMCs, as it profoundly impacts the composite material's mechanical, microstructural, and tribological properties, as well as its cost-effectiveness. Based on desired specifications and processing considerations, the following reinforcements were taken into account: Graphite (Gr) and Molybdenum Disulfide (MoS_2). Among the numerous processes, stir casting stands out as one of the best liquid-state processing techniques for the fabrication of MMCs. In stir casting, the dispersed phase (reinforcing particles) is incorporated into a molten matrix metal, followed by its solidification. This versatile and effective manufacturing method allows for the production of MMCs with tailored properties, making them invaluable in industries where lightweight, corrosion resistance and enhanced mechanical properties are essential. After the fabrication, a comparative study of the different physical properties and machinability study of the MMCs is done using the Wire-EDM process.

Keywords: Metal Metrix Composites, AA6063, Graphite, Molybdenum Disulphide, Stir Casting, Machinability, Wire EDM.

Paper ID #408

Estimation of Critical Heat Sources for High-Speed Motorized Spindle using Inverse Optimization Method

Anirban Tudu*, Amal Prasad, D.S. Srinivasu
Department of Mechanical Engineering, Indian Institute of Technology Madras, Chennai, 600036, India
*devadula@iitm.ac.in

Abstract. As manufacturing companies endeavour to meet market expectations and adjust to Industry 4.0, they face the challenge of producing high-quality products at a maximum production rate. Machine tools (MTs) utilized in various industries must maintain performance to guarantee precision and functionality throughout their run. However, the quality and productivity of MTs are significantly affected by uncontrolled heat flow within the MT components, mainly in the spindle. The transient heat flow within the complex geometry structures of spindle components, such as bearings and spindle motors, creates a complex thermal gradient that leads to nonlinear thermal deformation in the MTs. Inaccurate evaluation of heat sources can lead to the compromised performance of machine tool spindles. The present study introduces a comprehensive framework incorporating a 3D finite element model and an inverse method for estimating the three primary heat sources, including the spindle motor, using experimentally measured temperatures within the spindle housing with minimal sensors. This approach relies on directly measured temperature data to accurately assess thermal properties, bypassing the need for analytical calculations. The optimization process converges when the simulated temperature profiles closely align with the corresponding experimental data, yielding the respective heat flux values. Mean square error (MSE) values of 0.73, 2.7, and 0.36 are achieved for the front bearing, motor, and rear bearing, respectively. The experimentally measured temperature data from the spindle housing serves as the basis for this estimation process.

Keywords: Machine tool spindle, Finite element analysis, Inverse method.

Paper ID #409

Experimental Investigation of Material Removal Mechanism and Residual Stress in Grinding of HVOF Sprayed Conventional and Nano-Structured WC-Co Coating

Saurabh Kumar[1*], Puneet Nasna[1], Gourhari Ghosh[1*], Ajay Sidpara[2], P. P. Bandyopadhyay[2]
[1]Mechanical Engineering Department, Indian Institute of Technology Jodhpur, Jodhpur-342030, India
[2]Mechanical Engineering Department, Indian Institute of Technology Kharagpur, Kharagpur-721302, India
*gourharighosh@iitj.ac.in

Abstract. High velocity oxy-fuel (HVOF) sprayed WC-Co coatings are extensively employed as wear and corrosion resistance applications in aerospace, automobile, printing, die manufacturing, and power generation industries. The mechanical and tribological properties of the coating can be further enhanced by reducing the grain size of WC particles to nanometer scale from the micron scale and that indicates the fabrication of nanostructured WC-Co coating. The coating produced by HVOF process exhibits a comparatively higher surface roughness and that needs to be precisely finished to attain the desirable surface roughness for its end uses. In the present study, precision grinding of both conventional and nanostructured WC-Co coating is performed. At first, commercially available conventional and nanostructured WC-12Co powder were sprayed on the prepared Ti-6Al-4V substrate using HVOF spraying technique. Mechanical properties including micro-hardness, fracture toughness, elastic modulus of nanostructured coating were measured and it was found that nanostructured WC-Co coating possesses comparatively better mechanical properties. The grinding forces and specific cutting energy associated with nanostructure coating were found to be considerably higher than that of conventional coating. The residual stress (compressive) is also found to be higher for nanostructured coating as the material removal takes place through plastic deformation in this case.

Keywords: HVOF spray, Grinding, WC-Co coating, Nanostructured coating, Residual stress.

Paper ID #410

Machine Learning based Erosion Response Analysis of Hybrid FRP Composites

Sourav Kumar Mahapatra[1*], Alok Satapathy[1]

[1]Department of Mechanical Engineering, National Institute of Technology, Rourkela 769008, Odisha, India

*sourav.mahapatra311092@gmail.com

Abstract. The present investigation reports on the application of machine learning techniques and statistical methods to analyze and predict the erosion wear performance of ramie fiber reinforced epoxy based composites filled with different proportions of titania (TiO_2) particles for wear resistant applications. These hybrid composites are fabricated using conventional hand lay-up technique and subjected to solid particle erosion tests following the design-of-experiments as per Taguchi's L_{16} orthogonal array. The effects of filler content and other control factors on the erosion wear rate of these composites are studied. It reveals that filler content, followed by impact velocity and impingement angle have significant effect on the erosion wear rate. The analysis of variance (ANOVA) also confirms the same. The data generated from experimentation are further processed to predict the erosion performance of the composites with a machine learning (ML) approach following support vector machine (SVM) algorithm with different kernel functions (SVM_LIN, SVM_POLY, SVM_RBF, SVM_SIGMOID) and to analyze the absurdity among obtained experimental results and predicted response. It is found that the support vector machine with polynomial kernel function (SVM_POLY) outperforms other models with a R^2 value as high as 0.9814 and has thus emerged as the best performing prediction model.

Keywords: Erosion wear rate; machine learning; ANOVA; regression model; support vector machine.

Paper ID #411

Investigation on Mechanical and Metallurgical Properties of CMT- WAAM of Copper Coated Mn-Si Alloy Steel

S. Dhanush[1*,] K. Suresh[1], C. Mahesh[1], J. Venkatesh[1], D Tushar Sai Teja[1], Sk. Arshad[1], CH R. Vikram Kumar[1*]

[1]N B K R Institute of Science & Technology, Vidyanagar, AP - 524 413, India

*cvikramkumar@gmail.com

Abstract. Wire Additive Arc Manufacturing (WAAM) is an alternative to the conventional steel fabrication processes due to free-form capabilities. The major challenges in WAAM are the properties of the components fabricated. In this work the mechanical and metallurgical properties of the components fabricated with copper coated Mn-Si alloy steel using WAAM under Cold Metal Transfer (CMT) is studied. The variation in the properties of components before and after heat treatment also studied. The experimental results showed that with increase in welding current consumed more of wire material and results in increased thickness and width of the deposited layers. The variations in hardness values were observed among different layers of the component at as deposited conditions due to cyclic thermal loading of previously deposited layers in case of multiple layer deposition, whereas uniform hardness was found among different layers after heat treatment. The tensile and compressive strength of the component were increased after heat treatment due to formation of carbides and restructuring of the deposited layers. The experimental results showed that the heat treatment of WAAM components play significant role in producing homogeneous structures with improved properties of the components.

Keywords: WAAM, Alloy steel, copper coated wire.

Paper ID #413

Effect of Electrode Load Schedules on Nugget Size and Residual Stresses in Resistance Spot Welding of Mg-alloy/Steel Sheets: A Numerical study

Prashanth Kumar Reddy Gillela[1*], Jeevan Jaidi[2], Raman Murthy Bagadi[3], Gandham Phanikumar[4]
[1]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, India
[2]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, India
[3]Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, India
[4]Department of Metallurgical and Materials Engineering, IIT Madras, Tamil Nadu, India
*p20200040@hyderabad.bits-pilani.ac.in

Abstract. Lightweight Mg-alloys are used for the construction of Body-in-White (BIW) structures in automotive industry. However, joining of Mg-alloy with steels would be a challenge owing to distinct physical and chemical properties, besides the insolubility. In the present numerical study, the Resistance Spot Welding (RSW) of dissimilar (Mg-alloy/steel) sheets with dome-to-dome electrodes is considered and investigated on the effect of fixed and varied electrode load schedules in terms of the current density, temperature and stress fields and nugget sizes. A fully coupled 2-D axisymmetric electrothermal-mechanical model is developed, considering the elastoplastic behaviour of the sheets and temperature dependent thermophysical and electrical properties of the electrode and sheets. Also, the contact conductance model for flow of current and heat across the interfaces and the apparent heat capacity model for phase change effects are used. It is found that the current density is nonuniform during the weld-stage, and it is maximum at the tip of Mg alloy-steel interface than the Mg alloy-electrode interface because of high electrical resistivity of steel (3 times the Mg-alloy). Also, the high temperatures in steel sheet acted as heat source to the Mg-alloy sheet and formed its nugget at the faying surface, while the steel nugget is within itself. The coupled model predicted nugget sizes are in good agreement with the experiments from the literature. Further, the continuous heating of Mg-alloy by the steel resulted in compressive residual stresses in the former and tensile residual stresses in the later, and both have decreased with varied electrode load in contrast with the fixed load.
Keywords: Resistance Spot Welding, Mg-alloy/steel, current density, nugget size, residual stress.

Paper ID #414

Numerical Investigation of Laser Micromachining of Al-SiC Composite

Denise Kudakwashe Aisha Erica Mangunda*, Simson D., Samarjeet Chanda, S. Kanmani Subbu*
Indian Institute of Technology Palakkad, Palakkad, Kerala - 678623, India
*sksubbu@iitpkd.ac.in

Abstract. Al-SiC composites have numerous applications in many fields such as aerospace, automobile, defense, etc. This is owing, among other things, to their remarkable strength-to-weight ratio. The Al-SiC composite’s usefulness, however, is limited by its low machinability. This, in turn, increases the need for an acceptable machining technology that avoids the machinability problems that have been identified, and laser micromachining becomes the best option. The advantage of this approach is that it can create complex geometry as well as micro features with a high aspect ratio. A numerical investigation of laser micromachining of Al-SiC is carried out in this paper. Initially, three parameters were used to develop a set of single-channel laser micromachining experiments. The properties of the single channels were then examined. To anticipate the melt pool characteristics with the pulsed moving heat source, a 2D transient model is constructed. The model was built with a set of assumptions, and the resulting simulation was reviewed.
Keywords: Metal matrix composite, Laser micromachining, Simulation.

Paper ID #415

Fabrication Process Development of a Three Dimensionally Rotated FSS Unit Cell for Wide-Angle Microwave Absorbers

Jyoti Yadav[1*], Kajal Chaudhary[2], Kumar Vaibhav Srivastava[2], J. Ramkumar[3]
[1]IIT Kanpur, Material Science Program, Kanpur, India, 208016
[2]IIT Kanpur, Department of Electrical Engineering, Kanpur, India, 208016
[3]IIT Kanpur, Department of Mechanical Engineering, Kanpur, India, 208016
*jyotiyadav403@gmail.com

Abstract. Frequency Selective Surfaces and Metasurfaces offer a range of applications such as absorbers, sensors, filters, energy harvesters, and Reflective Intelligent Surfaces (RIS). In this work, a new degree of freedom is proposed for unit cell element of an FSS based absorber. This is achieved with the help of additive manufacturing. The 3D rotation of cells is embedded in a 3D printed substrate. The final prototype is developed using a stereolithography based 3D printer using photo resistive resin material. Separately, unit cell patterns are screen printed on a matt PET sheet. On top of the substrate, these resistive unit cells are cut and mounted. By doing so, oblique incidence performance has been improved. More than 90% absorption is achieved for oblique incidence angle up to 60^o. This article particularly discusses the fabrication challenges and how to deal with it. This includes optimization of printer parameters and substrate design as well as screen printing of the resistive ink.

Paper ID #417

Modeling of Thermophysical and Physicochemical Characteristics of SMAW Coating

Alok Gupta[1*], Jaiveer Singh[1], Rahul Chhibber[1]
[1]Indian Institute of Technology, Jodhpur, Rajasthan, 342030, India
*gupta.49@iitj.ac.in

Abstract. This research explores the characteristics of electrode coatings intended for application in weld joints within nuclear power plants. Specifically, the study focuses on evaluating the electrical, thermophysical, and physicochemical properties of shielded metal arc welding electrodes formulated with an Al2O3-CaF2-CaO-SrO-based composition. These electrodes were developed using an extreme vertices design technique. To assess the coating's structure and phases, X-ray diffraction analysis was employed, while Fourier transform infrared spectroscopy was utilized to identify the types of chemical bonds within the composition. Advanced characterization techniques were applied to analyze the physicochemical, thermophysical, and structural attributes of the coating formulations. Thermal properties such as specific heat and conductivity were examined using a hot disk apparatus. Additionally, thermogravimetric analysis was utilized to ascertain the enthalpy change and thermal stability of the flux coating. Statistical analysis was applied to construct regression models for various coating properties, aiming to explore how the mineral constituents influence these properties within the flux coating. Regression analysis is a statistical tool employed to establish connections between mineral interactions. Furthermore, artificial neural network (ANN) models were constructed and compared with regression analysis to evaluate prediction accuracy. In the context of selecting flux compositions, it aids in understanding the meaningfulness of each factor and its connection to the coating's overall performance. The findings reveal that the individual elements of mineral constituents, as well as their binary and tertiary interactions, have a noteworthy impact on the physicochemical, electrical, and thermophysical properties of the flux composition.

Keywords: SMAW electrode coating, regression modeling, ANN modeling, welding Flux.

Paper ID #418

Application of Design Thinking Attributes for Product Innovation in Manufacturing Sector: ISM based Framework

Sudeshna Roy[1 *], Nipu Modak[2]
[1]Maulana Abul Kalam Azad University of Technology, Haringhata, W.B.-741249, India
[2]Jadavpur University, Kolkata, West Bengal, 700032, India
*sudeshnaroy689@gmail.com

Abstract. Adoption of product innovation (PI) has become essential for sustaining in the global competition. It requires to identify the customers' needs in detailed manner for satisfying their expectations to achieve the success in long-run basis. It needs to decode the customers' requirements in terms of products to quantify them through the successful PI. Design thinking is the pivotal tool to recognize those needs and provide with a technical solution for successful PI. The attributes of design thinking are identified as empathy, experimental & learning oriented, diversity, creativity, collaboration, visualization, problem restoration, risk-embracing, instant action, difference creation and prototyping. This paper applies interpretive structural modeling (ISM) for developing a tiered framework to rank these recognized drivers of design thinking for identifying the importance of these human-centric competencies to enhance the PI. This empirical research uses the primary data from manufacturing experts of India which categorizes the drivers in six levels among which empathy is identified as the most vital one followed by visualization and difference creation in level 2, experimental & learning, diversity, collaboration and instant action in level 3, risk embracing in level 4, creativity in level 5 and prototyping in level 6. Finally, the Matrice d'impactscroisés multiplication appliquée á un classment (MICMAC) analysis, a cross-impact matrix multiplication is performed to classify these drivers in four clusters such as autonomous, dependence, linkage and driving clusters based on their driving and dependence powers which signifying the vitality of these drivers for successful PI.
Keywords: Design Thinking, Product Innovation, Interpretive Structural Modeling (ISM), MICMAC Analysis.

Paper ID #419

An Experimental Investigation on the Behavior of Voltage and Current in Plasma Electrolytic Polishing

Sushil Kumar[1*], Vyom Sharma[2], J. Ramkumar[1,3*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur, UP, 208016, India
[2]Department of Mechanical, Materials and Aerospace Engineering, Indian Institute of Technology Dharwad, Dharwad, Karnataka, 580011, India
[3]Department of Design, Indian Institute of Technology Kanpur, Kanpur, UP, 208016, India
*jrkumar@iitk.ac.in

Abstract. The increasing demand for smooth surfaces in many industries has exerted a significant thrust to develop new methods for rapid post-processing of parts. The existing polishing methods are limited to polishing free-form surfaces and complex geometries. Chemical-based techniques such as Electrochemical (EP) and plasma electrolytic polishing (PeP) have the advantages to fulfill drawbacks. The EP process utilizes aggressive media such as acids, whereas, in PeP, a low-concentrated, environment-friendly salt solution is used. In this work, we utilized the PeP process for polishing stainless steel AISI 304 workpieces. The experiments were carried out to investigate the behavior of current according to different applied voltages and their effect on surface roughness. The study suggested that in PeP, high voltage results in the quick formation of vapor gas envelope followed by initiation of plasma stream, hence instant reduction in current.
Keywords: PeP, Surface Roughness, Current, Voltage.

Paper ID #420

Effect of Addition of CNT in Mitigating Dissociation of B_4C and In Situ formation of TiC on Ti64 Substrate during Laser Cladding process to Achieve Hard Condensed Coating

Mohammad Shahid Raza[1*], Prasenjit Patra[2], Partha Saha[1*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, India
[2]Rajendra Mishra School of Engineering Entrepreneurship, Indian Institute of Technology Kharagpur, India
*psaha@mech.iitkgp.ac.in

Abstract. The aerospace industry finds Ti-6Al-4V to be a suitable material due to its higher specific strength. Nevertheless, the limited mechanical and surface properties limit its potential use in crucial components. The objective of the present investigation was to enhance the microstructural and mechanical characteristics of Ti-6Al-4V, through the application of a thin metal matrix composite (MMC) coating. The coating was fabricated using the laser cladding technique, with Ti as the matrix and boron carbide (B_4C) as the reinforcement material. The weight percentage of B_4C was varied to investigate its impact on the MMC coating. The dissociation of B_4C and subsequent synthesis of titanium carbide (TiC) occured due to the observed affinity between titanium and carbon when exposed to a high-energy laser beam. In order to reduce the dissociation of B_4C and facilitate the formation of in situ TiC, carbon nanotubes (CNT) were included into the composite powder layer. The Raman spectroscopy revealed a rise in the number of defects within carbon nanotubes (CNTs) subsequent to deposition. The increase in defects strongly suggested the existence of unbound carbon within the molten pool, which subsequently reacted with titanium (Ti) to generate TiC. The microstructural and microhardness findings revealed the presence of in situ generated TiC and intact B_4C within the CNT included clad layer. Furthermore, it was observed that the hardness of the coating increased as a result of CNT addition. Phase analysis and elemental mapping were conducted to get insight into the reaction mechanism of the cladding zone.
Keywords: Laser Cladding, Metal Matrix Composite, Titanium, Hard Coating, Carbon Nanotubes.

Paper ID #421

Novel Johnson-Cook Constitutive Model for Hot Tensile Response Prediction of AZ31B alloy

Aarjoo Jaimin[1*], Nitin Kotkunde[1*], Swadesh K. Singh[2,3]
[1]Mechanical Engineering Department, BITS Pilani- Hyderabad Campus, Hyderabad Telangana, 500078India
[2]Mechanical Engineering Department, GRIET, Hyderabad, Telangana, 500090 India
[3]Institute for Sustainable Industries & Livable Cities, Victoria University, P.O. Box 14428, Melbourne, VIC 8001, Australia
*nitink@hyderabad.bits-pilani.ac.in

Abstract. Hot uniaxial tensile test is conducted on AZ31B alloy within 200 to 350°C temperatures with intervals of 50°C and at a quasi-static strain rate ranging from 0.1 to $0.001s^{-1}$. A novel Johnson-Cook (J-C) model has been implemented and evaluated againstthe traditional J-C model and its previous modifications. The traditional J-C model independently relates flow stress to strain-hardening, strain-rate and temperature effects. However, it cannot able to capture flow stress efficiently. While the modified J-C model accounts for the combined impact of temperature and strain-rate, it may not yield accurate flow stress predictions. The current approach combines the strain-hardening parameter from the traditional J-C model with the modified J-C model's temperature and strain-rate effects into a novel J-C for better flow stress prediction. The average absolute relative error (AARE) and correlation coefficient (R) are determined. The traditional J-C model captured the plastic stress with 39% AARE and R-value of 0.87. However, the new J-C model’s prediction is within a 95% confidence band, with AARE and R values of 14% and 0.96, respectively.
Keywords: Magnesium alloy, Tensile test, Flow stress prediction, Novel Johnson-Cook model.

Paper ID #422

Effect of Build Direction Planes on Microstructure, Corrosion and Wear of Selective Laser Melted Components

Bhavani Tharra[1*], C S Kumar[1], Ajay M. Sidpara[1*]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, Kharagpur-721302, India
*ajaymsidpara@mech.iitkgp.ac.in

Abstract. AlSi10Mg is widely used material in automobile, aerospace industries owing to good strength to weight ratio. Fabrication of AlSi10Mg using Laser Powder Bed Fusion (L-PBF) process allows to fabricate complex structures having high strength due to grain refinement. However, in the SLM process, the microstructure on the plane parallel (XY-plane) to the build direction is different from the plane perpendicular (XZ-plane) to the build direction. It results in different mechanical properties in different planes of the L-PBF product. So, In the present study the tribological and corrosion tests are carried on the different planes of the AlSi10Mg samples. The wear volume, corrosion rate is studied and their surface morphologies are observed to understand the wear and corrosion mechanism.

Keywords: SLM, Microstructure, Corrosion and Wear.

Paper ID #423

Application of Value Engineering Function Analysis on FDM 3D Printer Development

Tara Chhetri[1*], Amandeep Singh[2], Sarvesh Mishra[1], J. Ramkumar[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur 208016, India
[2]Imagineering Laboratory, Indian Institute of Technology Kanpur, Kanpur-208016, India
*tarac21@iitk.ac.in

Abstract. Value Engineering (VE) is a systematic process that involves a team of experts from different fields who look at every part of a project to find ways to cut costs, improve performance, and reduce risks. It helps to identify the poor values and maximize the functional performance and quality of a project, product, or service while minimizing costs. Fused Deposition Modeling (FDM) is an Additive Manufacturing (AM) process that builds 3D objects in a layer-bylayer fashion, where it melts and deposits a thermoplastic filament material onto a build platform. This paper conducts a Value Engineering (VE) function analysis of an FDM 3D printer, focusing on assessing its core functions and performance. Defining these functions and applying numerical evaluation techniques reveals areas of suboptimal performance. Employing a function cost matrix and the Value Improvement Potential (VIP) index, critical areas for improvement are prioritized. The study reveals specific shortcomings in the examined FDM printer performance relative to its intended functions. This research contributes to optimizing FDM 3D printing technology, providing valuable insights for enhancing functionality and reliability, with potential implications across diverse industries.

Keywords: Function Analysis, Value Engineering (VE), Fused Deposition Modeling (FDM), Function cost matrix.

Paper ID #424

Formability Analysis of an Automotive Sheet Metal Component

Ravinder Kumar*, D. Ravi Kumar
Department of Mechanical Engineering, Indian Institute of Technology Delhi
New Delhi - 110016, India
*mez168556@iitd.ac.in

Abstract. In this work, formability of a two-wheeler fuel tank has been investigated to explore the feasibility of reducing thickness and/or changing the steel grade in order to reduce the weight and improve fuel efficiency. Formability analysis has been carried out using numerical simulations on 0.8 mm thick sheet of Extra Deep Drawing (EDD) steel which is being used to manufacture the fuel tanks. The tensile properties, strain hardening exponent, and normal anisotropy have been determined using uniaxial tensile tests. Simulations were carried out using AutoForm software to find out the minimum initial sheet thickness which can be formed successfully without necking/failure. Effect of blank holding force and friction coefficient was also analyzed. Experiments were carried out to validate the predicted results such as strain distribution and thinning in the formed components. By reducing the thickness to the minimum possible (0.70 mm), it has been found that the weight of the product can be reduced by nearly 12%. Simulations have also been carried out by changing the grade from EDD to Interstitial Free (IF) steel. Due to the superior drawability of IF steel, it has been found that thickness can be further reduced to 0.65 mm which is expected to result in 19% reduction in the weight of the component. Both the predictions have been validated by the actual press trials with reduced sheet thickness.
Keywords: Formability, Fuel Tank, Deep Drawing.

Paper ID #425

A State-of-an-Art Review of Challenges Associated with Different Drilling Methods in Carbon Fibre Reinforced Polymer and Their Solution Techniques

Shubham M. Mevada[1*], Vaibhav N. Pawar[1], Dhaval B. Shah[1]
[1]Mechanical Engineering Department, Institute of Technology, Nirma University, Ahmedabad, Gujarat, 382481, India
*dbshah@nirmauni.ac.in

Abstract. Due to its excellent mechanical qualities, carbon fibre reinforced polymer (CFRP), has gradually increased demand for a few decades, particularly in the aviation and automobile industries. The remarkable anisotropic and non-homogenous structure of CFRP, which includes a polymer matrix and carbon reinforcement fibres, causes more challenges during integrated drilling than conventional metal. This research provides a complete understanding of drilling-induced defects, such as delamination, fibre pull-out, heat damage, and burr development that jeopardize structural integrity. This review study compiles the information found throughout the literature on drilling CFRP, different drilling approaches on CFRP, experiments conducted on them, and defects observed in them. The methods of Ultrasound Vibration Assisted Drilling (UVAD), Abrasive Air Jet Drilling (AAJD), laser drilling, Electric Discharge Drilling (EDD), and cryogenic drilling for CFRP are covered in this paper. In addition to serving as the paper's primary objective, this article addresses & covers the solution techniques for optimizing drilling defects after a thorough examination of numerous drilling operations on CFRP.
Keywords: CFRP, Drilling, Defects, Delamination.

Paper ID #426

A Numerical Simulation of Ceramic Powder Particles Interaction with Laser Powder Feed Additive Manufacturing

Amit Kumar[1*], GL Samuel[1*]
[1]Department of Mechanical Engineering, Indian Institute of Technology, Madras, India - 600036
*samuelgl@iitm.ac.in

Abstract. Additive manufacturing has gained prominence in recent times. Laser powder feed additive manufacturing (LPF-AM) is a method to deposit materials layer by layer sequentially. The laser power attenuation is pivotal in determining the quantity of power that ultimately arrives at the surface during laser cladding. Investigating the laser power attenuation necessitates an in-depth analysis of the intricate interplay involving the laser beam and the powder. In the present work, the laser intensity and powder particle distribution are analyzed analytically. The amount of loss of power for three jet powder feed (PF) nozzles while interacting with the laser beam is estimated. Mathematical tools are employed to solve the pertinent equations, simulate the process, and determine the distribution of particles, laser intensity distribution, and the relationship between the laser beam and powder. The simulations provide the dependence of power attenuation by the LPF-AM on the varying power size, carrier gas flow rate, and powder flow rate. The simulation results provide more profound insights into the interaction among the laser beam and powder particles at the consolidated plane below the nozzle, where the powder is deposited on the work surfaces. The findings from current research work will be helpful in estimating the absorbed energy by the powder particles and also the rise in powder temperature before depositing on the substrate surface.
Keywords: Laser Additive Manufacturing, energy attenuation, powder distribution.

Paper ID #427

Preparation, Characterization, and Hydrothermal Performance of Carbon Quantum Dots-based Nanofluid for Coolant Application

Kartik Srivastava[1*], Rashmi Rekha Sahoo[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi, India
*kartiksrivastava.rs.mec21@itbhu.ac.in

Abstract. This study aims to investigate the characteristics of Carbon Quantum Dots (CQD) and assess their thermal performance as an engine cooling coolant. Additionally, it seeks to calculate the thermal stress generated, considering both thermal and design aspects of the fluid. The primary contribution of this research is to conduct a comparative analysis of nanofluid and traditional coolants. Furthermore, the study will explore different concentrations of the nanofluid to identify any optimal compositions. The thermophysical properties of the coolant can exhibit minor variations (such as density and specific heat) or more significant changes (e.g., thermal conductivity and viscosity). The results indicate a substantial enhancement in thermal conductivity, with a maximum increase of 177.18% observed at an N-CQD volume fraction of 0.01. However, the introduction of N-CQD nanoparticles leads to an adverse effect on viscosity, resulting in a maximum increase of 24.5% at a volume fraction of 0.01. Additionally, the density experiences a slight increase of 0.0414%, while the specific heat decreases by 0.809% at a volume fraction of 0.01. The impact of NCQD nanoparticles is also noticeable in the heat transfer rate and the thermal stress generated in the radiator tubes. The highest heat transfer rate is achieved by the N-CQD-based nanofluid at a volume fraction of 0.01, with an 11.85% increase compared to water. Moreover, the use of this nanofluid results in a 36.722% reduction in thermal stress when compared to traditional coolant at a volume fraction of 0.01. Hence, N-CQD-based nanofluids are a good alternative for the role of coolants.
Keywords: Carbon Quantum dots, radiator, characterization, hydrothermal performance.

Paper ID #428

Powder Layer preparation by Novel Gravity-Based Powder Spreading System for Additive Manufacturing

Aakash Tyagi*, Sajan Kapil, Manas Das
Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, 781039, India
*t.aakash@iitg.ac.in

Abstract. The demand for producing industrial-grade metallic parts using AM technique is increasing day-by-day. Powder bed fusion (PBF) process appears to be one of the promising techniques to achieve this. Spreading a smooth layer with high repeatability is the primary requirement for PBF process. The spreading of layers in an efficient manner decides the mechanical properties of the final product. The powder layer is conventionally spread with the help of a roller or a doctor blade. In the current study, a novel gravity-based non-contact type method is proposed for spreading the powder layer. To understand the capability of the system a miniaturized model is simulated on Altair EDEM® software. The system comprises a hopper, when subjected to vibration will dispense powder through a narrow opening present beneath the hopper. The hopper is subjected to movement in the appropriate direction and thus a powder layer can be formed on the bed present below the hopper. The system is first tested for different values of amplitudes. After analyzing the effect of amplitude the system is tested for different frequencies also. A mass sensor is placed on the bed which is used to check the uniformity of the layer on the bed. The system appears to be in an unsteady state but after a certain time duration, the system goes into a steady state. Mass flow analysis of the bed reveals that the layer forming on the bed appears to be uniform in nature.
Keywords: Powder bed fusion, Discrete element model, Mass sensor.

Paper ID #429

A Novel 5 Axis Hybrid Scissor-Based Machine Tool For Additive Manufacturing

Kanak Jindal*, Sajan Kapil, Basireddy Sandeep Reddy
Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, 781039, India
*k.jindal@iitg.ac.in

Abstract. The Additive Manufacturing (AM) processes require the use of multi degree of freedom systems which unlocks the potential of AM with abilities like out of plane printing, printing with minimal support structure and better surface quality. The general 3 axis AM machines have many limitations, the use of multi degree of freedom systems can mitigate most of the limitations as well as provide the mechanisms with additional capabilities. 5 axis machines have the additional capacity to tilt and rotate part along with the general 3 axis motion. The machines generally contain serial mechanism for better operating workspace which lags behind parallel manipulators in terms of high stiffness and compactness. The parallel mechanisms provide better results in precision and compactness of system as compared to serial mechanisms. We propose a hybrid scissor based parallel mechanism with a novel mechanism for planer motion. The 3 degree of freedom scissor based parallel mechanism in conjuncture with a two degree of freedom serial manipulator gives the mechanism best of both type of manipulators. The 5 degree of freedom system provides good rigidity and work envelope. The link lengths could be fixed for a desired workspace. The proposed mechanism has the potential of printing the parts with zero support structure and high accuracy.
Keywords: Parallel kinematics, Hybrid machine tool, Additive Manufacturing.

Paper ID #430

Simultaneous Electric Discharge and Electrochemical Polishing of Metal Additive Manufactured Components

Tejas Petkar[1*], Jibin Boban[1], Afzal Ahmed[1], Ozkan Gokcekaya[2]
[1]Discipline of Mechanical Engineering, Indian Institute of Technology Palakkad, Palakkad, Kerala 678447, India
[2]Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University, 2-1, Yamadaoka, Suita, Osaka 565-0871, Japan
*tejasp2011@gmail.com

Abstract. Metal Additive Manufacturing (AM) is one of the rapidly growing technologies for fabrication of complicated geometries with excellent design freedom and minimum scrap formation. However, the fabricated metal AM component suffers from defects such as stair stepping, balling defect, unmelted particles, cracks and voids which leads to poor surface integrity and dimensional accuracy. For polishing of rough surface, electric discharge machining (EDM) and electrochemical machining (ECM) are one of the established nonconventional machining techniques. EDM uses dielectric as a medium and ECM uses electrolyte as a medium, usually both have different conductive properties. EDM has higher material removal rate but poor surface finish whereas ECM has good surface finish but low material removal rate. These processes are done sequentially EDM and then ECM to have good material removal rate and surface finish, but they are done separately because of different properties, mediums and material removal mechanism. Low resistivity deionized water has partial properties of both the mediums so both the processes can be done simultaneously. In this research, we use simultaneous electric discharge and electrochemical machining (SEDCM) to improve the surface of AM components.
Keywords: SEDCM, Hybrid-EDM, Hybrid-ECM.

Paper ID #431

Non-Invasive Digital Twin for Pedagogical Purposes in Digital Manufacturing

Tarun Boni*, Tanuj Reddy, VennishmuthuVajiravelu, Prakruthi Hareesh
Birla Institute of Technology and Science, Pilani, Rajasthan, 333031, India
*prakruthi.hareesh@pilani.bits-pilani.ac.in

Abstract. This paper discusses the initial stages of the development and implementation of a Non-Invasive Digital Twin for Pedagogical Purposes in Digital Manufacturing, focusing on predictive maintenance in an Industrial Internet of Things (IIoT) water bottling plant. The physical setup of the IIoT water bottling plant is detailed, emphasizing transparency with interconnected tanks and solenoids for visual accessibility. The incorporation of non-invasive sensors is discussed for monitoring water volume and optimizing flow rates. Challenges related to solenoid valve performance are addressed through the development of a digital twin, providing insights into process understanding, monitoring, and maintenance. The overall contribution lies in advancing digital twin technology education and enhancing the efficiency of remote laboratories in the context of digital manufacturing.
Keywords: IIoT, Digital Twin, Smart Manufacturing, Digital Manufacturing, Industry 4.0.

Paper ID #432

Activated Tungsten Inert Gas Welding Process: A Review

Manish Kumar Jindal[1*], Jinesh Kumar Jain[1], Rajendra Kumar Goyal[2]
[1]Department of Mechanical Engineering Malaviya National Institute of Technology, Jaipur -302017, India
[2]Department of Metallurgical and Materials Engineering Malaviya National Institute of Technology, Jaipur - 302017, India
*Jineshjain.mech@mnit.ac.in

Abstract. In the present era of competition, many organizations are very keen to control costs, maintain high productivity, meet various expectations of customers, and attain the best quality. The industrial application of Tungsten inert gas welding is limited due to the lower depth of penetration. The limitation of the TIG welding process can be overcome by the new advancement in the process called the activated tungsten inert gas welding process (ATIG). Researchers identified that the ATIG process enhances the depth of penetration up to three times and increases the weld depth-to-width ratio which leads to an increase in productivity. It also helps to achieve better mechanical properties. The demand for ATIG has risen over the past few years. In the Activated TIG process, a layer of flux material is used over the surface of the material before welding. In the present work, an attempt has been made to review the activated flux welding process (ATIG), its mechanism & Theories and its future scope and industrial application, along with theories that give authentication to the effect of process parameters which led to increased penetration depth and hence productivity.
Keywords: ATIG; Penetration depth; activated flux; microstructure; productivity.

Paper ID #433

Design, Simulation, and Testing of 3D Printed Auxetic Structure for Vibration Isolation

A. Joshita[1*], V. Jahnavi[1], A. Kowsik[1], A.R. Vighnesh[1], I. Siva[1], KNS. Pavan Kumar[2], Vineeth P. Ramachandran[2], G.M. Karthik[1], Sabareesh Geetha Rajasekharan[3]
[1]Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi
[2]DRDO Young Scientist's Laboratory for Smart Materials, Kanchanbagh, Hyderabad
[3]Birla Institute of Technology and Science (BITS) Pilani, Hyderabad Campus, Hyderabad, India.

Abstract. Automobile vibrations increase noise levels and potential mechanical damage that hampers ride comfort. Engine mounts play a crucial role in maintaining the vehicles' stability, performance, and convenience by securely supporting the engine and reducing the transmission of vibrations. Typical vibration dampeners are made of viscoelastic materials such as rubber or viscous fluid to absorb the energy. They need periodic maintenance as either rubber age with time or need refilling of viscous liquid. This research explored the possibility of using more reliable structures, such as auxetic materials, for vibration isolation in the above-mentioned practical applications. Using auxetic structures for manufacturing engine mounts in automobiles offers promising capabilities for vibration attenuation and enhanced damping. While metallic auxetic structures are predominantly used in practical applications, this study focuses on analyzing the behavior of polylactic acid (PLA) material to understand the behavior of auxetic structures. Experiments have been carried out on 3D-printed auxetic structures, and the vibration amplitude is noted at both the excitation and tip ends. The experimental data was used to build a machine learning model to design the auxetic structure that can provide the best vibration attenuation for a given frequency value in the given range of length and thickness. Then, a finite element analysis (FEM) on the auxetic structures was done using COMSOL Multiphysics software, and the FEM results were validated with the experimental data.
Keywords: Auxetic Structures, Polylactic Acid, Vibration Attenuation, Machine Learning, Finite Element Analysis.

Paper ID #434

Quantitative Phase Analysis and Image Processing Using MATLAB

P. Abid Singh[1*], B. Ganesh[1], J. Aravind[1], K. Ram Prathab[1], G.M. Karthik[2]
[1,2]Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi, 221005, Uttar Pradesh, India
*gmkarthik.mec@itbhu.ac.in

Abstract. Quantitative phase analysis and image processing are essential for understanding material behavior and properties. Image analysis tools assist in extracting useful information from microstructure images. Micrographs provide valuable insights into the composition, distribution, and characteristics of different phases within a material. Existing image analysis software, such as ImageJ, Fiji, OpenCV, etc., provides a user-friendly interface for visualizing, analyzing, and processing microstructure images. However, they do not have features to detect phase boundaries, grain boundaries, and color different phases with colors other than RGB, limiting the number of phases that can be analyzed and identified with the desired color notation. MATLAB is a programming language and computational environment widely used in scientific and engineering applications. Developed by MathWorks, MATLAB offers a comprehensive platform for data analysis and algorithm development. The MATLAB code has been developed in the current work to overcome existing image processing software limitations, as indicated above. The MATLAB code can analyze a microstructure image, accurately estimate the phase fraction, identify and color the phase and grain boundaries, and assign different colors to different phases. For validation, the phase fraction results obtained from the MATLAB code are compared with those from the existing image analysis software ImageJ, and the results closely match.
Keywords: Image Processing; MATLAB; Phase Detection; Phase Boundary; Volume Fraction.

Paper ID #435

Fracture Modes During Quasi-Static and Shock Tube Impact Testing of Friction Stir Extrusion Joined Metallic Structures

Saurav Prajapati[1*], R. Ganesh Narayanan[1,2], Niranjan Sahoo[2]
[1]CDMR, Indian Institute of Technology Guwahati, Guwahati 781039, India
[2]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati 781039, India
*ganu@iitg.ac.in

Abstract. The present work focuses on exploring an environmentally friendly solid-state spot welding technique known as Friction-Stir Extrusion (FSE) joining, commonly used for joining dissimilar sheet metals. The study aims to understand the dynamic behavior of FSE joints through shock tube experiments. Specifically, it employs the FSF method to join AA5052-H32 and SS304, both 1.5 mm thick. The investigation aims to evaluate the effect of rotational speed on fracture modes observed in lap shear tests and shock tube impact tests. It is observed that common fracture modes are observed in lap shear and shock tube impact tests and these occur randomly without any systematic effect of tool rotational speed. The fracture modes also change during repeated experiments. Such results are applicable in the product design and estimation of process limits of joined structures in the automotive and aerospace industries.
Keywords: Shock Tube, FSSW, Strain Distribution.

Paper ID #436

Experimental Analysis and Optimization of Input Control Variables on Milling of SS316L Steel using Hybrid MCDM Method (AHP-TOPSIS)

Sandeep Kumar[1*], Abhishek Singh[*1], Rahul Davis[2], Anand Kumar[3]
[1]Department of Mechanical Engineering, National Institute of Technology Patna, Patna, 800005, India
[2]Department of Mechanical Engineering, Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, 211007, India
[3]Department of Mechanical Engineering, Birla Institute of Technology, Mesra Patna Campus, 800005, India
*abhishek.singh@nitp.ac.in

Abstract. In this research work, TOPSIS (technique for the order of preference by similarity to ideal solution) -AHP (Analytical hierarchy process) technique was employed to determine the effectiveness of the optimization of multiple response variables of milling stainless steel (SS) 316L. The influence of input control variables such as spindle-speed, feed-rate, and depth-of-cut on two response variables material subtraction rate (MSR) and surface roughness (SR) were investigated. Initially, the experimentation was performed based on Taguchi's design of the experiment (DOE) – L_{27}-orthogonal array and outcomes were recorded. In addition, analysis of variance (ANOVA), P value hypothesis test, and F-test were performed to evaluate the influential input control variables at the 95% confidence level. Also, the regression analysis was performed on the obtained MSR and SR to develop the mathematical model explaining the correlation among the machining output variables. The optimal combination of input control variables comprised spindle-speed: 4500 rpm, feed-rate: 0.05 mm, and depth-of-cut: 0.5mm, achieving maximum MSR and minimum SR. ANOVA conducted for MSR found feed-rate as most significant input control variable with the highest individual contribution of 63.02%, followed by depth-of-cut (26.04%) and spindle-speed (2.22%). Whereas, ANOVA executed on SR, revealed that spindle-speed had the most significant influence with highest individual contribution of 84.45%, followed by feed-rate (4.56%) and depth-of-cut (0.51%). The developed mathematical model and regression analysis for MSR were found to be sufficiently accurate and acceptable as the coefficient of determination were R^2= 91.28%, R^2-adj=90.14%, R^2-predicted =86.82%, with an average error of 8.72%. Also, the developed mathematical model and regression analysis for SR were found to be sufficiently accurate and acceptable as the coefficient of determination were R^2=89.51%, R^2-adj=88.14%, R^2-predicted =84.68%, with an average error of 10.49%.

Keywords: Milling, material subtraction rate, surface roughness, TOPSIS, AHP, ANOVA, regression.

Paper ID #437

Investigation on Surface Morphology During Sequential Turning and Laser Post Treatment Processing

Neeraj Deswal[1*], Ravi Kant[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology Ropar, Rupnagar, Punjab, 140001, India
*ravi.kant@iitrpr.ac.in

Abstract. Surface morphologies for a finished product are desired to be defectfree to achieve better part performance and durable life. However, defects are observed on the machined surface due to the interaction between the cutting tool and the workpiece surface during the machining process. Different processes have been explored to minimize the challenges observed during the machining process such as utilization of different energy sources, preheating of the material, cryogenic machining, vibration machining, hybrid machining, etc. Besides, post-processing has also been performed to further improve the surface morphology such as grinding, polishing, etc. However, the production cost and time are increased which significantly influences the manufacturing industries. Therefore, the present article aims to investigate the surface morphology of mild steel

during the sequential turning and laser post treatment processing. The laser heat source is positioned in such a way that it polishes the workpiece surface after the turning process. Cutting speed, laser power, and laser spot diameter have been varied to analyze the surface roughness and machined surface damage during the conventional turning (CT) process and sequential postprocessing via laser. The surface roughness and machined surface damage are found to be higher for the sequential post-processing via laser when compared with the CT process for most of the conditions due to the higher thermal damage on the workpiece surface by the laser heat source. However, for certain cases, the surface roughness and machined surface damage are observed to be lower for sequential post-processing via laser than the CT process.
Keywords: Surface Morphology, Sequential Turning, Laser Post Treatment.

Paper ID #438

Optimization of Process Parameters for Ultrasonic Welding of Al-Al Sheets

Vishwajeet Kumar*, Aryan Kumar, J P Misra
Department of Mechanical Engineering, IIT (BHU) Varanasi, U.P, 221005, India
*Vishwajeetkumar.rs.mec20@itbhu.ac.in

Abstract. Ultrasonic metal welding (USMW) is a well-known solid-state process for joining non-ferrous metals without the need of filler materials. UW is a solid-state joining process that uses frictional heating and highfrequency mechanical vibrations to soften material at the weld interface and induce high plastic deformation and layer sliding, resulting in joining at the interface. Due to its unique manufacturing features, USMW is commonly utilised in battery cells, wire harness, cooling technologies, and high-power electronics. Multiple applications, including alternators, the electrical and electronics sectors, etc., rely heavily on bonded aluminium sheets. Present work is focused on USW of Al-Al sheets of 0.4 mm thickness. Using Box-Behnken Design of Experiment, this experimental effort aims to comprehend the mechanism of the USMW process and to identify the optimum welding parameters. Weld pressure, amplitude, and time are the three variables that were taken into consideration for this experimental study in order to optimise the ultrasonic welding process parameters using the full factorial technique.
Keywords: Ultrasonic Welding, Aluminium, Response Surface Design, Box-Behnken Design.

Paper ID #439

Investigation on the Mixing Behavior in Microfluidic Channels with Varying Cross Sections

Deepak Singh D[1*], Gouthami N[1], Rajkumar[2], M Shanmuka Srinivas[3], Sangeeth Purushothaman[3], M Ravi Sankar[3], Nagahanumaiah[1], J. Ramkumar[2]
[1]Central Manufacturing Technology Institute, Bangalore, Karnataka, 560022, India
[2]Department of Mechanical Engineering, Indian Institute of Technology, Kanpur, 208016, India.
[3]Indian Institute of Technology, Tirupati, Andhra Pradesh, 517619, India
*deepak@cmti.res.in

Abstract. Microfluidic systems play a pivotal role in various fields, including biotechnology and chemistry, due to their ability to efficiently mix small volumes of fluids. Achieving rapid and precise mixing is essential for applications such as chemical reactions and diagnostics. These microfluidic systems need to efficiently mix different substances at the microliter or nanoliter scale. The importance of microfluidic mixing lies in its applications across various fields, including chemical analysis, drug development, biology, and diagnostics. In this study, an attempt was made to understand the mixing performance of Rectangular, trapezoidal, semi-circular and triangular or V shaped channels just by pure diffusion and to study if there are any chaotic advections created during the flow owing to the geometry. The models were analysed using ANSYS, and studied turbulence kinetic energy, velocity streamlines, and mixing time. From the results, it can be

observed that the trapezoidal and triangular micro-channels have exhibited better mixing performance than the other designs.
Keywords: Cross section, mixing, microfluidics.

Paper ID #440

An Investigation on Tensile Strength of Additively Manufactured Recycled PET Material Parts

Jatinder Singh[1*], Kapil Kumar Goyal[1], Rakesh Kumar[1]
[1]Department of Industrial and Production Engineering, Dr B R Ambedkar National Institute of Technology Jalandhar, Punjab, 144008, India
*jatindersinghacet@gmail.com

Abstract. In light of growing worldwide concerns about plastic waste pollution and a heightened awareness of sustainability and circular economy principles, the utilization of recycled polymers in 3D printing technologies has garnered considerable attention as a promising research area. Beyond the prototyping process, the potentiality of the 3D printing technology can be unlocked with fused filament fabrication which emerges as an advance process for production of functional parts using recycled plastic bottle filament material. In the present work the authors focused on the potential use of recycled, polyethylene terephthalate (rPET) plastic bottles material in additive manufacturing of tensile samples. The preparation of the tensile samples was performed based on L_9 orthogonal array. Three printing process parameters namely layer height, print speed and infill density were considered to study the effect of these parameters on the tensile behaviour of printed samples. The highest tensile strength 31.927 MPa was obtained for the sample no. 2, produced with infill density of 70%, layer height 0.3mm and print speed of 30mm/s. The SEM analysis was performed the analyze the layer adhesion and fracture behaviour. The current study underscores the feasibility of producing 3D printed structures that exhibit both high strength and light weight by utilizing recycled plastic bottles PETG material. This versatile approach holds significant potential for a broad scope of applications.
Keywords: Additive manufacturing, Fused deposition modeling, PETG, tensile property.

Paper ID #441

Impact of Lean Management in Automotive Industry: A Case Study

Rakesh Kumar[1*], Amit Surya[2]
[1]Associate Professor, Jalandhar,Punjab, 144008, India
[2]Research Scholar,Jalandhar, Punjab,144008, India
*sharmark@nitj.ac.in

Abstract. Japan is the country where lean manufacturing was first adopted, especially by Toyota. The industrial industry has always prioritized waste development and minimization. In the twenty-first century, manufacturing relies on satisfying customer demands. Industries requiring minimal production costs, superior quality, and high output. The short lead time for production, rapid switchover, and lack of faults and failures make maintenance challenging. Total Productive Maintenance (TPM) is a methodology that aims to increase the product's efficiency, quality, and productivity while keeping track of overall progress. This study examines the concrete and intangible benefits gained by properly implementing tool management, the most important TPM pillar, in the automobile industry through the use of the PDCA technique, Why-Why analysis, and before-after comparison.
Keywords: Total Productive Maintenance (TPM), automotive industry, Tool management, Kaizen.

Paper ID #442

Utilization of Agro Waste (Barley Husk) for Development of Sustainable Packaging with Improved Physicochemical Properties

Aanchal Mittal[1*], Sangeeta Garg[2*], Shailendra Bajpai[2]
[1]School of Biosciences and Technology, Vellore Institute of Technology, Tamil Nadu, India
[2]Department of Chemical Engineering, Dr B R Ambedkar National Institute of Technology, Jalandhar, India
*gargs@nitj.ac.in

Abstract. The utilization of non-degradable packaging materials in large amount has created the problem of waste disposal for last 40 years as their recycling is very costly and releases toxic chemicals. Therefore, development of sustainable packaging using natural resources has captured the interest of many researchers. In the present work, different biocomposite films were prepared using grafted barley husk (0.2-2% w/w) and urea formaldehyde crosslinked PVA/starch matrix. The incorporation of barley husk into composite films improved the mechanical properties of the films however, was lower than grafted barley husk based composite films. The light barrier properties and water resistant properties of the films improved after incorporation of barley husk or grated barley husk as they acted as barrier for transmission of light. Biodegradability of the films improved after incorporation of biodegradable barley husk in the composite films and was observed using scanning electron microscopy. The utilization of starch and barley husk for composite films may provide a sustainable alternative to the conventional packaging films with improved properties.
Keywords: Biocomposite, barrier properties, biodegradability, crosslinked, sustainable.

Paper ID #443

Additive Manufacturing of Stainless Steel 316L By Fused Deposition Modeling

Sankata Tiwari[1*], Santosh Kumar[1], Imtiyaz Ahmad[2], Govind Kumar Verma[1]
[1]Department of Mechanical Engineering, IIT (BHU), Varanasi, Uttar Pradesh, 221005, India
[2]Department of Ceramic Engineering, IIT (BHU), Varanasi, Uttar Pradesh, 221005, India
*sankatatiwari.rs.mec19@itbhu.ac.in

Abstract. Metal parts can be manufactured through various 3D printing techniques. The most commonly used 3D printing method for polymers is fused deposition modeling (FDM). However, metal powder mixed with polymer in the form of filament can also be used for cost-effective metal 3D printing. With respect to the other metal-based AM (Additive Manufacturing) process, the FDM of the metal process produces green components. The organic additives are removed from these green components in post-treatment steps. Then, the part is sintered to provide strength. During the sintering process, there is an unintentional shrinkage in every direction. However, because FDM produces green parts, shrinkage of parts depends on the built orientation on the platform and filament deposition approach. In the present work, the FDM of stainless steel 316L has been investigated, a PLA (Polylactic acid) polymer mixed with stainless steel (316L) metal particles (86 wt%), used as a filament in printing. The FDM processing of 316L stainless steel is done on HYREL 3D, and the green part was printed. After printing debinding process was carried out to remove the binder by heating it at 200°C for 2 hrs and then heating it at 450°C for 2 hrs, respectively. The part was then sintered at 1380°C for 4 hours. Figure 2 shows a printed green part where the layer-by-layer deposition can be seen macroscopically. Sintered Sample was polished on SiC emery paper and then etched with the carpenter's etchant for a few seconds, and then a microscopic investigation was carried out. The Microhardness of the sample was measured through micro indentation.
Keywords: Fused deposition modelling, Stainless steel 316L, Additive manufacturing.

Paper ID #444

Effect of Porosity and Inter-metallics on the Microstructure Based Finite Element Analysis of Al-Si Alloy

Gangarapu Akhila[1*], Srihari Dodla[2], Sree Harsha Nandam[3]
[1]Department of Mechanical Engineering, IIT BHU, Varanasi, Uttar Pradesh, 221005, India
[2]Department of Mechanical Engineering, IIT BHU, Varanasi, Uttar Pradesh, 221005, India
[3]Department of Metallurgical Engineering, IIT BHU, Varanasi, Uttar Pradesh, 221005, India
*Sdodla.mec@itbhu.ac.in

Abstract. Aluminium silicon alloys have good weldability, castability, wear, and corrosion resistance, and they are employed in most of the structural parts in automobile and aerospace industry. The second phase plays a major role in determining the mechanical properties of the alloy. These mechanical properties are highly microstructural dependent. Microstructure-based finite element analysis of aluminum-silicon alloys has been done to predict the mechanical properties of the alloy. The alloy has been prepared using gravity casting, and its microstructure has been observed through optical and Scanning electron microscope (SEM). Orientation of the secondary phase (eutectic silicon) has been observed. The effect of porosity is also studied as a part of the preliminary understanding of microstructure-based finite element analysis of multiphase alloys using aluminium silicon alloy.
Keywords: Aluminium Silicon alloy, Microstructure based modelling, Intermetallic.

Paper ID #445

3D printing of Clay Ceramics using Direct Ink Writing (DIW) Technique

Pankaj Bothra[1*], Sankata Tiwari[1*], Santosh Kumar[1], Govind Kumar Verma[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi-221005, Uttar Pradesh, India
*sankatatiwari.rs.mec19@itbhu.ac.in

Abstract. Additive manufacturing has been an enormous development in the last three decades, and it has found its way into many industrial applications with significant impact and opportunities. Among all AM processes, DIW (Robocasting)is a cost-effective method of developing products using direct ink extrusion layer-by-layer, consisting of ceramics, biomaterials, polymers, and other colloidal pastes. Due to the excellent combination of mechanical, thermal, chemical, and physical properties of ceramics, AM of ceramics is gaining more and more exploration in academics and Manufacturing organizations. It can produce complex structures and scaffolds and find use in various industries, including microelectronics and biological tissue engineering. In the present work, Direct extrusion of terracotta clay has been done with the help of a modified setup to form various complex shapes, and parameters like layer height, printing speed, and nozzle diameter have been optimized for better surface properties. The flexural strength of the clay has been improved by dispersing Graphite powder and metal powders of Aluminum, Copper respectively. Solid volume fractions of 30 %, 40 %, 50 %, and 60 % have been used to print the product, and the effect of various parameters has been discussed in detail. Slumping of the printed strands occurs as the solid volume fraction is low, which makes the object unable to maintain its shape. Clogging occurs when the solid fraction is more and the paste cannot be extruded from the nozzle despite applying pressure. The present work discusses the different solid volume fractions and their effect on the final product. The effect of sintering temperature on the density of the final part has been analyzed. Clay with optimized water content showed excellent flowability and shape retention after Printing. Layer thickness during Printing affected the surface properties. Strength improved after dispersing graphite and metal powders. The present study highlights manufacturing complex clay parts for pottery and artifacts applications.
Keywords: 3D Printing, Direct Ink Writing, Terracotta clay.

Paper ID #446

Investigation of Micro-milling of Copper Oxide Nanostructured CFRP Composites

Abhipsa Kar[1*], Ravi Shankar Rai[1,2], Vivek Bajpai[1]
[1]Indian Institute of Technology (ISM), Dhanbad-826004, India
[2]Sandip Institute of Technology and Research Centre, Nashik- 422213, India
*22dr0005@iitism.ac.in

Abstract. The machining of carbon fiber-reinforced plastic (CFRP) materials remains difficult despite their growing use in numerous industries, including aerospace, because of their anisotropic character and heterogeneity. Machining on a micro-scale is even more challenging for CFRP composites due to the high accuracy requirement. Machining quality can be improved by optimizing machining parameters, using suitable tools, and modifying materials composition. In this paper, a comparison has been made between CFRP composite and CuO nanostructured CFRP composite. 400-micron width slots were made in CFRP composite and CuO nanostructured CFRP composites. Delamination damage, burr height, and fiber pullout were compared between these two materials.
Keywords: Micromilling, CFRP composite, nanostructured composite.

Paper ID #447

Direct Ink Writing of Medical Grade Silicon Nitride: A Review of Material, Method, Applications and Challenges

Govind Kumar Verma[1*], Santosh Kumar[1], Sankata Tiwari[1], Pramod Kumar Jain[2]
[1]Department of Mechanical Engineering, Indian Institute of Technology (B.H.U), Varanasi, Uttar Pradesh, 221005, India
[2]Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, 247667, India
*govindkumarverma.rs.mec20@iitbhu.ac.in

Abstract. Silicon nitride (Si_3N_4) has excellent biocompatibility in vivo, partial radiolucent implant material on radiographic imaging, antibacterial properties, along with attractive metallurgical and mechanical characteristics. Manufacturing intricate Si_3N_4 components through conventional techniques presents a significant challenge due to its elevated physical and mechanical properties. Biomedical implants require complex, freeform architecture with graded porosity to fit into patient anatomy. Additive bioceramics manufacturing has been recognized as a potential solution to the problems raised by biological implants for bone deformity treatment due to limited bone supply and the risk of pathogen transmission or immunological rejection. Direct ink writing (DIW) is a type of additive manufacturing that has gained considerable popularity in recent years due to its ability to fabricate near-net anatomical shapes. However, the fabrication of highly dense ceramics using DIW is still constrained by certain limitations, primarily due to the numerous challenges involved in the development of suitable feedstock. This article summarizes the current research on DIW of medical-grade Si_3N_4. It begins with literature on the properties of Si_3N_4 and its potential applications in medical devices. Then, this review discusses binders and dispersants for developing inks with improved rheological properties to achieve high printing resolution with accuracy, together with in situ sintering of Si_3N_4 green parts to achieve high density and strength. Finally, Si_3N_4bioceramics and their bioactivity, osteogenesis, density, fracture toughness, and strength are also explored to achieve the ideal properties for their application in the human body.
Keywords: Silicon Nitride, Additive Manufacturing, Direct Ink Writing.

Paper ID #448

Finite Element-Based Simulation of Thermal Stresses Developed during Micro-Electric Discharge Machining (μEDM) of AISI 1080 Stainless Steel

Rajiv kumar[1*], SanasamSunderlal Singh[1], G L Samuel[1*]
[1]Department of Mechanical Engineering, IIT Madras, Chennai, India
*samuelgl@iitm.ac.in

Abstract. Electrical discharge machining (EDM) is an electro-thermomechanical process in which material is removed by melting and vaporization. Heat generated during the EDM process causes a very high temperature gradient, and hence thermal stress in the workpiece. Thermal stress induced sometimes exceeds the ultimate tensile strength and can cause crack initiation. In the present work, an attempt has been made to predict the temperature distribution and thermal stress developed during the micro-EDM (μEDM) process. Compressive stress has been found to dominate in the spark radius zone, while in the heat-affected zone, both compressive and tensile stress are present. The maximum value of the compressive stress is as high as 3496 MPa. Along depth direction, the variation in stress is from 2850 MPa (compressive) to 500 MPa (tensile). The results of the current simulation work are in good agreement with previously reported literature. When this thermal stress is not released while cooling, it gets locked in the workpiece in the form of residual stress. This high thermal stress is detrimental to performance and should be minimized.
Keywords: μEDM, steep temperature gradient, thermal stress.

Paper ID #449

Multi-Objective Optimization-based Design of High-Speed Machine Tool Spindle Considering Thermo-Mechanical Behavior

Anirban Tudu*, Praneeth Pathipati, D.S. Srinivasu
Department of Mechanical Engineering, Indian Institute of Technology Madras,
Chennai- 600 036, India
*devadula@iitm.ac.in

Abstract. Machine tool spindle design is critical for high speed precision machine tools. Dynamic characteristics of spindle, such as spindle speed, torque, dynamic stiffness and thermal characteristics, are influenced by heat generated in the spindle that depends on bearing locations, preload, and bearing geometry. With the increase in bearing preload the spindle stiffness increases. However, heat generation increases with increase in preload, which is detrimental for the bearings. A tradeoff between these two characteristics need to be maintained. A multi-objective optimization formulation was proposed in the present work to optimize the natural frequency and power loss from bearings using thermomechanical model of the spindle. Non-Dominated Sorting Genetic AlgorithmII, a multi-objective optimization algorithm, was used towards this for identifying the design parameters of high-speed machine tool spindle. A pareto optimal front was identified which describes optimal tradeoff solutions between the two objective functions.
Keywords: Multi-objective optimization, Machine tool spindle, Thermomechanical model.

Paper ID #450

Quality Evaluation of Precision-Shaped Film Cooling Holes Machined on Aerospace Nickel-Based Superalloy Using Femtosecond Laser Trepan Drilling Technique

Sunil Kumar[1*], G.L. Samuel[1]
[1]Mechanical Engineering Department, IIT Madras, Chennai, India (600036)
*samuelgl@iitm.ac.in

Abstract. Due to the development of the aerospace industry, the thrust-to-weight ratio of new aero engines keeps increasing. Increasing the turbine inlet temperature is the most effective method to realize a high thrust-to-weight percentage. Shaped hole film-cooling technology has become the standard in today's highly cooled gas turbine airfoils. This study uses a femtosecond laser drilling technique to drill shaped micro-holes. The shaped film hole contains some initial round entry length that acts as the throat section, though not necessarily choked, followed by an expanded diffuser-type exit intended to spread the coolant flow laterally or into the surface. Acute-angle cylindrical holes of diameter 700 µm and inclination angle 60 º from the substrate surface are drilled on 550 µm thick IN718 substrate. According to the material thicknesses, the corresponding drilling scanning strategies are proposed. The entrance and exit of holes are considered elliptical shapes. The effects of different processing parameters on hole quality are described and discussed in detail. The hole quality regarding the entrance and exit elliptical roundness and taper angle of film cooling holes has been evaluated. Results showed that femtosecond laser drilling is an effective hole-processing method that produces high-quality film cooling holes.
Keywords: Acute angle holes, femtosecond laser, elliptical roundness.

Paper ID #451

A Comparative Analysis of Finishing Performance of Abrasive Flow Machining (AFM) Variants

Nitin Dixit[1*], Varun Sharma[2], Pradeep Kumar[3]
[1]Assistant Professor, Mechanical Engineering Department, Punjab Engineering College (Deemed to be University), Chandigarh-160012, India
[2]Assistant Professor, Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Uttarakhand-247667, India
[3]Professor, Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Uttarakhand-247667, India
*nitindixit@pec.edu.in

Abstract. The conventional Abrasive Flow Machining (AFM) process shows poor finishing performance due to inadequate finishing forces. Therefore, external assistance-based AFM processes are used. A comparative analysis has been performed for different AFM variants in this paper. In this regard, an indigenously developed Ultrasonic Assisted Magnetic Abrasive Flow Machining (UAMAFM) setup has been used to compare the finishing performance of conventional AFM process with Ultrasonic Assisted Abrasive Flow Machining (UAAFM), Magnetic Abrasive Flow Machining (MAFM), and UAMAFM. A hydrogel-based abrasive media composed ofnatural gum-based hydrogel, SiC abrasives, and iron powder has been prepared and used to finish Titanium (Grade II) workpieces. The effect of Media Flow Rate (FR), Abrasive Mesh Size (MS), and Hydrogel Concentration (HC) has been investigated on the amount of Material Removed (MR) and percentage improvement in surface roughness (% ΔR_a). UAMAFM was found to have the best finishing performance compared to conventional AFM and other variants due to higher finishing forces, improved length of contact, and velocity of active abrasives. The experimental study reveals the most increased MR of 23.03 mg and % ΔR_a of 48.48 % at a media flow rate of 0.0213 m^3/min., 500 abrasive mesh size 500, and 65% hydrogel concentration.
Keywords: Abrasive Flow Machining, Variants, Ultrasonic, Magnetic Field, Hydrogel, Abrasive Media.

Paper ID #452

Optimization of Die Design Parameters for Connecting Rod using FEM and Taguchi Methodology

Siddharth Yadav[1*], Santosh Kumar[2], Shailendra Sinha[3], Govind Kumar Verma[4], Sushil Kumar Choudhary[5], Rajat Upadhyaya[6], Ajit Kumar Jha[7], Anil Kumar Yadav[8]
[1, 7, 8]Department of Mechanical Engineering, Institute of Engineering and Technology, Lucknow, Uttar Pradesh, 226021, India
[2, 4]Department of Mechanical Engineering, Indian Institute of Technology, (B.H.U.), Varanasi, Uttar Pradesh, 221005, India
[3]Department of Mechanical Engineering, Institute of Engineering and Technology, Lucknow, Uttar Pradesh, 226021, India
[5]Department of Mechanical and Automobile Engineering, Babasaheb Bhimrao Ambedkar, Lucknow, Uttar Pradesh, 226025, India
[6]Department Foundry and Forge Technology, National Institute of Advanced Manufacturing Technology, Ranchi, Jharkhand, 834003, India
*siddharthy.rs.mec15@itbhu.ac.in

Abstract. The conventional approach to design the forging die is reliant on costly, time-consuming shop floor trials, especially when faced with stringent design requirements. Consequently, current research is dedicated to optimizing design parameters through the Taguchi optimization methodology. The design parameters under scrutiny include flash thickness, fillet radii, and draft, each assessed at three different levels. The forging die was modeled using Catia 3D modeling software, followed by simulations using Deform 3D forging simulation software. The examination of the results was carried out using Taguchi's L9 orthogonal array. This investigation primarily focuses on analyzing how design parameters impact die filling and yield improvement. A total of 18 simulations and compared the outcomes between two distinct designs. Preform one emerged as the superior choice, achieving an impressive yield of 88% at a forging load of 1.37 × 104 N, with complete die filling observed.
Keywords: CATIA V5, DEFORM, Taguchi Method, FEM, ANOVA, Connecting Rod, Yield, Die filling.

Paper ID #460

Improvement of Weld Properties by Friction Stir Processing

Sanjay Kumar Gupta[1*], Kuldeep Singh Chauhan[1,2], MeghanshuVashista[1], M.Z.K. Yusufzai[1]
[1]Department of Mechanical Engineering, Indian Institute of Technology (BHU), Varanasi-221005, India
[2]Banaras Locomotive Works, Varanasi-221004
*mzkhan.mec@iitbhu.ac.in

Abstract. The AISI409L is a ferritic stainless steel (FSS). It is widely used by industries because of cheaper in cost and higher corrosion resistance but less than austenitic and martensitic stainless steel. It is used in different industrial applications i.e., mufflers of vehicles, tail pipes, catalytic converters and exhaust manifold are so many applications. The study and analysis of AISI409L ferritic stainless steel (FSS) to improvethe weld joints as well as heat affected zone of GMAW welded plate processed by friction stir welding (FSW). Because the grain coarsening in weld metal zone (WMZ) and heat affected zone (HAZ) are the major drawback of GMAW process. To increase the strength of the GMAW welded plate using spool ER304Land we have processed the plates by FSW. The welds were examined by optical microscopy, microhardness testing. The grains refinement has been observed.So, the mechanical properties of processed plateshave improved.
Keywords: GMAW, friction stir processing, SS409L, grain refinement.

Paper ID #461

Surface Topography of Additively Manufactured Carbon Fiber Reinforced Polymer Composites

Anand Sankar M[1*], Rajkumar Velu[1], Anand Kumar S[1]
[1]Additive Manufacturing Research Laboratory, Indian Institute of Technology Jammu, Jagti, PO Nagrota, NH-44, Jammu – 181221, J&K, India
*anand.m@iitjammu.ac.in

Abstract. Additive Manufacturing (AM) of Carbon Fiber Reinforced Polymer (CFRP) Composites is emerging, with multiple studies focusing on the design and reinforcement mechanisms. Due to the enhanced strength-to-weight ratio of parts and the capability to produce complex geometries, the technology has a huge potential for aerospace and automotive applications. The present article pro-vides insights on build quality and surface morphology of 3D printed short car-bon fiber reinforced polymer composites (SCFRPCs) vs continuous carbon fiber reinforced polymer composites (CCFRPCs). Test specimens are fabricated in industrial grade Fused Filament Fabrication (FFF) machine called Markforged X7 with OnyxTM (nylon with short carbon fiber) material and custom developed co-extrusion 3D printing system with Markforged continuous carbon fiber and Polylactide (PLA) material. The fiber distribution and arrangement during print-ing are found to vary with print conditions. The obtained composite's surface and cross sectional morphology study found to be effective in exploring the failure causes in 3D printed short and continuous CFRP composites. The short fiber composites are characterized by fiber clustering, pull outs whereas fiber-matrix interface voids contributes to the defects in the case of continuous fiber compo-sites. The reported trends in this study have the potential to provide guidelines for the development of high-quality FFF-fabricated short CFRP composites.
Keywords: Additive manufacturing; composites; Carbon fiber-reinforced poly-mer (CFRP); Micrography; Surface morphology.

Paper ID #462

Effects of Lamellar Thickness on the Deformation Behavior in Cu/Ag Bicrystals - An Atomic Simulation Study

Srihari Dodla[1 *], Sebastian Hütter[1 *], T. Halle[1]
[1]Institut für Werkstoff- und Fügetechnik (IWF), Otto-von-Guericke-Universität Magdeburg D-39106, Magdeburg Germany

Abstract. As strength of two phase crystalline materials mainlly depends on their ability to nucleate new dislocations or move the existing ones from the soft phase/interface, a proper knowledge of factors that play a major role at the first stages of plastic deformation is highly desirable. However, basic understanding of the role of deformation mechanisms during wire drawing of the nanocomposites, on the onset of plastic deformation is still lacking. In this work, atomistic simulations are applied to study and correlate the materials response to deformation for two different Cu/Ag bilayers. The aim of these investigations is to study the deformation mechanisms involved during wire drawing of the Cu-Ag composites using Molecular Dynamics. This is simulated using uniaxial compression of the nanocomposites Cu/Ag bilayers. The simulated results suggest that the nucleation of partial dislocations from the Cu/Ag interface on multiple slip systems. It is observed tha the leading partial dislocations nucleate first in the Cu phase on the {111} plane in the <112> directions. This may reveal that the dominant texture for the Cu-Ag material is brass. The stress-strain curves under compression are presented for two dfferent aspect ratios of Cu/Ag bilayers. The [111] simulated stress-strain curves reveal that higher value of yield stress with increase in the drawing reduction.
Keywords: Two-phase Cu-Ag laminate, Molecular dynamics simulations, Dislocations, texture, Compression testing.

Paper ID #463

Enhancing Surface-Mount Technology: Defect Detection and Inclusive Visual Monitoring

Amith Kumar Yadav[1], Raju Prasad Mahto[2]
Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, India
*u20me234@med.svnit.ac.in

Abstract. The task aims to develop a defect detection system for surface-mount technology (SMT) in electronic circuit production using image processing and computer vision techniques. The primary focus is on the solder paste printing (SPP) stage and the subsequent solder paste inspection (SPI) stage, which are crucial for ensuring high-quality electronic circuits. The goal is to automate the visual quality checks performed during these stages to improve efficiency and accuracy. The dataset used for this task is the PCB-AoI dataset, which includes images of electronic circuit boards and corresponding annotations indicating the presence of defects such as missing/less paste, bridging between pads, and misalignments. The dataset is divided into training and testing sets, allowing for the development and evaluation of the defect detection algorithms. The proposed approach involves loading the dataset, preprocessing the images, and implementing image processing and computer vision algorithms using YOLO detection models. The algorithms will be trained on the training dataset, considering various techniques to enhance defect detection precision and recall. The performance of the trained models will be evaluated on the testing dataset by comparing the predicted annotations with the ground truth annotations. The expected outcome of this research is an automated defect detection system that can effectively detect and classify defects in SMT processes, contributing to improved manufacturing quality and efficiency. The system will demonstrate the potential of image processing and computer vision techniques in enhancing defect detection capabilities.

Keywords: Solder paste inspection, SMT, Circuit, SPP.

Paper ID #464

Experimental Investigation on Face Turning of IN-100 Nickel-based Superalloy under Environment-Friendly Vegetable Oils

Sai Teja. D[1], Sai Revant. B[1], Adarsh. K[1], Sravanthi. C[1], Balasundar. I[2], Srinivasa Rao Nandam[2, *]

[1] Anurag Group of Institutions, Ghatkesar, Hyderabad - 500088, India
[2] Defence Metallurgical Research Laboratory, DRDO, Hyderabad - 500058, India

*srinivas-nandam.dmrl@gov.in

Abstract. This experimental investigation aims to investigate the effects of environmentally friendly vegetable oils including palm oil and coconut oil as cutting fluid while face turning of IN-100 nickel based superalloy. Two levels of cutting speed, table feed and depth of cut were selected as input factors. The machining experiments were performed by a DoE half factorial, L4 orthogonal array with a single point tungsten carbide brazed tool under dry, vegetable oils cutting environments and a commercial neat cutting oil for Ni-alloys. The machining performance such as cutting force and surface roughness were studied statistically for the vegetable oils and the results were compared with both dry and neat oil. The results show that vegetable oils have the potential to serve as alternative cutting oils in the machining of hard metals such as IN-100 superalloy towards more sustainable and environmentally friendly manufacturing.

Keywords: Face turning, IN-100 superalloy, vegetable oils, cutting forces, surface roughness.

Defence Research & Development Laboratory (DRDL)

DRDL is responsible for the design and development of state-of-the-art Missile Systems and technologies required for the deterrence and defence of the country. Systems and Technologies developed by DRDL are deployed on underwater, sea, land as well as air-based platforms.

DRDL is working on several technologies required for the Missiles and Strategic Systems including; Aerodynamics and Airframe Design, Computational Fluid Dynamics, Solid, Liquid, Ramjet and Scramjet Propulsion, Precision Fabrication, Systems Analysis, as well as the Command-and-Control systems for missile-based weapon systems.

DRDL has established all the necessary infrastructure and facilities required for design and development of state-of-the-art Missile Systems and technologies. These include; Aero Ballistic Range, Supersonic Wind Tunnel, Hypersonic Wind Tunnel, Hypersonic Shock Tunnel, Hydrobasin, Computational Facilities for System Analysis and Design and CFD, Precision Fabrication Facilities, Precision Measurement Systems, Structural Test Facilities, and Facilities for Static Testing of Rocket Motors.

Products

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DRDO was formed in 1958 from the amalgamation of the then already functioning Technical Development Establishment (TDEs) of the Indian Army and the Directorate of Technical Development & Production (DTDP) with the Defence Science Organisation (DSO). DRDO was then a small organisation with 10 establishments or laboratories. Over the years, it has grown multi-directionally in terms of the variety of subject disciplines, number of laboratories, achievements and stature.

DRDO is the R&D wing of Ministry of Defence, Govt of India, with a vision to empower India with cutting-edge defence technologies and a mission to achieve self-reliance in critical defence technologies and systems, while equipping our armed forces with state-of-the-art weapon systems and equipment in accordance with requirements laid down by the three Services. DRDO's pursuit of self-reliance and successful indigenous development and production of strategic systems and platforms such as Agni and Prithvi series of missiles; light combat aircraft, Tejas; multi-barrel rocket launcher, Pinaka; air defence system, Akash; a wide range of radars and electronic warfare systems; etc., have given quantum jump to India's military might, generating effective deterrence and providing crucial leverage.

"Balasya Mulam Vigyanam"—the source of strength is science-drives the nation in peace and war. DRDO has firm determination to make the nation strong and self-reliant in terms of science and technology, especially in the field of military technologies.

Today, DRDO is a network of around 41 laboratories and 05 DRDO Young Scientist Laboratories (DYSLs) which are deeply engaged in developing defence technologies covering various disciplines, like aeronautics, armaments, electronics, combat vehicles, engineering systems, instrumentation, missiles, advanced computing and simulation, special materials, naval systems, life sciences, training, information systems and agriculture. Several major projects for the development of missiles, armaments, light combat aircrafts, radars, electronic warfare systems etc. are on hand and significant achievements have already been made in several such technologies.

विज्ञान एवं प्रौद्योगिकी परिषद,उ.प्र.

(विज्ञान एवं प्रौद्योगिकी विभाग, उ.प्र.)

विज्ञान भवन

9, नबी उल्लाह रोड, सूरज कुण्ड पार्क, लखनऊ–226018

विज्ञान भवन

परिषद के प्रमुख कार्यक्रम

1– प्रदेश की आवश्यकता के अनुसार शोध एवं विकास ।

2– प्रौद्योगिकी हस्तांतरण व प्रदेश की आवश्यकतानुसार विकास और उपयोग।

3– जैव–प्रौद्योगिकी की उन्नति एवं विकास ।

4– विज्ञान लोकप्रियकरण एवं संचार।

5– नक्षत्रशालाओं के द्वारा खगोलीय दर्शन तथा विज्ञान पार्क।

6– असंगठित क्षेत्रों के कारीगरों, किसानों, युवाओं तथा माध्यमिक स्तर के विद्यार्थियों के लिये नवाचार।

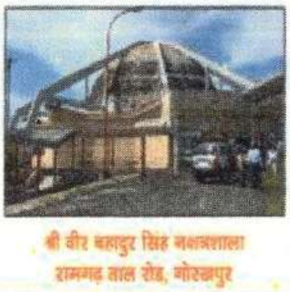
7– बौद्धिक सम्पदा संरण एवं पेटेण्ट सुविधा।

8– विज्ञान सम्मान।

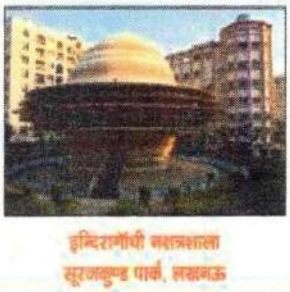
9– राष्ट्रीय़ व अन्तर्राष्ट्रीय स्तर के सेमिनार, सिम्पोजियम, कान्फ्रेन्स व वर्कशॉप से सम्बन्धित क्रार्यक्रम।

विशेष आकर्षण

- 75 जनपदों में गठित जिला विज्ञान क्लबों तथा 04 क्षेत्रीय विज्ञान एवं प्रौद्योगिकी केन्द्र (गोरखपुर, मुरादाबाद, आगरा एवं गाजियाबाद) के द्वारा विज्ञान लोकप्रियकरण एवं संचार।
- विद्यार्थियों के लिये वैज्ञानिक व्याख्यान व भ्रमण कार्यक्रम।
- समाज के विभिन्न वर्गों एवं लक्षित समुदायों में व्याप्त सामाजिक अंधविश्वासों व चमत्कारों के लिये वैज्ञानिक जागरुकता और विज्ञान प्रतियोगितायें।
- लखनऊ, गोरखपुर तथा रामपुर में संचालित 03 स्थायी नक्षत्रशालायें।
- मेधावी एमएससी विद्यार्थियों के लिये समर रिसर्च फेलोसिप।
- इंजीनियरिंग स्टूडेण्ट प्रोजेक्ट ग्राण्ट स्कीम।
- जनपद, मण्डल व राज्य स्तरीय विज्ञान मॉडल प्रतियोगिता कार्यक्रम।



श्री वीर बहादुर सिंह नक्षत्रशाला
रामगढ़ ताल रोड, गोरखपुर



इन्दिरा गाँधी नक्षत्रशाला
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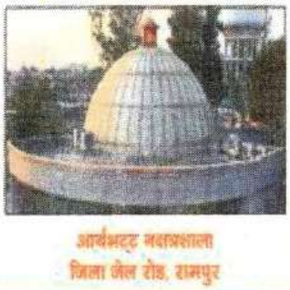

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विज्ञान एवं प्रौद्योगिकी परिषद,उ.प्र.

Email-cstup@gov.in; cstup1975@gmail.com

Website: dstup.gov.in | Ph. No. 0522-2202452,2974685

भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

"To be recognized globally for excellence in education, research and innovation, and nurture future leaders, to serve the society at large"

Indian Institute of Technology Guwahati, the sixth member of the IIT fraternity, was established in 1994. The academic programme of IIT Guwahati commenced in 1995. At present the Institute has eleven departments, seven inter-disciplinary academic centres and five schools covering all the major engineering, science, healthcare, management and humanities disciplines, offering B.Tech., B. Des., M.A., M. Des., M. Tech., M.Sc., MBA and Ph.D. programmes. Within a short period of time, IIT Guwahati has been able to build up world class infrastructure for carrying out advanced research and has been equipped with state-of-the-art scientific and engineering instruments. Besides its laurels in teaching and research, IIT Guwahati has been able to fulfil the aspirations of people of the North East region to a great extent since its inception in 1994.

Indian Institute of Technology Guwahati's campus is on a sprawling 285 hectares plot of land on the north bank of the river Brahmaputra around 20 kms from the heart of the city. With the majestic Brahmaputra on one side, and with hills and vast open spaces on others, the campus provides an ideal setting for learning.

IIT Guwahati is the only academic institution in India that occupied a place among the top 100 world universities – under 50 years of age – ranked by the London-based Times Higher Education (THE) in the year 2014 and continues to maintain its superior position even today in various International Rankings. IIT Guwahati gained rank 32 globally in the 'Research Citations per Faculty' category and overall, 364 rank in the QS World University Rankings 2024 released recently. IIT Guwahati has retained the 7th position among the best engineering institutions of the country in the 'India Rankings 2023' declared by the National Institutional Ranking Framework (NIRF) of the Union Ministry of Education. IIT Guwahati has been also ranked 2nd in the 'Swachhata Ranking' conducted by the Govt. of India. IIT Guwahati has been ranked as the top-ranked University in 2019 for IT developers by HackerRank in the Asia-Pacific region. Also, IIT Guwahati ranks 6th globally in Sustainable Development Goal 7 (Affordable and clean energy) of the Times Higher Education Impact Rankings 2023.

Board of Research in Nuclear Sciences (BRNS)

The Board of Research in Nuclear Sciences (BRNS) is an advisory body of the Department of Atomic Energy (DAE) to recommend financial assistance to universities, academic institutions and national laboratories. The key objective is to encourage and promote scientific research in areas of relevance to the mandate of DAE in research groups outside DAE to derive benefits from their expertise.

Primary mandate of DAE is the production of safe and economical nuclear power, using indigenous uranium and thorium resources. Towards this end, it is involved in developing, in stages, pressurized heavy water reactors, fast breeder reactors, and reactors using thorium with associated fuel cycle facilities. It builds research reactors for production of radioisotopes and carries out programmes on isotope and radiation technology applications in medicine, agriculture and industry. It develops advanced technology in areas such as accelerators, lasers, control and instrumentation, computers, biotechnology, information technology and materials technology and also encourages technology transfers to other users and industry. It supports basic research in nuclear energy and related frontier areas of science. The Department of Atomic Energy (DAE), was formed in August 1954.

BRNS supports high quality R & D projects in the areas of relevance to its programme as broadly mentioned above. BRNS lays emphasis on collaborative programmes between the DAE scientists and the scientific community outside the DAE family. Such a collaborative approach is expected to create and strengthen academic bond and promote closer interaction between the DAE and Universities/Research Institutions.

Activities

1. Identify and fund R & D Projects.
2. Financial support to conduct Symposia / Conferences.
3. Recruitment under Krishnan Research Associateship (KSKRA) scheme.
4. Award research projects under DAE-OIA scheme, through DAE-SRC council.
5. Award fellowships under DGFS M. Tech scheme.
6. Award fellowships to HBNI students under DGFS Ph. D scheme
7. Award Fellowships to retired Scientists under RRF & HBC schemes, through AEC.

Mahatma Gandhi Mission's

Colleges of Engineering & Technology

Mahatma Gandhi Mission's College of Engineering and Technology founded in 1986 under the ages of the Charitable Trust.

Mahatma Gandhi Mission has grown into a big banyan tree from the sapling planted in 1982 by the Chairman of the trust Shri Kamalkishor Kadam, an IIT Mumbai Alumnus, Member of Legislative Council, Ex-minister of education, State Govt. of Maharashtra with his brothers and friends. All the founders are a group of ingenious Engineers, Doctors, and Scientists having a high career profile, commitment to social interest and dedication to work. MGM has been working since last 40 years in Education and Health services sectors. Mahatma Gandhi Mission's group of institutes is trusted brand since 1982.

Mahatma Gandhi Mission believes in imparting quality education and over the years it has been proved with MGM pass-outs having employed in the best of the organizations world over.

The Mahatma Gandhi Mission's College Of Engineering and Technology provides excellent quality Engineering Education headed by Director Dr. Geeta S. Lathkar. Since 40 years she is leading the MGM Engineering institutes with her academic excellence and administrative capabilities. She is the recipient of many awards to her credit at State and National level.

To keep students and faculties updated with the latest trends in respective technologies is taken care of by Institute's Center of Excellence labs in collaboration with the industrial houses like Intel, IBM, SAP so that students grow in a holistic environment leading to total personality development of the students enabling them to get placed in most reputed companies across the country.

In the nutshell **"MGMCET is a student centric institute which is committed to the creation, acquisition and dissemination of knowledge."**

Science and Engineering Research Board (SERB)

One of the most notable developments in the S&T sector in the XI Plan has been the setting up of the Science and Engineering Research Board (SERB) through an Act of Parliament, viz. the Science and Engineering Research Board Act, 2008. Promoting basic research in Science and Engineering and to provide financial assistance to persons engaged in such research, academic institutions, research and development laboratories, industrial concerns and other agencies for such research and for matters connected therewith or incidental thereto are the primary and distinctive mandate of the Board.

SERB aims to build up best management systems which would match the best global practices in the area of promotion and funding of basic research.

The Science and Engineering Research Board (SERB) is a statutory body established through an Act of Parliament. Supporting basic research in emerging areas of Science & Engineering are the primary and distinctive mandate of the Board. The Board structure, with both financial and administrative powers vested in the Board, would enable quicker decisions on research issues, greatly improving thereby our responsiveness to the genuine needs of the research scientists and the S&T system.

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As the premier national research funding agency, raise the quality and footprint of Indian science and engineering to the highest global levels in an accelerated mode, through calibrated support for research and development.

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सत्यमेव जयते

DSIR

Department of Scientific and Industrial Research

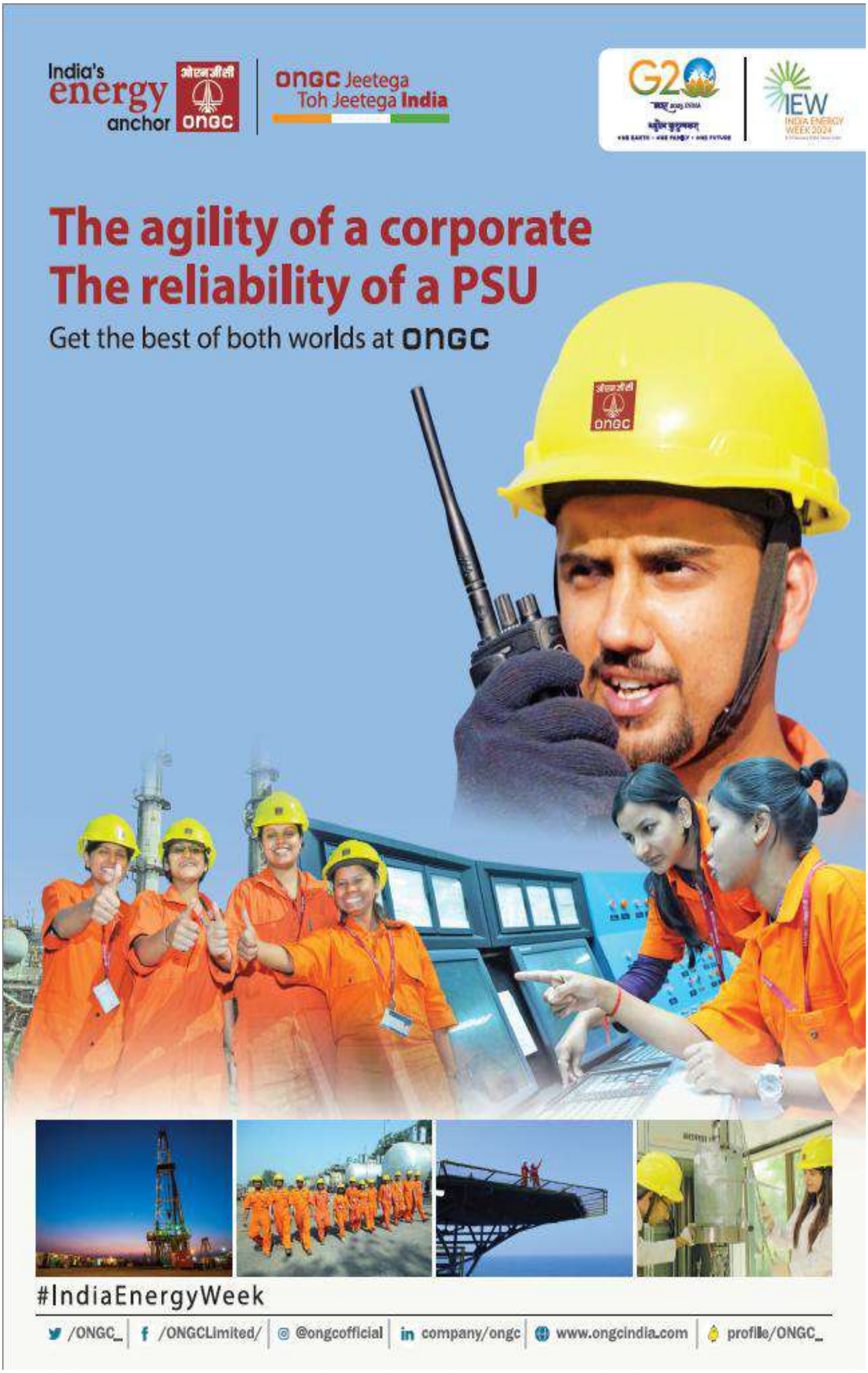
The Department of Scientific and Industrial Research (DSIR), under the aegis of the Ministry of Science and Technology, GoI was set up through a Presidential Notification, dated 4th January, 1985 (74/2/1/8 Cab). The mandate of DSIR is to promote industrial research for indigenous technology development, promotion, utilization and transfer. The Department of Scientific & Industrial Research (DSIR) operates the Umbrella Scheme on "Industrial Research & Development (IRD)" consisting following four sub-schemes: (i) Common Research and Technology Development Hubs (CRTDHs); (ii) Patent Acquisition and Collaborative Research & Technology Development (PACE); (iii) Access to Knowledge for Technology Development and Dissemination (A2K+) and (iv) Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM).

The aims of the four sub-schemes of the Umbrella Scheme – "Industrial Research & Development" are given below: i) Common Research and Technology Development Hubs (CRTDHs) – This is a scheme which focuses on creation of Common Research facilities for micro and small enterprises and components of scheme, viz Industrial R&D Promotion Programme; ii) Patent Acquisition and Collaborative Research & Technology Development (PACE) – This scheme focuses on development and demonstration of innovative technologies by industries and institutions, either stand alone or in collaboration; iii) Access to Knowledge for Technology Development and Dissemination (A2K+) – This sub-scheme has three components viz: 'Technology Development and Utilization Programme for Women' (TDUPW) - promotes adoption of new technologies by women for greater operational efficiency and reduction of drudgery; 'Support to Studies' – undertakes study and analysis of developments in the emerging technology areas and documents the findings, leanings and outcomes for wider dissemination including preparation of status reports on technologies from public funded institutions ready for commercialization and 'Support to Events' (seminars, workshops, conferences, exhibitions etc.) - provides a platform for exchange of views leading to useful insights on issues relating to industrial research and iv) Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM)– This scheme primarily focuses on supporting individual innovators, start-up companies, incubate companies in public funded technology business incubators and MSMEs.

DSIR has partially supported the conference under Event Program of Access to Knowledge for Technology Development and Dissemination (A2K+) Scheme of DSIR.

The primary endeavour of DSIR:

- Promote R&D by the industries,
- Support a larger cross section of small and medium industrial units to develop state-of-the art globally competitive technologies of high commercial potential,
- Catalyse faster commercialization of lab-scale R&D, enhance the share of technology intensive exports in overall exports,
- Strengthen industrial consultancy & technology management capabilities and establish user friendly information network to facilitate scientific and industrial research in the country.
- It also provides a link between scientific laboratories and industrial establishments for transfer of technologies through National Research Development Corporation (NRDC) and facilitates investment in R&D through Central Electronics Limited (CEL).



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I-DAPT Hub Foundation IIT (BHU) Varanasi

I-DAPT Hub Foundation at IIT (BHU) Varanasi is a section 8 company, jointly established by IIT (BHU) Varanasi and the Department of Science and Technology (DST), Government of India under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS). I- DAPT Hub Foundation IIT (BHU) was set up to address the emerging needs of the Country in the areas of interdisciplinary Data Analytics and Predictive Technologies. I-DAPT Hub Foundation aims to use the interdisciplinary nature of data analytics and predictive technology to fulfill the modernization of socio-technical systems and automotive services with disruptive innovations.

I-DAPT Hub Foundation at IIT (BHU) is currently working on five thrust areas i.e., Telecommunications, Power, Road Transport and Highways, Defense Research & Development, and Health & Family Welfare which have been identified as one of the emerging fields whose progress will add significant impact on several verticals of the economy.

I-DAPT Hub Foundation has broadly undertaken:
(i) Research and Development,
(ii) Start-up and Entrepreneurship Development,
(iii) Training Program and Human Resource Development, and
(iv) Joint/Collaborative Outreach Activities.
As of now, the I-DAPT Hub Foundation has sponsored 23 research projects undertaken by several renowned institutions in the Country. Further, the I-DAPT Hub Foundation is working with the National Science Foundation (NSF, USA) on various collaborative projects in the areas of Road Transport & Highways and Power.

As of now, more than 35 technologies have been developed and 6 patents have been filed. Majorities of technologies are between TRL 5-7 and some of them are ready to commercialize in the market (TRL8-9). Some of the technologies/products have already been installed at the actual site locations to perform real-time testing to validate the feasibility and performance.

Presently, I-DAPT is supporting 10 startups working on the five thrust areas, out of which, the majority of startups have developed and tested their technology/products with potential clients and are in the process of commercialization of their products in the market. Moreover, around 100 full/part-time job opportunities have been created by the startups.

I-DAPT has organized 35 training programs under Short Term Courses (STCs) and Human Resource Development programs which has benefitted approximately 8000 undergraduates, professionals, academicians, and students from India and abroad. I-DAPT has undertaken 15-20 collaborations both nationally and internationally with academia and industries for conducting several training programs, workshops, and conferences under these collaborative research project work.

Contact Information:

1. CEO, I-DAPT HUB Foundation, IIT (BHU): ceo.idapt@itbhu.ac.in
2. Project Manager: manager.idapt@itbhu.ac.in; manager2.idapt@itbhu.ac.in
3. Office (I-DAPT Hub Foundation): office.idapt@itbhu.ac.in

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Platinum Sponsorship

DATA ANALYTICS AND PREDICTIVE TECHNOLOGIES
I-DAPT HUB FOUNDATION
Indian Institute of Technology (BHU), Varanasi

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THE SOUVENIR

Manufacturing today ranks first amongst all the principal real wealth producing activities of most industrialised countries. The current domestic and international market place demands that manufacturing companies & academia must change their way they design, produce and deliver their products. The new millennium full of AI/GBT/Automation is round the corner. The Department of Mechanical Engineering, Indian Institute of Technology (Banaras Hindu University) Varanasi sets the sight on the new scientific and technological frontiers of the manufacturing challenges in the new coming decade of Manufacturing Research.

The Souvenir of the 9th International and 30th All India Manufacturing Technology and Design Research-2023 contents more than 380 reviewed research papers presented by distinguished authors from all corners of the world. The Souvenir include papers and talk on various fields such as advanced manufacturing processes, artificial intelligence, expert system, agile manufacturing, software development for process planning and other latest manufacturing strategies. Engineers, technologists, entrepreneurs, researchers and academicians related with futuristic manufacturing field development will be highly benefitted by this unique compilation. Later the full papers will also be published in 10 volumes of Springer's proceedings.

The Organizing Team – AIMTDR-2023
Department of Mechanical Engineering, IIT (BHU) Varanasi

Prof. Pramod Kumar Jain, Er. R. N. Tripathi, Dr. B. B. Ahuja, Dr. Santosh Kumar, Prof. R. K. Gautam, Prof. P. Bharadwaj, Dr. M. Z. Khan, Dr. M. Vashista, Dr. U. S. Rao, Dr. Joy Prakash Misra, Dr. Saurabh Pratap, Dr. Lakshay, Dr. J. V. Tirkey, Dr. C. Samuel, Dr. D. Khan, Dr. Amit Tyagi, Mr. P. C. Mani, Dr. Anubhav Sinha, Dr. Akhilendra Pratap Singh, Dr. Srihari Dodla, Dr. Pawan Sharma, Dr. G. M. Karthik, Dr. Manmeet S. Raina