30th PAMFP
11-13 December'24
Hyderabad, India

Jointly Organised by

IA-PMFP – International Association for Processing of Materials and Fabrication of Products

భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

30th International Conference on Processing of Advanced Materials and Fabrication of Products

Theme:

Smart NextGen PAMFP: Sustainable Materials and Green Manufacturing

Conference Venue: IIT Hyderabad, India

www.iapmfp.org/2024

SOUVENIR

Chief Guest

Message

It is heartening to know that the 30th International Conference on Processing of Advanced Materials and Fabrication of Products, 2024 is being organized at IIT Hyderabad from 11th to 13th December, 2024. The conference is organized to bring together scientists, technologists, researchers, engineers, industry leaders for exploring the new vistas with respect to recent advances, emerging trends in spectrum of products spanning both performance-critical and non-performance critical.

The underlying theme of this conference i.e., 'Design and Manufacturing of Sustainable Materials, Process and Products' and 'Sustainable Metallurgy and Energy-Efficient Materials for Transition & Decarbonization in Metal Manufacturing Sectors' is the need of the hour and occupies a significant role in achieving the Hon'ble Prime Minister's vision of "Viksit Bharat-2047".

To achieve the "Viksit Bharat" vision, it is absolutely important to integrate 'innovation' and 'sustainability' in the field of design and manufacturing of advanced materials to minimize the environmental impact. The significance of sustainability and environmental stewardship is expected to grow in the realms of manufacturing and design in future and are likely to influence the main priorities for advancing manufacturing operations and technologies.

Recognizing this importance, I am glad to know that IIT-Hyderabad has been playing a very significant role in this direction and taken up the initiative. May this conference foster new collaborations and improve understanding of sustainability in manufacturing and design, and to enhance applications of AI/ML for process optimization.

Warm Regards,

Dr. Sanjay Kumar Jha
CMD Mishra Dhatu Nigam (MIDHANI) Hyderabad India

Message

Dear Participants,

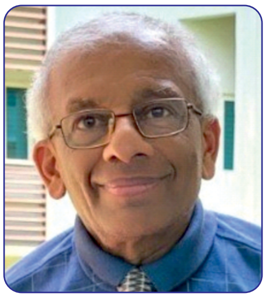
We live in an era marked by rapid technological advancements. The technology is evolving so unprecedented pace that redefines our lives and brings innumerable possibilities. “Viksit Bharat”, a developed India, requires a multifaceted approach that embraces the contributions of various fields.

We should create solutions that address pressing societal challenges, improving quality of life for all. Our focus should extend beyond mere technological advancement and empower communities and promote sustainability. We should envision a future where technology enriches lives and fosters a more equitable world.

Metallurgists and Material Scientists play a significant role in Viksit Bharat, by designing materials and technologies that keep India ahead of others, making our Bharat not only a global player but a global leader.

Thank you.
Jai Hind.
Prof. B.S. Murty
Director, IIT Hyderabad

President of International Association for Processing of Materials and Fabrication of Products [IA PMFP]



Message

Greetings, cheers and abundance of thanks I extend to each one of you either opting to be physically present in person and make your presence felt or tuning in on-line to make your "valued" presence felt and participating by way of delivering your presentation. In the last few days and weeks, I have been fortunate to receive messages from individuals, both involved and committed to investigating, contributing and furthering the prevailing knowledge base in the domains specific to Materials (to include both Science and Engineering) and Manufacturing Processes (to include Manufacturing Technologies), congratulating me for 33 years [1991-2024] of dedicated, diligent and devoted commitment to the execution and delivery on aspects specific to both promoting and furthering the prevailing knowledge base specific to the Processing of Materials as a viable outcome for the fabrication of products for use in a spectrum of applications.

This technical event being held at Indian Institute of Technology (IIT) (Hyderabad), India., is the 30th in a series of conferences on the specific topic of "***Processing of Advanced Materials***", with the prime objective of bringing together engineers, technologists, and researchers from nations scattered through the globe and intimately associated with industries, universities and national/government laboratories, and committed to working on aspects and intricacies related, relevant and applicable to the processing, fabrication, characterization and evaluation of

(a) Materials spanning biomaterials, composites [to include metal-matrix composites, ceramic-matrix composites, and polymer-matrix composites], fuel cell materials, functionally-graded materials, high-energy materials, intermetallic(s), magnetic materials, foam materials, nanomaterials and nanocomposites, phase-change materials, porous materials and super-conducting materials, and
(b) Many marvels of manufacturing to include Additive manufacturing, Green manufacturing, Sustainable manufacturing, Artificial Intelligence (AI), Machine Learning (ML), and MEMS/NEMS, for potential use on a spectrum of products spanning the domains of both performance-critical and non-performance critical.

In net essence the "Theme" of this Scholarly Technical Event is on the following two key aspects:

1. The Design and Manufacturing of Sustainable Materials, Process and Products
2. Sustainable Metallurgy and Energy-Efficient Materials for Transition & Decarbonization in Metal Manufacturing Sectors

The key participants are encouraged to present and discuss their findings, observations, inferences and even the potentially viable outcomes culminating from their study

The earlier conferences on "***Processing and Fabrication of Advanced Materials***" have been held in seven nations to include the following: (i) Hong Kong (# 1), (ii) India (# 6), (iii) Japan (# 2), (iv) New Zealand (# 2), (v) Singapore (# 4), (vi) S. Korea (# 1), (vii) Sweden (# 1) and (viii) USA (# 12).

As organizers we have made every effort to ensure that each one of you in attendance, has an excellent experience that spans the domain of education with the prime objective of (i) enabling and ensuring enlightenment for all of the participants and interested attendees, and (ii) importantly encouraging and promoting entrepreneurship, growth and prosperity. Giving due consideration to the scale and caliber of the qualified and intellectually inclined individuals that we have been able to attract, encourage and even reward, this scholarly technical event the "***Thirtieth International Conference on the topic of Processing of Advanced Materials and Fabrication of Products***" does look forward to meeting the desired objectives specific to enabling excellence in the execution of research and possibly entrepreneurship by way of development of products for selection and use in a large number of applications. In essence, this conference seeks to bring out excellence, while concurrently striving to enable and promote (i) diversity and (ii) celebrate accomplishments and achievements made possible either independently or through collaboration. Our key objective is to both nurture and promote the overall wellbeing of research done by each one of you while concurrently ensuring a platform for the presentation of your research with an emphasis on innovations and findings and the possibility of entrepreneurship that does necessitate the need for both stewardship and direction (focus).

Srivatsan T S
President (IA PMFP)

Programme

PROGRAM | Day -1 | Wednesday, December 11, 2024

08:00-09:00 | Registration
09:00-10:00 | Inauguration
09:00-09:05 | Lignting of Lamp and Prayer
09:05-09:10 | Welcome Address by the Convener- Prof. Saswata Bhattacharya, IIT Hyderabad India
09:10-09:20 | Confernence Address by Prof. T. S. Srivatsan, IA-PMFP
09:20-09:35 | Inaugural Address by the Chief Guest 30th PAMFP 2024 - Dr. Sanjay Kumar Jha, MIDHANI Hyderabad India
09:35-09:50 | Special Address by the Guest of Honor 30th PAMFP 2024 – Prof. B.S. Murty, Director IIT Hyderabad India
09:50-09:55 | Release of Conference Souvenir and Bound Volume
09:55-10:00 | Vote of Thanks - Prof. Ashok Kamaraj IIT Hyderabad followed by the National Anthem
10:00-10:15 | Group Photo followed by High Tea
Plenary Session 1- Auditorium-1
10:15-11:00 | Session Chair - Prof. Surya Kalidindi, Georgia Tech. USA
10:15-11:00 | (TBD) Prof. B S Murty, IIT Hyderabad

Parallel Sessions

Parallel Session-1 - Sustainable Metallurgy and Energy-Efficient Materials for Transition & Decarbonization in Metal Manufacturing Sectors (Auditorium-1)

Session Coordinator - Prof. Ashok Kamaraj IIT Hyderabad, Session Chair: Prof. Viswanathan N, IIT Bombay

11:00-11:30 | KN-1 **Prof. Gour Gopal Roy,** IIT Karaghpur *Decarburizing iron and steel industry for coal based developing economy*
11:30-11:50 | IL-2 **Dr. Deepoo Kumar**, IIT Bombay *Processing of electronic waste at low temperature*
11:50-12:05 | OP-1 **Dr. Rashmi Singla**, NML Jamshedpur *Next generation aluminosilicate-organic hybrid geopolymers: Microstructural and mechanical characterisation*
12:05-12:15 | FT-5 **Mr Syed Furqan Bukhari**, Indian Institute of Technology, Hyderabad *Mathematical Modeling of Motion of Carrier Gas and Mg Particle in the Top Lance during Hot Metal Desulphurization Process*
12:15-12:35 | FT-1 **Mr Manish Kumar Tiwari**, Indian Institute of Technology Bhilai, Durg *A novel green manufacturing route for developing metal powders for additive manufacturing: An experimental investigation of IN718 alloy*
12:35-12:45 | FT-4 **Mr Guru Srikanth Reddy Uppaluru**, Indian Institute of Technology Hyderabad, Hyderabad *Slag Free Eccentric Bottom Tapping in Electric Arc Furnace by Physical Modelling Studies*

Parallel Session-2 - Additive Manufacturing (Hall-2)

Session Coordinator - Prof. Rajesh Korla, IIT Hyderabad

11:00-11:30 | KN
Prof. Bala Vaidhyanathan, Loughborough University, Loughborough
Additive Manufacturing of Advanced Ceramic Components for Demanding Applications

11:30-11:50 | IL
Dr. Shany Joseph, Centre For Materials For Electronics Technology, Panchwati
LTCC based Multilayer Package Fabrication using 3D Printed Digital Technology

11:50-12:05 | OL-1
Dr. Thirupathi Samala, IIT ISM Dhanbad
Predictive modeling of additive manufactured Ti6Al4V lattice structures design using simulation-based machine learning models

12:05-12:20 | OL-2
Dr. Anilchandra A R, BMSCE
MECHANICAL RESPONSE OF 3D PRINTED REINFORCED NYLON FOR USE IN PERFORMANCE-SPECIFIC APPLICATIONS

12:20-12:30 | FT-1
Mr Sarabjit Singh, Uiet Hoshiarpur
Steady-State Thermal analysis of Inconel Material Based on 3D Metal Printed Exhaust valve for IC Engines : An innovative approach

12:30-12:40 | FT-2
Ms Sayli Madhukar Jadhav, D.Y. Patil College of Engineering Akurdi, Pune
Fault Tree Analysis of FDM 3 D Printer for improved maintainability

12:40-12:50 | FT-3
Mr Pabitra Kumar Sahu, IIT Madras, Madras
Enchancing energy absorption characteristics of modified Euplectella aspergillum-inspired lattice structure

Parallel Session -3-Advanced Materials and Manufacturing Technology (Hall-3)

Session Coordinator - Prof. Saswata Bhattacharya, IIT Hyderabad

11:00-11:30 | KN-1
Prof. Raman Singh, Monash University, Australia
Circumventing Processing Challenges in Developing Graphene Coatings on Mild Steel for Remarkable and Durable Corrosion Resistance

11:30-11:45 | OL-1
Dr. Ravi G, Sri Sai Ram Engineering College, chennai
Experimental Investigation of PWHT on gas tungsten arc welded nickel based superalloy Inconel 718

11:45-12:00 | OL-2
Dr. Ch.V.M.S.N.Pavan Kumar, Bapatla Engineering College, Bapatla
Improved Bandgap Prediction of 2D Materials using Ensemble of Hyperparameter Optimized Boosting Algorithms

12:00-12:15 | OL-3
Dr. Mayur A. Makhesana, Institute of Technology, Nirma University, Ahmedabad
Synthesis and characterization of metallic nanoparticles via Laser ablation synthesis in solution

12:15-12:30 | OL-4
Dr Santosh Sampath, Sri Sivasubramaniya Nadar College of Engineering, Chennai
Optimizing laser machining parameters for enhanced surface quality and structural integrity of magnesium alloy composite

12:30-12:45 | OL-5
Mrs Thejeswini P G, VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY BALLARI
Sustainable Synthesis of Cu- doped ZnO Nanoparticles Using Bixa orellana L. Leaf Extract for Antimicrobial and Cytotoxic Investigations

12:45-01:00 | FT-01
Ms URMILA HARISH DAKAVE , Sanjay Ghodawat University Atigre Maharashtra
Identifying the advancements of Friction Stir Welding: Innovations in Numerical Modeling and Simulation

Lunch Break - 13:00-14:30

Parallel Session-4 - Smart Manufacturings (Auditorium-1)

Session Coordinator - Prof. Kishalay, IIT Hyderabd

14:30-15:00 | KN-1 **Prof. Satish Kailas** , IISc Bangalore, Bangalore *Scalable Severe Plastic Deformation Process to Produce Sheets with Controllable Properties*
15:00-15:30 | KN-2 **Prof. M. P. Gururajan** , IIT Bombay *Atomistic and continuum modelling of segregation induced microstructural changes*
15:30-16:00 | KN-3 **Prof. Pinaki Prasad Bhattacharjee**, IIT Hyderabad *Strategies for Tailoring Microstructure and Properties of High Entropy Alloys*
16:00-16:20 | IL **Dr. Abhik Choudhury**, IISc, Bangalore *Modeling assisted workflows for the processing of single crystal Ni-base alloys: Adaptions from Bridgman to Additive*
16:20-16:35 | OP-1 **Mr Uday Kumar**, Indian Institute of Technology Madras, Chennai *Eco-friendly Electropolishing of SS304L Stainless Steel for Nuclear Fusion Applications*

Parallel Session-5 - Additive Manufacturing (Hall-2)

Session Coordinator - Prof. Gopinath, IIT Hyderabad

14:30-15:00 | KN-1 **Prof. Eric MacDonald**, The University of Texas at El Paso, Texas (Virtual) *Additive Manufacturing of Elastomer, Ceramic and Metal Multi-functional Structures*
15:30-15:45 | OP_1 **Mr Sai Siddhartha Kadiri** , Larsen & Toubro Ltd, Coimbatore *Study on deposition characteristics of Ti6Al4V alloy fabricated through wire arc additive manufacturing using TIG and CMT mode*

15:45-16:00 | OP_2
Mr Ganta Venkateswara Rao , NIT, Mizoram
COMPARATIVE STUDY OF HEAT SOURCE MODELS TO ANALYSE THEIR EFFECT ON PRECISE MODELLING OF ARC WELDING PROCESS

16:00-16:10 | FT-1
Ms Khushi Hemant Sharma , Fr. C. Rodrigues Institute of Technology, Vashi. Vashi, Navi Mumbai
ADJUSTABLE PROSTHETIC DESIGN OF FEET FOR THE AGE GROUP 5-10

16:10-16:20 | FT-2
Mr Shivraj Gahir , Indian Institute of technology, Bhilai
Wire Arc Additive Manufacturing based alloy development approach for Copper: A comparison study on the pure copper and Cu-Ni alloy against Vacuum Arc Melting method

Parallel Session-6 - Sustainable Metallurgy and Energy-Efficient Materials for Transition & Decarbonization in Metal Manufacturing Sectors (Hall - 3)

Session Coordinator - Dr Ashok Kamaraj, Session Chair - Prof. G G Roy, IIT KGP

14:30-15:00 | KN-1
Prof. N Viswanathan, IIT Bombay
Challenges & Opportunities Towards Sustainable Indian Steel Sector

15:00-15:20 | IL-1
Dr Snehashish Tripathy, CSIR National Metallurgical Laboratory Jamshedpur
Computational design of Compositionally Complex Alloys (CCAs) for solid-state Hydrogen storage applications

15:20-15:30 | FT-2
Mr Yogesh Dandekar, National Institute of Technology, Raipur
Modelling and Analysis of Essential Parameters in Green Sand Process to Minimize Shrinkage Porosity in Grey Iron Components

15:30-15:40 | FT-3
Mr Badireddi Lakshman Kumar, Indian Institute of Technology Hyderabad
Investigating the Integration of Hydrogen and Biomass in Iron Ore Pellet Reduction Process

Tea Break - 16:20-17:00

PROGRAM | Day -2 | Thursday, December 12, 2024

09:00-09:30| Registration
Plenary Session-2_Auditorium-1
09:00-09:45 | Session Chair - Prof. Balasubramaniam Vaidhyanathan, UK
09:00-09:45 | Dr Anil K. Sachdev, General Motors (Retired) United States
Tea Break | 09:45-10:00

Parallel Session-7 - Smart Manufacturing _Auditorium-1

Session Coordinator - Prof Kishlay and Prof Pinaki, IIT Hyderabad

10:00-10:45 | KN-1 **Prof. Saswata Bhattacharya**, IIT Hyderabad *Mesoscale Modeling: The Key to Accelerated Design of Electronic Materials Using Multiferroics as a Case Study*
10:45-11:30 | KN-2 **Prof. Kishalay Mitra**, IIT Hyderabad *Confluence of Machine Learning and Optimization in Manufacturing*
11:30-12:00 | IL Shri Vinod Prakash, CMTI, Bangalore *AI Propelled Smart Manufacturing*
12:00-12:15 | OL-1 **Dr. Tamil Selvan S**, Coimbatore Institute of Technology, Coimbatore *Optimization of Water Jet Pressure, Feed Rate and Abrasive Flow Rate in Abrasive Waterjet Machine to enhance Kerf Taper, Surface Roughness and Material Removal Rate of Aluminium 6061 using Response Surface Methodology and Grey Relational Analysis*

12:15-12:30 | OL-2
Mr Harshitsinh Ganpatsinh Padhiyar, Larsen & Toubro PES-IC, Surat
Development of IoT based Real-Time weld defect monitoring system

12:30-12:45 | OL-3
Mr Yogesh Dandekar, Cummins College of Engineering for Women, Nagpur
Manufacturing of hollow parts with light weight for automotive industry: A case Study

12:45 - 13:00 | OL-4
Ms Sujata Sahoo, Department of Mechanical, Materials and Aerospace Engineering (MMAE), IIT Dharwad, Karnataka
Optimizing Friction Stir Processing Parameters to Enhance Microstructure and Mechanical Properties of Aluminum Plates: An Experimental Approach

Parallel Session-8 - Polymers and Biomaterials _Hall-2

Session Coordinator - Prof. Mahesh Ganesan, IIT Hyderabad

10:00-10:30 | KN-1
Prof Thorsten Halle, Otto-von-Guericke-University, Germany
Influence of the microstructure of TiAl6V4 on in vivo crevice corrosion on metallic implants

10:30-10:45 | OP_1
Dr Anjaneyulu Dirisala, Innovation Center of NanoMedicine (iCONM) Kawasaki Institute of Industrial Promotion, Kawasaki
Selective and transient stealth coating of the liver sinusoidal walls for targeted organ delivery of nanomedicines

10:45-11:00 | OP_2
Mr. Devara Venkata Krishna, IIT Tirupati
Dynamic Mechanical and Tribological Properties of Multimaterial Hydrogel Films Under Physiological Solutions for Biomedical Applications

11:00-11:15 | OP_3
Dr. Manjunatha Shidiginamola, Kishkinda University

Ambient Temperature Humidity Sensing Properties of Polypyrrole - Neodymium Oxide Composite
11:15-11:30 | OPO_4 **Mr. Anurag Kumar**, IITH *TBD*
11:30-11:35 | FT_1 **Mr Mani Sankar A**, Coimbatore institute of technology *Optimization of Kerf Taper, Material Removal Rate and Surface Roughness of POLYOXYMETHYLENE in in Abrasive Waterjet Machining*
11:35-11:40 | FT_2 **Mr Kaarthik A N**, COIMBATORE INSTITUE OF TECHNOLOGY *Enhancing Polyoxymethylene (POM) Strength for Gearing Applications through Alumina Reinforcement and Comprehensive Testing*
11:40-11:45 | FT_3 **Mr Ranjan Kumar**, Birla Institute of Technology, Mesra, Ranchi *Assessment of the linear reciprocating tribological (LRT) performance of Graphene nanoplatelets (GnPs) loaded Polyamide-6,6 (PA-6,6) composite under dry sliding contact*
11:45-11:50 | FT_4 **Mr Hemantha Kumar K R**, Dayananda Sagar University, Bangalore *Transport properties and EMI SE studies of Silver decorated Polyaniline-Banana carbon ternary nanocomposites*

Parallel Session-9 - Advanced Materials and Manufacturing Technology _Hall-3

Session Coordinator - Dr. Nagendra Singh, MSRUAS

10:00-10:30 | KN-1 **Prof Andre Katterfeld**, University of Magdeburg, Germany *Modelling, Simulation and Validation of Abrasive Wear in Mining and Process Industry*

10:30-10:45 | OL-1 **Dr Santosh Sampath**, Sri Sivasubramaniya Nadar College of Engineerin, *INFLUENCE OF WATER-JET PEENING ON ENVIRONMENT-INDUCED DEGRADATION AND SURFACE CHARACTERISTICS OF A MAGNESIUM-ZINC ALLOY*
10:45-11:00 | OL-2 **Dr. Rani Rohini**, Indian Institute of Technology, Jammu *Understanding effect of processing parameters on microstructural and physical properties of MXenes*
11:00-11:15 | OL-3 **Dr Krishnkant Sahu**, Sharad Institute of Technology College of Engineering, Kolhapur *Investigating the Impact of Applied Current and Chevron Pattern Groove on Slot Entry Hybrid Conical Journal Bearings*
11:15-11:30 | OL-4 **Mrs Sunita K. Srivastava**, PES University, Bengaluru *Mechanical and Microstructure Analysis of AlSi10Mg Alloy Fabricated by Selective Laser Melting Process*
11:30-11:45 | OL-5 **Dr Vimal Kannan I**, Sri Sai Ram Engineering College, Chennai *OPTIMIZATION ON WEAR TEST PARAMETERS OF AL7075 BASED HYBRID METAL MATRIX COMPOSITES USING TAGUCHI APPROACH*
11:45-12:00 | OL-6 **Dr Jose Immanuel**, Indian Institute of Technology Bhilai, Durg *Tribological performance of a novel AA6061 based high strength composite reinforced with TiAl a metallurgical investigation on the combined effect of precipitation and grain refinement*
12:00-12:15 | OL-7 **Dr Srinivasa Babu Ramisetti**, CSIR-Structural Engineering Research Centre, Chennai *Role of Stone-Wales Defects on Nano Friction of Graphene/h-Boron Nitride Heterostructures*

12:15-12:30 | OL-8
Dr Santosh Sampath, Sri Sivasubramaniya Nadar College of Engineering, Chennai
An investigation of abrasive aqua jet machining characteristics of a hybrid composite reinforced with waste EDM wire and carbon fiber

12:30-12:40 | FT-1
Dr Uma Maheswara Rao Seelam, NIT Warangal, Warangal
Phase separated Cu-Fe bulk metastable alloys prepared by mechanical alloying and spark plasma sintering

12:40-12:50 | FT-2
Mr Dolagobinda Sethi, IIT Bhubaneswar
Establishing a process map of microstructural and phase changes through molten pool thermal history for ex-situ and in-situ laser cladding of TiN/ Inconel 625 MMC

12:50-13:00 | FT-3
Mr Sabari C, Sathyabama Institute of Science and Technology, Chennai
Diamond - Like Carbon Coating - Tribological applications

Lunch Break-13:00 - 14:30

Parallel Session-10 Advanced Materials Processes _(Auditorium-1)

Session Coordinator - Prof. B. Vaidhyanathan, Loughborough University, UK

10:30-10:50 | IL-1
Dr. Anbukkarasi Rajendran, Indian Institute of Technology Dharwad
Advances of Friction Stir Welding: An Overview

10:50-11:05 | OL-1
Dr. Ravi G, Sri Sai Ram Engineering College, Chennai
Influence of post-weld heat treatment of GTA welded Nickel-Based Superalloy Inconel 718

11:05-11:20 | OL-2
Mr. Bhavesh Rana, Larsen & Toubro, Surat

Case Study on Repair Welding of Nickel Aluminium Bronze Alloy Casting (BS1400 AB2) using Tungsten Inert Gas Welding Process

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11:20-11:30 | FT-1
Mr. Abhishek Shukla, IIT Madras, Chennai
Micro-segregation behaviour of â„½-â„½â€™ Precipitate Hardened Additively Manufactured Nickel Based Superalloy

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11:30-11:40 | FT-2
Ms. Arpita Priyadarshani Samal, PhD Research scholar, Rourkela
An ICME approach to investigate the processâ€“structureâ€“property co-relation of aluminium alloys

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11:40-11:50 | FT-3
Mr. Harinarayan Namdev, IIT Bhilai
High-Temperature Mechanical properties of Haynes 282 Nickel base superalloy processed through Laser Powder Bed Fusion Additive Manufacturing Process

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11:50-12:00 | FT-4
Mr. Rahul Patel, Indian institute of technology Bhilai
Influence of tool profile on temperature distribution and residual stress development during friction stir processing of Al 7068 alloy

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12:00-12:10 | FT-4
Dr. Santosh Sampath, Sri Sivasubramaniya Nadar College of Engineering, Chennai
The Influence of Isothermal Surface Oxidation on the Microstructure and Mechanical Properties of NiTiCo Shape memory alloy

Parallel Session-11 - Additive Manufacturing _Hall-2

Session Coordinator - Prof. Gopinath, IIT Hyderabad

14:30-15:00 | KN-1 **Prof. Satyam Suwas**, IISc Bangalore *Influence of heat treatment on mechanical properties of additively manufactured Superalloy Hastelloy X*
15:00-15:15 | OL-1 **Mr Swapnil Doke**, Centre for Material for Electronics Technology (C-MET) Pune *Development of Multimaterial DLP-Based 3D Printing Process to fabricate 3D ceramic electronics using ceramic matrix and metal conductors*
15:15-15:25 | FT-1 **Mr Sidhartha Sankar Swain**, Indian Institution Of Technology, Bhubaneswar, Odisha, Bhubaneswar *Fabrication and analysis of dual hardness steel through laser DED*
15:25-15:35 | FT-2 **Mr Sahil Dhiman**, Indian Institute of Technology Hyderabad & Deakin University, Hyderabad *Focal Offset Distance as a Key Enabler for Microstructure Control in Additively Manufactured Ti-6Al-4V during High Power LPBF*
15:35-15:45 | FT-3 **Mr Shivraj Gahir**, Indian Institute of technology, Bhilai *Wire Arc Additive Manufacturing based alloy development approach for Copper: A comparison study on the pure copper and Cu-Ni alloy against Vacuum Arc Melting method*

Parallel Session-12-Semiconductor Materials (Hall_3)

Session Coordinator- Dr. Suresh Garlapati (IITH)

14:30-15:10 | KN **Dr. Medhuri Ravi**, STAR-C Bangalore *MEMS manufacturing in India*
15.10 - 15.30 | LI_1 **Dr. Rajamani Ragunathan**,UGC-DAE, Indore *Grain boundary engineering: Insights from Multi-scale Modeling*
15.30-15.50 | LI_2 **Prof. Anbarasu M**, IIT Madras *Advanced Memory Technology for High Speed computing*
15.50-16.10 | IL_3 **Prof. Tanushree H. Choudhury** *Strategies for Scalable synthesis of layered semiconductors*
16:10-16:25 | OL-1 **Dr Partha Sarathi Mondal**, National Institute of Advance Manufacturing Technology, Ranchi *Dielectric energy storage properties of BaTiO3 ceramics prepared by reactive cold sintering using a novel transient flux*
16:25-16:35 | FT-02 **Ms Usharani Valaparla**, Indian Institute of Information Technology *Effects of Antimony vacancies and nanostructuring on thermoelectric properties of n-type InSb.*
Tea Break and Poster Sessions 16:30-17:30

PROGRAM | Day -3 | Thursday, Friday 13, 2024

Session Chair - Prof. T S Srivatsan, University of Akron USA
09:30-10:15 | Session Chair - Prof. T S Srivatsan, University of Akron USA
09:30-10:15 | (TBD) Prof. Ramamoorthy Ramesh, Rice University, USA (Virtual)
Tea Break - 10:15-10:30

Parallel Session-13 - Polymers and Biomaterials _Auditorium-1

Session Coordinator - Dr. Mudrika Khandelwal, IIT Hyderabad

10:30-10:50 | IL_1 **Dr. Mahesh Ganesan**, IITH *Rheological Design of Pressure Sensitive Adhesives for Vibration Damping*
10:50-11:10 | IL_2 **Dr. Balaji Iyer**, IITH *Multiscale Modeling and Simulation Approaches For Design of Polymer Nanocomposites*
11:10-11:25 | OP_1 **Dr Dungali Sreehari**, NIT Uttarakhand, Srinagar, Pauri Garhwal, Uttarakhand *Drilling Analysis of Coir Fiber/Pine Needle Powder Reinforced Hybrid Epoxy Composite*
11:25-11:40 | OL-2 **Mr Santu Panja**, TVS Motor Company Limited, Hosur *Study on the effects of properties to polypropylene blends with the addition of recycled material*
11:40-11:55 | OL-3 **Dr. Santosh Sampath**, SSN College, Chennai *Mechanical Response of Hybrid Glass/Kevlar Epoxy Polymer Composite Reinforced with Multi-Walled Carbon Nanotubes: An Experimental Study*

11:55-12:00 | FT-1
Ms Lavanya B Gunjal, Rao Bahaddur Y Mahabaleshwarappa Engineering college, Ballari, Belagavi
Dielectric behaviour and AC Conductivity of Polypyrrole Neodymium oxide Composites

12:00-12:05 | FT-2
Mr Nagaraja H, Vijayanagara Sri Krishnadevaraya University Ballari, Karnataka,India
Bio-inspired Synthesis of Metal oxide Nanoparticles from Neltuma juliflora (Sw.) Raf. Leaf Extract for Antimicrobial and Anticancer applications

12:05-12:10 | FT-3
Ms Bhavya Surendran VS, Indian Institute of Technology Hyderabad
Synthesis of Superabsorbent Polylactic acid- Dextran Composites

12:10-12:15 | FT-4
Mr Devindrappa Patil, School of Applied Sciences, REVA University, Bangalore
AC Conductivity and Humidity Sensing behaviour of PTh-Nanoclay composites

12:15-12:20 | FT-5
Mr Girisha T N, Research Center-Physics, PES University-Electronic City Campus, Banglore
Graphite oxide embedded polyaniline hybrids for high frequency electromagnetic wave attenuation and EMI shielding

Parallel Session-14- Additive Manufacturing (Hall - 2)

Session Coordinator - Prof. Muvvala Gopinath, IIT Hyderabad

10:30-10:45 | OP-1
Arkajyoti Jha, Indian Institute of Information Technology

10:45-11:00| OP-2
Arkajyoti Jha, Indian Institute of Information Technology

11:00-11:15 | OP-3
Aditya Manoj Madgulkar, Indian Institute of Information Technology

11:15-11:30 | OP-4
Ashish Parihar, IIT Hyderabad

11:30-11:45 | OP-5 **Prasannakumar Biradar,** IIT Hyderabad
11:45-12:00 | OP-6 **Dharavathu Raja,** IIT Hyderabad
12:00-12:15 | OP-7 **Bikram K. Khandai**, IIT Hyderabad
12:15-12:30 | OP-8 **Bikram K. Khandai**, IIT Hyderabad

Parallel Session 15 - Advanced Materials and Manufacturing Technology_Hall-3

Session Coordinator - Dr. Vikas Kumar Saxena, DRDO

10:30-11:00 | KN-1 **Prof. Surya Kalidindi**, Georgia Institute of Technology, Atlanta, USA *Digital twins for accelerated materials innovation*
11:00-11:15 | OL-1 **Dr K Shashank Kumar**, Central Manufacturing Technology Institute, Bengaluru *Advanced Processing and Optimization of NiOx as a Hole Transport Layer in Perovskite Solar Cells*
11:15-11:30 | OL-2 **Dr Anusha Epparla**, Central Manufacturing Technology Institute (CMTI), Bengaluru *Effect of Spheroidization on Laser Surface Hardening and Sliding Wear Performance of Bearing Steel*
11:30-11:45 | OL-3 **Mr Srikanth Venkata Duriseti Sreenidhi**, Institute of Science and Technology, Hyderabad *FUSION 360 BASED DESIGN OF A COMPOSITE LEAF SPRING*
11:45-11:55 | FT-1 **Mr Dinesh P**, Sathyabama Institute of Science and Technology, Chennai *Duplex treatment of Nitriding and PVD coating - An Insight*

11:55-12:05 | FT-2 **Mr Reshab Pradhan**, Shiv nadar institution of Eminence, Greater Noida *One-Step Biofuel-Assisted Flame Treatment for Fabricating Flexible, Durable, and Transparent Superhydrophobic Films*
12:05-12:15 | FT-3 Ms Sagarika Bhattacharjee, Research scholar, Rupnagar *Patterning of colloids by freeze drying*
12:30 to 13:00 - Valedictory at Auditorium-1
Lunch-13:00-14:30

Plenary Talk

Materials Development in a Multiscale Computational Framework Coupled with Advanced In-Situ Microstructure Characterization

Anil K. Sachdev

December 13, 2024

Abstract

This talk will provide examples of structural materials developed by combining a multi-scale computational design methodology with advanced in-situ experiments to elucidate physical mechanisms that define material behavior. Materials with engineered microstructures including steel, aluminum, magnesium and metal matrix composites encompassing manufacturing methods spanning the bandwidth of machining, forming, casting, and additive manufacturing will be described. Examples will include the use of density functional theory to develop diamond-like carbon coatings for machining aluminum and additives for controlling corrosion behavior of magnesium; nano-pillar deformation inside the microscope to determine single crystal properties of oriented crystals milled using focused ion beam which get incorporated into polycrystal models; nano-scale precipitation in alloys specifically designed for additive manufacturing; large castings designed by integrating multiple individual stampings. Future challenges and opportunities for sustainable materials development using coupled multiscale modeling and advanced microstructure characterization tools will be identified.

Keynote Talks

Additive Manufacturing of Advanced Ceramic Components for Demanding Applications

Prof. Bala Vaidhyanathan
Department of Materials, Loughborough University, United Kingdom
Email: B.Vaidhyanathan@lboro.ac.uk

Abstract

The processing of advanced functional ceramic powders and suspensions into useful engineering components has been investigated via a series of research projects each focusing on a different stage of the manufacturing route viz., (i) the ability to control the agglomerates present in the ceramic powder resulting in the production of a free-flowing and crushable powders, (ii) the formation of low viscosity but high solids content nanoceramic suspensions suitable for 2D and 3D additive layer manufacturing (3D printing) and (iii) the use of novel field assisted sintering techniques (FAST). This holistic approach helped to transfer the developments achieved in each stage of the manufacturing process to the next and resulted in the ability to form fully dense, complex advanced ceramic components whilst restricting the grain growth to a minimum.

The methodology has been employed to develop various advanced functional ceramic components such as 3D printed $BaTiO_3$ based light-weight PTCR heaters for automotive and high temperature filters for aerospace applications that surpasses existing commercial counterparts, ultra-low loss microwave dielectrics for beyond 5G communication devices, high temperature filter/battery structures, conformal antennas, additively manufactured (AM) zirconia based biomedical components exhibiting vastly superior hydrothermal ageing resistance and mechanical performance suitable for use in biomedical implants (eg., hip/knee prosthesis, finger joints, dental and jaw repairs), as well as armours for ballistic applications. Significant sustainability advantages were noted with AM+FAST combination compared to conventional manufacturing methods in terms of reduction in material wastage and process energy efficiency. 3D printing of hydrothermally immune nanostructured dental implants was regarded as one of the six best modern technological developments in materials science by a recent BBC documentary (Materials of the Modern Age: The Secret Story of Stuff). These novel advancements are covered by a series of patents and papers and this talk will provide an overview of some of these developments.

Circumventing Processing Challenges in Developing Graphene Coatings on Mild Steel for Remarkable and Durable Corrosion Resistance

Raman Singh
Department of Mechanical & Aerospace Engineering, AND Department of Chemical & Biological Engineering,
Monash University, Australia
raman.singh@monash.edu

Abstract

The talk will discuss the challenges in developing corrosion resistant graphene coating on most common engineering alloys, such as mild steel, and present recent results demonstrating circumvention of these challenges. In spite of traditional approaches of corrosion mitigation (e.g., use of corrosion resistance alloys such as stainless steels and coatings), loss of infrastructure due to corrosion continues to be a vexing problem. So, it is technologically as well as commercially attractive to explore disruptive approaches for durable corrosion resistance. Graphene has triggered unprecedented research excitement for its exceptional characteristics. The most relevant properties of graphene as corrosion resistance barrier are its remarkable chemical inertness, impermeability and toughness, i.e., the requirements of an ideal surface barrier coating for corrosion resistance. However, the extent of corrosion resistance has been found to vary considerably in different studies. The author's group has demonstrated an ultra-thin graphene coating to improve corrosion resistance of copper by two orders of magnitude in an aggressive chloride solution (i.e., similar to sea-water). In contrast, other reports suggest the graphene coating to actually enhance corrosion rate of copper, particularly during extended exposures. Authors group has investigated the reasons for such contrast in corrosion resistance due to graphene coating as reported by different researchers. On the basis of the findings, author's group has succeeded in demonstration of remarkable and durable corrosion resistance of mild steel as result of development of suitable graphene coating.

Keywords: Graphene; Corrosion; Corrosion resistant coating

Influence of the microstructure of TiAl6V4 on in vivo crevice corrosion on metallic implants

Maria Herbster, Thorsten Halle

Chair of Metallic Materials, University of Magdeburg, Germany

Abstract

The TiAl6V4 wrought alloy is used as a standard material for artificial joint replacement due to its advantageous biocompatibility, which enables direct bone connection, so-called osseointegration. However, explant studies on hip endoprostheses show that the alloy has insufficient resistance to wear and corrosion under extreme physiological conditions. During implantation, increased formation of wear particles, corrosion products and the increased release of metal ions into the body can occur, which are the cause of harmful tissue reactions and the aspetic loosening of joint prostheses. In order to avoid premature revision surgery, an improvement in the corrosion and wear properties of the TiAl6V4 alloy is sought.

The aim of the study was to identify and analyze suitable phase and microstructural states of a TiAl6V4 alloy with advantageous implant properties. By varying the temperature and cooling rate, three heat treatments were derived that produced different microstructural states that differed according to the morphology, arrangement and proportions of existing phases. The states were characterized with regard to their mechanical, tribological, corrosive and biocompatible properties.

The needle-shaped, martensitic microstructure achieves a significant increase in hardness and shows improved corrosion and wear resistance compared to the forged state. While the modified microstructures exhibit similar corrosion properties in polarization tests with different electrolytes, selective α or β phase dissolution occurs under ignitable cleavage conditions. The microstructurally induced corrosion processes are similar to the damage patterns of TiAl6V4 explant components and allow a better understanding of the in vivo corrosion mechanisms. In addition, a microstructural effect on cell attachment was found to correlate with the size of the vanadium-rich β phase. These results emphasize the importance of adapted processing of the TiAl6V4 alloy to increase the longevity of implants.

Indian Institute of Technology Hyderabad
30th PAMFP 11-13 December'24 Hyderabad, India
IA-PMFP

Modelling, Simulation and Validation of Abrasive Wear in Mining and Process Industry

Thomas Roessler, Andre Katterfeld

Chair of Material Handling, University of Magdeburg, Germany

Abstract

Wear is a general problem in the field bulk material handling e.g. in mining or process industry. Here, often abrasive materials are handled with a high mass flow rate. Abrasive wear on machine parts like chutes is one of the main maintenance issues not only for handling minerals but also in the “Agribulk” field. DEM simulations became in the past a standard tool for the optimization of processes in bulk material handling. For a qualitative wear prediction such DEM simulations are also used since more than a decade. However, the quantitative prediction of wear and hence, the prediction of wear liners lifetime and maintenance intervals are still a challenge.

The chair of material handling of the University of Magdeburg is working on this problem since more than 5 years. This paper will summaries the obtained results regarding the key problems of this topic:

- What kind of wear models should be used?
- Can a DEM simulation with a short observation time predict the long-time wear behavior?
- How should the wear factors in the DEM model be calibrated to reproduce realistic results?
- How well will the calibrated DEM simulations predict chute wear with different and combined types of flow?

The paper will focus on both mechanisms of abrasive wear: sliding and impact. Two calibration tests including a ring sliding wear tester and an impact wear tester were used. The experimental results for granite and aluminum alloy as the the wall liner material are presented. This combination allowed a relatively fast evaluation of the mass loss of the wear liner and limited the attrition of particles. The validation was carried out on a 15 m belt conveyor test rig which allowed the measurement of the wear in several transfer zones.

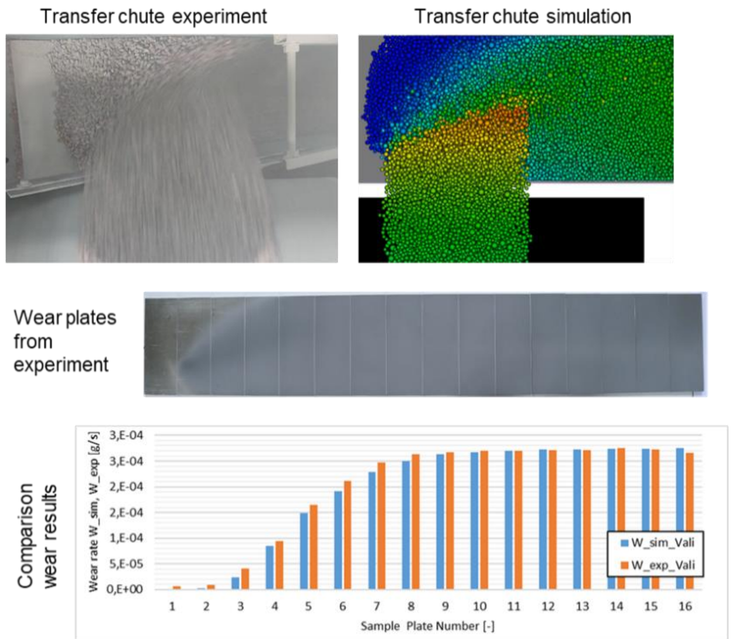


Fig. 1: Validation experiment and simulation, comparison of the wear measurements.

Additive Manufacturing of Elastomer, Ceramic and Metal Multi-functional Structures

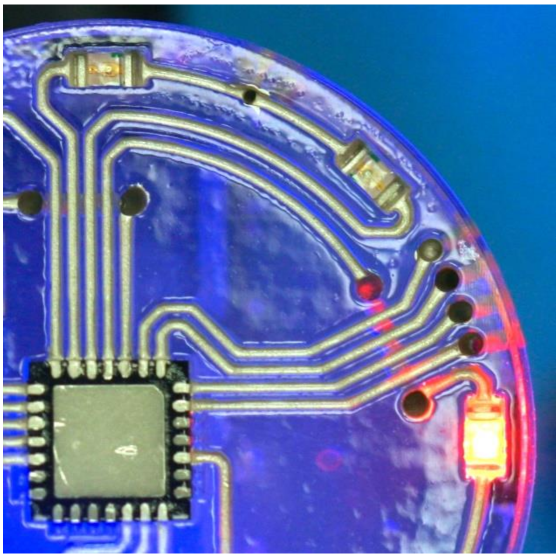
Eric MacDonald, Ph.D., P.E.,

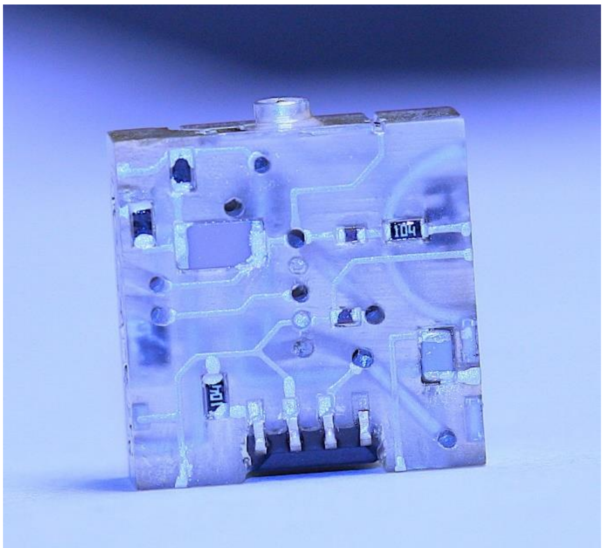
Murchison Chair and Professor, Aerospace and Mechanical Engineering
Associate Dean of Research and Graduate Studies, College of Engineering
Joint Faculty Appointment, Oak Ridge National Laboratory

Abstract

3D printing has been historically relegated to fabricating conceptual models and prototypes; however, increasingly, research is now focusing on fabricating functional end-use products. As patents for 3D printing expire, new low-cost desktop systems are being adopted more widely and this trend is leading to a diversity of new products, processes and available materials. However, currently the technology is generally confined to fabricating single material static structures. For additively manufactured products to be economically meaningful, additional functionalities are required to be incorporated in terms of electronic, electromechanical, electromagnetic, thermodynamic, chemical and optical content. By interrupting the 3D printing and employing complementary manufacturing processes, additional functional content can be included in mass-customized structures. This presentation will review work in multi-process 3D printing for creating structures with consumer-anatomy-specific wearable electronics, electromechanical actuation, electromagnetics, propulsion, embedded sensors in soft tooling and including metal and ceramic structures.

Other projects to be presented include stereovision process monitoring of powder bed fusion, 3D printed smart molds for sand casting, complex ceramic lattices for electromagnetic lenses, elastomeric lattices for the athletic gear, computation geometry and complexity theory for 3D printing.





Digital twins for accelerated materials innovation

Surya R. Kalidindi

Georgia Tech, USA

Abstract

This presentation will expound the challenges involved in the generation of digital twins (DT) as valuable tools for supporting innovation and providing informed decision support for the optimization of material properties and/or performance of advanced heterogeneous material systems. This presentation will describe the foundational AI/ML (artificial intelligence/machine learning) concepts and frameworks needed to formulate and continuously update the DT of a selected material system. The central challenge comes from the need to establish reliable models for predicting the effective (macroscale) functional response of the heterogeneous material system, which is expected to exhibit highly complex, stochastic, nonlinear behavior. This task demands a rigorous statistical treatment (i.e., uncertainty reduction, quantification and propagation through a network of human-interpretable models) and fusion of insights extracted from inherently incomplete (i.e., limited available information), uncertain, and disparate (due to diverse sources of data gathered at different times and fidelities, such as physical experiments, numerical simulations, and domain expertise) data used in calibrating the multiscale material model. This presentation will illustrate with examples how a suitably designed Bayesian framework combined with emergent AI/ML toolsets can uniquely address this challenge.

Influence of heat treatment on mechanical properties of additively manufactured Superalloy Hastelloy X

Shavi Agrawal, G.S. Avadhani, and Satyam Suwas

Department of Materials Engineering,
Indian Institute of Science, Bangalore 560012 India

Abstract

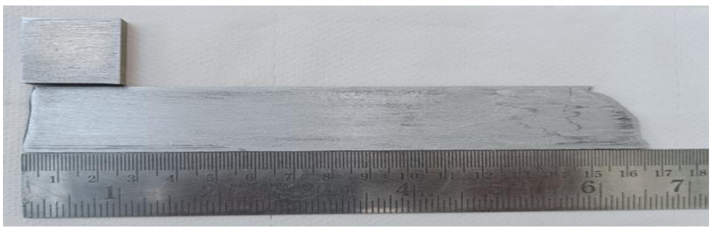
Additive manufacturing (AM) is one of the emerging technologies to manufacture near-net-shape engineering components layer-by-layer using a suitable heat source. The blend of AM with nickel-based superalloys enables the production of intricate and durable components for the aerospace industry. To ensure the industrial implementation of additively manufactured Hastelloy X, validating its viability through an extensive array of experimental investigations is imperative. This presentation reports the results of an investigation on the microstructural features of as accepted and mechanical properties of LPBF-processed Hastelloy X to establish a correlation between different microstructural states and their corresponding mechanical behaviours at both room and elevated temperatures. Our study concludes that the LPBF Hastelloy X is a suitable candidate for replacing its wrought counterpart as both room and elevated temperature properties are comparable to its wrought counterpart.

Scalable Severe Plastic Deformation Process to Produce Sheets with Controllable Properties

Nikhil T. G.[1], Govind Kumar[2], Sanika A. Paranjape[2], Prashant Huligol[1], Satyam Suwas[3],
Laszlo S. Toth[4,5], Satish V. Kailas[1]*
[1] Department of Mechanical Engineering, Indian Instiute of Science, Bengaluru 560 012, India
[2] Department of Design and Manufacturing, Indian Instiute of Science, Bengaluru 560 012, India
[3] Department of Materials Engineering, Indian Instiute of Science, Bengaluru 560 012, India
4LEM3, University of Lorraine, Metz, France
5Institute of Physical Metallurgy, Metalforming and Nanotechnology, University of Miskolc, Miskolc, Hungary
**E-mail Address satvk@iisc,ernet.in*

Abstract

Severe Plastic Deformation (SPD) process have been used to produce high strength material through grain refinement (mostly). However, this increase in strength leads to a lower ductility. SPD process where the strains imposed are large generally is a slow process and the sample size is small. In this process we introduce two processes which are capable of producing laege sheets of SPDed material where the equivalent strain induced is more than 40. The first process, called High Pressure Compressive Reciprocating Shear (HPCRS) involves inducing shear strain on a billet under plane strain condictions using a reciprocating die, while under a normal load. The machine used to shear the material can reciprocate at frequencies ranging from 0.01 Hz to 50 Hz. By changing the frequency the strain induced in the material does not change, but the temperature rise of the material due to plastic deformation changes. The results of two materials are presented; aluminum and magnesium. It is shown that by increasing the frequency and thus the temperature rise, the strength of the material can be controlled with a concomitant change in ductility. In magnesium it is seen that strength increases while the decrease in ductility is not large. Under certain frequencies both the strength and ductility increases. Using HPCRS it is possible to procuse sheets of dimensions that can be used directly for applications. The loads for a sample of 25 X 25 mm are low enough (normal load and shear loads are less than 200 kN) to enable this. The deformed material for both alumium and magnesium shows strong texturing.



Application of MicroSim and IRFs for Additive Manufacturing

Gandham Phanikumar1*, V.S. Hariharan, Dasari Mohan

Department of Metallurgical and Materials Engineering, IIT Madras, Chennai, India

**gphani@iitm.ac.in*

Abstract

Integrated computational materials engineering (ICME) approach to perform vertical integration of models for the process additive manufacturing (AM) involves a bottleneck in the microstructure simulation step. This is because microstructure simulation is a high performance computational task. To perform such simulations faster, a suite of multi-CPU and multi-GPU solvers has been made publicly available under the name "MicroSim". The different phase field models as well as different implementations have been benchmarked and validated. A python based solver to help in calculating interface response functions (IRF) has also been made open source on github recently. This solver has also been benchmarked and validated with data from open literature. In this talk, I will present the applications of these tools for AM on nickel based super alloys. Phase selection aspects will be covered as part of discussion.

Acknowledgments (if any)

The authors thank Department of Science and Technology for project funding under the scheme National Supercomputing Mission and Cleancoal Technology.

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4. *Dr. Vikas Saxena DRDO*

Challenges & Opportunities Towards Sustainable Indian Steel Sector

Dr. Viswanathan N Nurni

Sajjan Jindal Steel Chair Professor & Head
Department of Metallurgical Engineering and Materials Science
IIT Bombay

Abstract

India is the second largest producer of steel. On one hand our ambition is to produce 300 million tonnes by 2030. At the same time, we are also looking towards reaching the zero-emission target by 2070. This poses great challenges and opportunities as far as the Indian steel sector is concerned. As it is well known that almost 40% of the steel comes from the Rotary Kiln-steel Scrap-Induction Furnace Route and the rest comes through the integrated steel plants primarily through BOF-BF route. In this talk I would like to put my perspective on the challenges and opportunities for the Indian Steel Sector.

Decarburizing iron and steel industry for coal based developing economy

Gour Gopal Roy

Professor, Department of Metallurgical & Materials Engineering, Indian Institute of Technology Kharagpur.
ggroy@metal.iitkgp.ac.in

Abstract

With an average emission of 2.0 t CO_2/t crude steel, the blast furnace (BF)-basic oxygen furnace (BOF) steelmaking method currently accounts for 70% of global steel output. The blast furnace is a productive, efficient, and major asset in the integrated steel plant. Therefore, eliminating it is difficult, particularly for emerging economies that rely heavily on coal. An approach of progressive amalgamation with alternative and renewable energy-based processes can reduce the emission intensities. Coal-based smelting reduction technology like HISARNA with carbon capture and storage (CCS), a top gas recycling BF, or the use of biochar in BF could be the other way outs. Combining renewable energy-based 'green electrolytic hydrogen' processes with/without natural gas with existing coal-based processing is also an important option for reducing emissions. Capacity limitations of alternative processing routes and high green hydrogen costs are hurdles to overcome in progressive amalgamation. Attention should also be paid to the circular economy using more scrap in steelmaking. Iron-based solid waste utilization using rotary hearth furnaces could be another sustainable route using the secondary resource. A recent study of author's research group indicated that thermodynamic efficiency of RHF-EAF could be better than BF-BOF route by process modifications. Experimental study on laboratory scale RHF indicated carbon efficiency in composite mix by operating with carbon much below its stoichiometric limit. A parallel CFD study identified the RHF conditions for higher efficiency of RHF in terms of lower fuel consumption, and less reoxidation of DRI.

Keywords: CO_2 emission, Decarburization, Iron & Steel industry, RHF, Thermodynamic & CFD study.

Challenges & Opportunities Towards Sustainable Indian Steel Sector

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Computational design of Compositionally Complex Alloys (CCAs) for solid state hydrogen storage application

Snehashish Tripathy, Premkumar M, Vikas Chandra Srivastava, Gopi Kishor Mandal
CSIR – National Metallurgical Laboratory, Jamshedpur, India
snehashish@nml.res.in

Abstract

Abstract: In the recent global initiatives for averting adverse effects of greenhouse gas emissions on environment, hydrogen is envisaged as the most ideal energy carrier for both static as well as mobile applications. Serious efforts are being poured in all over the world for developing economically viable and environmentally suitable (with maximum possible renewable energy proportion as input energy) technologies for hydrogen production. Concurrently, in order to develop sustainable hydrogen economy, efficient bulk hydrogen storage systems are also being explored worldwide. Amongst various explored storage systems, solid state metal/alloy hydrides have shown tremendous promise, but are associated with their own limitations/challenges. Here, a brief review of the global efforts on solid state hydride based storage systems along with some recent efforts at CSIR-NML will be presented, wherein thermodynamic simulation based design of Laves phase type as well as BCC type alloys has been done, followed by experimental alloy preparation and hydrogen storage evaluation. Two of the core effects of compositionally complex alloys (CCAs) viz. high entropy effect and sluggish diffusion effect will be shown to aid the retention of desired high temperature phases till room temperature, which are suitable for hydrogen storage in the form of alloy hydrides while at the same time exhibiting good kinetics of absorption and desorption.

Processing of electronic waste at low temperatures

Dr. Deepoo Kumar

Department of Metallurgical Engineering and Materials Science, IIT Bombay

Abstract

Abstract: Every year, millions of tons of electronic waste (e-waste) are discarded, with most of it ending up in landfills. Printed circuit boards (PCBs) are among the most commonly used and valuable components in waste electrical and electronic equipment. Pyrometallurgical processes are commonly used as a first step to separate metallics from waste printed circuit boards (WPCB). Preliminary work presented here shows that low temperature separation of metallics from WPCB via melting is hindered by the high melting point of fiberglass. Current work includes physical and chemical separation of surface mounted devices from WPCB followed by pyrometallurgical treatment. Pyrolysis of WPCB was performed at 800°C under the argon atmosphere. We report separation of about 60% of metallics present just after pyrolysis. In order to smelt the remaining pyrolyzed mass, a CaO-SiO_2-FeO-B_2O_3 flux was designed such that complete melting of the pyrolyzed residue of WPCB is achieved at a temperature of 1200°C. FactSage software (FToxid and FactPS databases were used) was used to calculate melting behavior and viscosity of the flux and expected slag composition. The smelting operation allowed successful removal of the remaining 40% of metallics in WPCB. The concentrations of tin and silver in the metal obtained from pyrolysis and pyrolysis + smelting routes were found to be approximately 10% and 1750 ppm of Sn, and 980 ppm and 140 ppm of Ag, respectively. However, iron pickup from slag to metal was observed during the smelting experiment likely due to the reduction of FeO from slag by char residue in the pyrolyzed WPCB.

Next generation aluminosilicate-organic hybrid geopolymers: Microstructural and mechanical characterisation

Rashmi Singla [1,2] , T.C. Alex [1,2] , T. Mishra [1,2] and Sanjay Kumar [1,2]

[1] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad - 201002, India
[2] CSIR-National Metallurgical Laboratory, Jamshedpur, 831007, India
Corresponding email address: rashmi.singla@nml.res.in
Contact: +91 7781830640, +91 657 2345048

Abstract

In order to overcome the brittle mechanical behavior of conventional geopolymers, the development of hybrid geopolymers has commenced lately. The physical and mechanical properties of such hybrids are anticipated to be entirely dependent upon the extent of molecular level interactions and microstructural evolution during geopolymerisation. In this study, inorganic-organic hybrid geopolymers are synthesized by co-milling metakaolin (MK) and solid organics- epoxy resin: diglycidyl ether of bisphenol A (DGEBA) and hardener: dicyandiamide (DICY) in a planetary ball mill before geopolymerisation. The hybrid geopolymer with 20 mass% epoxy resin illustrates an enhanced compressive strength of ~50.6 MPa (superior than only MK-based geopolymer (~20.2 MPa)) and a higher flexural strength of 5.4 MPa. Detailed assessment of pore characteristics using MIP, BET, and TEM has revealed reduction in pore size and pore volume in hybrid geopolymer vis-à- vis only inorganics-based geopolymer. Comprehensive characterization to unveil the plausible mechanism responsible for enhanced mechanical and physical properties in hybrid geopolymers has been carried out. Thermogravimetric analysis (TG-DTG) reveals that hybrid geopolymers exhibit delayed and lesser organics degradation compared to their milled counterparts suggesting strong inorganic-organic interactions. Molecular structure assessment has been done for both the precursors (co-milled samples) and hybrid geopolymers using FTIR and 27 Al, 13 C, 29 Si solid-state NMR spectroscopy. The formation of stronger Si-O-C bonds in hybrid geopolymers observed during NMR analyses confirm the occurrence of inorganic-organic chemical reactions, ultimately leading towards enhanced properties. XRD and FTIR studies corroborate the MK-DGEBA-DICY reactions during geopolymerisation. Microstructural studies (SEM-EDS and TEM-EDS) confirm the uniform distribution of carbon (from organics) in the inorganic geopolymer matrix and no phase separation. Further, the developed hybrids have been assessed for fire-retardant properties for mass transit applications.

Keywords: Hybrid geopolymer; mechanical properties; milling; metakaolin; epoxy resin

Invited Talks

Advances of Friction Stir Welding: An Overview

Anbukkarasi1,[2*]and Satish V.Kailas[2]

[1] *Department of Mechanical, Materials and Aerospace Engineering,*

Indian Institute of Technology Dharwad, India

[2] *Department of Mechanical Engineering, Indian Institute of Science Bengaluru, India*

**anbukkarasi.r@iitdh.ac.in*

Abstract

Friction Stir Welding (FSW) is a solid state welding invented by the welding institute. FSW is working with the principle of plunging and moving a non-consumable rotating tool along the faying surface of the plates to be joined. The technique is well-establihed for aluminium joining and successfully used in many applications. However, the the challenging part of the joining of dissimilar welds is the formation of intermetallics due to the complex mixing. Some researchers suggested the offset weld to minimize the intermetallics formation by how the successful dissimilar weld is carried out using friction stir welding. On the otherside, the intermetallics growth and phase transformation at high temperature applications affects the properties of the joined at elevated temperature. Therefore, multi pass process was suggested by some of the researchers to break the intermetallics to enhance the properties. Further, the thicker plates were successfully joined by double-sde weld. Friction stir processing which is different from friction stir welding is initially used to break the casting structure. Later, it is extended to use for the repair work and depositing a coating. The method of layer deposition by friction stir processing is used for the coating deposition as well as biuld the components.

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2. *Anbukkarasi, R., and Satish V. Kailas, The International Journal of Advanced Manufacturing Technology 106*
3. *(2020) 5071-5083.*

LTCC based Multilayer Package fabrication using 3 d printed digital technology

Dr. Shany Joseph, CMET, Pune

Low Temperature co-fired ceramic (LTCC) is one of the most promising packaging technologies for electronic devices. With its multi-layering capability, it has the ability to accommodate denser circuits and integrate multiple chips and devices providing a system in package solutions for several applications in microwave , sensor packaging, microfluidic , optical devices. The conventional 2.5 D process using LTCC tapes and thick film pastes have been used for several decades. The additive manufacturing process is now being explored for rapid prototyping and low cost option for fabrication of LTCC packages. Most of the research reports mention use of hybrid technologies for printing of LTCC dielectric with conductor tracks. Digital light projection (DLP) based 3 d printing is used for fabrication of multilayered LTCC packages with buried and on surface conductors. The package also features channels and cavities along with Ag and Ag-Pd based conductor lines and pads. Interconnections across the layers are realised through Ag filled via. The multi-material multilayered LTCC package is fabricated using in-house developed LTCC and Ag/Ag-Pd composites with light sensitive resin using DLP based 3 d printing process. The material properties are tuned to develop an appropriate composite that can print fine lines and features that can provide customised packages for electronics manufacturing.

Computational design of Compositionally Complex Alloys (CCAs) for solid state hydrogen storage application

Snehashish Tripathy, Premkumar M, Vikas Chandra Srivastava, Gopi Kishor Mandal
CSIR – National Metallurgical Laboratory, Jamshedpur, India
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Abstract

Abstract: In the recent global initiatives for averting adverse effects of greenhouse gas emissions on environment, hydrogen is envisaged as the most ideal energy carrier for both static as well as mobile applications. Serious efforts are being poured in all over the world for developing economically viable and environmentally suitable (with maximum possible renewable energy proportion as input energy) technologies for hydrogen production. Concurrently, in order to develop sustainable hydrogen economy, efficient bulk hydrogen storage systems are also being explored worldwide. Amongst various explored storage systems, solid state metal/alloy hydrides have shown tremendous promise, but are associated with their own limitations/challenges. Here, a brief review of the global efforts on solid state hydride based storage systems along with some recent efforts at CSIR-NML will be presented, wherein thermodynamic simulation based design of Laves phase type as well as BCC type alloys has been done, followed by experimental alloy preparation and hydrogen storage evaluation. Two of the core effects of compositionally complex alloys (CCAs) viz. high entropy effect and sluggish diffusion effect will be shown to aid the retention of desired high temperature phases till room temperature, which are suitable for hydrogen storage in the form of alloy hydrides while at the same time exhibiting good kinetics of absorption and desorption.

Oral Presentations

Strategies for Scalable synthesis of layered semiconductors

Prof. Tanushree H. Choudhury

Indian Institute of Technology, Bombay

Abstract

Layered semiconductors like transition metal dichalcogenides (MX_2, M=Mo, W and X=S, Se) exhibit novel layer-dependent properties. These atomically thin materials have been successfully integrated in various optoelectronic and quantum applications on the lab-scale. A key hurdle in the industrial integration of these materials are scalable techniques for synthesizing large-scale layered semiconductors. This talk will discuss two contrasting techniques to achieve large-scale synthesis. Metalorganic chemical vapor deposition of MX_2 will be presented with emphasis on epitaxial growth using surface chemistry modulation. Low-cost solution synthesis of layered transition metal oxides will be discussed, with emphasis on solvent and substrate engineering

Role of Stone-Wales Defects on Nano Friction of Graphene/h-Boron Nitride Heterostructures

Srinivasa B. Ramisetti1*, Bharat Selvam S.2

[1] *CSIR - Structural Engineering Research Centre, Chennai, Tamil Nadu, Pin/Zip 600113*

[2] *CSIR - Structural Engineering Research Centre, Chennai, Tamil Nadu, Pin/Zip 600113*

**E-mail: ramisetti@serc.res.in*

Abstract

Heterogeneous two-dimensional (2D) layered nano-materials have gained interest in the recent past as lubricant additives and solid lubricants in order to increase the energy efficiency of tribological systems. Heterogeneous layered interfaces, composed of graphene and hexagonal-boron nitride (h-BN), have been shown to exhibit excellent superlubricity owing to their weak interlayer van der Waals (vdW) interactions, inherent lattice mismatch and the presence of moiré patterns. In this work, we use molecular dynamics simulations to study the dependence of the friction of graphene/h-BN on structural defects. We use a molecular dynamics model with a silicon tip sliding over graphene/h-BN heterostructure mimicking atomic force microscopy experiments. The effect of Stone-Wales (SW) defects on frictional characteristics of graphene/h-BN heterostructure is investigated. The variations of lateral force during the sliding process with SW defects on the topmost layer are measured and compared with defect-free cases.

Acknowledgments

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Optimization of Water Jet Pressure, Feed Rate and Abrasive Flow Rate in Abrasive Waterjet Machine to enhance Kerf Taper, Surface Roughness and Material Removal Rate of Aluminium 6061 using Response Surface Methodology and Grey Relational Analysis

K. Karthik[1], S. Tamil Selvan[2] S. Vishnudharsan[3], B. Vignesh[4], K. Karthick[5], S. Mahesh Kumar[6]

[123456] Department of Mechanical Engineering, Coimbatore Institute of Technology, Tamil Nadu, India, 641014 71762202108@cit.edu.in

Abstract

The purpose of this study is to optimize different input process variables in abrasive waterjet (AWJ) cut surfaces in order to maximize material removal rate, minimize surface roughness and reduce Kerf Taper. This method is good for cutting materials that are sensitive to temperature changes. Three input process parameters were varied in three levels. The selected process parameters are water jet pressure (90,100,110 Bar), Feed rate (80,90,100 mm/min) and abrasive flow rate (250 300 350 g/min) are used. Kerf taper, Material removal rate, and surface roughness are all assessed as outcome variables. In this research, three tiers of input parameters and a total of twenty-seven run orders are employed. Aluminium grade 6061 is employed because of the material's extensive technical and structural applications. After the trial work, the output parameters, top and bottom kerf size, are identified using a Video Measuring Machine (VMM). Material Removal Rate is determined using CAD software by computing kerf area and multiplying it by the feed rate. The Response Surface Methodology yields a Response Graph, a Regression equation for the Kerf Bottom Width, Kerf Top Width, Material Removal Rate and Surface roughness and the interaction between the input responses. Response Surface Methodology and Grey Relational Analysis are two examples of effective optimization strategies. Pressure (K) (110 Bar), Feed Rate (M) (100 mm/min), and Abrasive Flow Rate (V) (350 g/min) are the optimized input parameters obtained from the optimization processes. The material removal rate rises during the rise of abrasive particles flow rate and nozzle speed. The material removal rate is directly influenced by the rate of flow of abrasive particles and the traverse speed. Increased pressure and decreased feed rate have an inverse effect on surface roughness. Both optimization strategies may be used to compute the results.

Keywords: Abrasive Waterjet Machining, Kerf Taper, Grey Relational Analysis, Surface Roughness, MRR,

Response surface Methodology Experimental Investigation of PWHT on Gas Tungsten Arc welded Nickel-Based Superalloy Inconel 718

Ravi G1*, Jonah2 and Arulmani R3

[1] Sri Sai Ram Engineering College, (Mechanical & Automation Engineering, Chennai, India) 2 PSG College of Technology (Robotics & Automation Engineering, Coimbatore, India) 3Cameron, Schlumberger Company (Senior Welding Engineer, Coimbatore, India))
**ganesanravi.87@gmail.com*

Abstract

A Nickel-based superalloy Inconel 718 is widely used in the oil and gas industry applications as it has superior mechanical properties and excellent weldability, good corrosion resistance and high-Temperature strength. The strength is mainly due to the precipitates of gamma prime γ' Ni3 (Al, Ti) and gamma double prime γ" (Ni3Nb) obtained from the post-weld heat treatment (PWHT) of the alloy. Different welding processes like Gas Tungsten Arc Welding (GTAW) and Gas Metal Arc Welding (GMAW) have been employed to join the alloy. The strength and other mechanical properties of the welded inconel alloy dependes on many factors such as type and amount of precipitates, temperature, time, type of PWHT, etc,.

In the present research work, GTAW process was used to join Inconel 718 round disc plate of 13 mm thickness by depositing multi-layer of same composition filler wire. The effect of PWHT such as solution annealing and aging on microstructure and mechanical properties of GTAW of Nickel based superalloy Inconel 718 was investigated. The heat treatment was carried out by initially localized Solution Annealing at 1040 °C and then single step Aging was carried out to increase the strength of the alloy. The Solution Annealing plus Aging heat treatment was more significant to enhance the microhardness and mechanical properties of alloy 718. The % of Elongation was higher in PWHT compared to the base metal of As-received condition. Also, it was found that the impact toughness of the Aged As-Received condition was lower than that of the post weld heat treated and the tensile strength of welded coupon was low compared to base metal. Metallurgical characterization was performed using FESEM/EDAX and Optical Microscope (OM). From the result, it was found that the micro-hardness of the post weld heat treated alloy was less compared to that of the As-welded condition. The bend test was conducted to evaluate the ductility of welded coupon in post-weld heat treated condition.

Keywords: Aging Post-Weld Heat Treatment, Mechanical Property, Optical Microstructure, Vickers hardness and FESEM / EDAX.

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Understanding effect of processing parameters on microstructural and physical properties of MXenes

Rani Rohini*, Priyam Srivastava

Assistant Professor (Materials Engineering, IIT Jammu, Jammu, India)
Ph.D. scholar (Materials Engineering, IIT Jammu, Jammu, India)
**rani.rohini@iitjammu.ac.in*

Abstract

Two dimensional (2D) materials are becoming more popular after the discovery of graphene having promising electrical conductivity, thermal conductivity with large and tunable surface area. Many 2D materials have been developed after graphene and MXene have attracted much attention among all after its development in 2011. MXene is group of early transition metals (such as Sc, Ti, Zr, Hf etc.) combined with carbides and nitrides. More than 30 types of MXene are discovered at present, whereas the firstly Ti3C2Tx (where, Tx = surface termination i.e., -F, -OH, =O) MXene is mostly explored because of high metallic conductivity and hydrophilic nature. Ti3C2Tx have layered hexagonal structure and its surface terminations are tunable based on the synthesis methods. Due to its tunable properties, it has been used widely in super capacitors, flexible sensors, EMI shielding, water purification, and many other applications. There are multiple top down and bottom up methods, but wet etching (in top down method) has got much attention because of ease in processing. Minimally Intensive Layer Delamination (MILD) method in wet etching, has provided highest conductivity compared to other wet etching methods.

Herein, we have studied the effect of processing parameters on the structure and quality of MXene (Ti3C2Tx) by synthesizing it using MILD-method. It is concluded the effect of temperature has very crucial role to get good quality of MXene and also considering prevention of its oxidation. Also, sonication during the reaction has a significant improvement to get exfoliated structure and controllable size of the flakes. Different morphology were obtained at various processing parameters. The results are supported by different characterization techniques including XRD, SEM, HR-TEM, AFM and XPS. These highly exfoliated modified MXenes were then embedded in polymer matrix of PEEK and PI for thermal management applications.

Acknowledgments
We are thankful to Saptrishi facility in IIT Jammu for providing high-end instruments for characterization. We are also thankful to our lab staff and research group for their support during the experiments.

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Influence of Water-Jet Peening on Environment-Induced Degradation and Surface Characteristics of a Magnesium-Zinc Alloy

A. Arun [1], S. Santosh [1,*] and T.S. Srivatsan [2]

[1] Department of Mechanical Engineering, Sri Sivasubramaniya Nadar (SSN) College of Engineering, Old Mahabalipuram Road, Kalavakkam 603110, Tamil Nadu, INDIA
[2] Department of Mechanical Engineering, The University of Akron, Akron, Ohio 44325, USA
*** E-mail Address of Presenting Author: santoshs@ssn.edu.in*

Abstract

In this technical presentations the results of a recent research study aimed at examining the impact of water jet peening on resistance to environment-induced degradation or corrosion resistance and surface characteristics of a Magnesium-Zinc [Mg-Zn] alloy will be highlighted. The research study essentially examined the influence of water-jet peening variables, namely, standoff distance, traverse speed, and number of passes, on the chosen Mg-Zn alloy. To understand the effects and impact of the variables specific to water-jet peening, the surface topography, X-ray diffraction analysis and electrochemical tests were systematically conducted and the results analyzed. An investigation was conducted to analyze the magnitude of improvement in both the hardening effect and roughening effect that occurs as a result of the water-jet peening process. The peened surfaces exhibited a 35.38 percent increase in microhardness and a 22.56 percent decrease in surface roughness. The surface topography metrics, were Sa and Sq. Test results revealed the peened surface to be appropriate for cell development. Upon comparison with the un-peened Mg-Zn alloy, the fill-width at half maximum [FWHM] value determined from the X-ray diffraction peaks did reveal a observable reduction in grain refinement on the peened surface. The test results did demonstrate promising improvements in the resistance of the chosen Mg-Zn alloy to environment-induced degradation or corrosion. Specfic details will be highlighted abnd discussed.

Keywords: Mg-Zn alloy, Water-jet peening, environment-induced degradation, characteristics of surface.

Optimizing laser machining parameters for enhanced surface quality and structural integrity of magnesium alloy composite

A. Arun [1], P. Vignesh[2], S. Santosh 1,* and T.S. Srivatsan[3]

[1] Department of Mechanical Engineering, Sri Sivasubramaniya Nadar (SSN) College of Engineering, Old Mahabalipuram Road, Kalavakkam 603110, Tamil Nadu, INDIA
[2]Centre for sustainable materials and surface metamorphosis, Chennai Institute of Technology, Chennai-600069, Tamil Nadu, INDIA
[3] Department of Mechanical Engineering, The University of Akron, Akron, Ohio 44325, USA
*** E-mail Address of Presenting Author: santoshs@ssn.edu.in*

Abstract

The machining of magnesium alloy-based composites, i.e., AZ31/YSZ, using the technique of laser technology does offer a noticeable advancement in the development of lightweight, high-strength materials for the purpose of selection and use in a spectrum of industrial applications. In this technical presentation, the results of a recent research study aimed at investigating the laser machining process parameters for the magnesium alloy (AZ31) that is reinforced with yttria-stabilized zirconia (YSZ) particles with the primary focus on optimizing surface quality while concurrently minimizing thermal damage will be highlighted. The specifics of this novel research exercise did focus on a systematic evaluation of the effects of laser power, pulse frequency, and scanning speed on material removal rate (MRR), surface roughness (SR), and microstructural integrity of the engineered magnesium alloy composite. The test results revealed that a precise control of these parameters can significantly enhance both the machining efficiency and surface finish while concurrently reducing the formation and presence of defects, such as fine microscopic cracks and heat-affected zone. This novel research study does provide valuable insight into the laser machining characteristics of the engineered AZ31/YSZ composites, contributing to the progressive development of novel manufacturing techniques for performance-specific composite materials.

Keywords: Laser Machining, Magnesium Alloy (AZ31), Reinforcement, Yttria-Stabilized Zirconia (YSZ), Surface Quality, Thermal Damage, Material Removal Rate.

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An investigation of abrasive aqua jet machining characteristics of a hybrid composite reinforced with waste EDM wire and carbon fiber

A. Arun [1], S. Santosh [1], * C. Balasubramaniyan[2] and T.S. Srivatsan [3]

[1] Department of Mechanical Engineering, Sri Sivasubramaniya Nadar (SSN) College of Engineering, Old Mahabalipuram Road, Kalavakkam 603110, Tamil Nadu, INDIA
[2] Department of Mechanical Engineering, Sri Venkateswaraa College of Technology, Sriperumbudur 602105,Tamil Nadu, INDIA
[3] Department of Mechanical Engineering, The University of Akron, Akron, Ohio 44325, USA
*** E-mail Address of Presenting Author: santoshs@ssn.edu.in*

Abstract

In the prevailing era, there does exist a need for lightweight composite materials for selection and use in a spectrum of performance-critical and non-performance-critical applications. However, the intricacies specific to the manufacturing of lightweight materials is still in shortage, with carbon fiber, which is reinforced with used wire electro-discharge machined (EDM) electrodes [i.e., brass wire] being an attractive and potentially viable candidate. The desired engineered composites were obtained by reinforcing the polymer matrix carbon fiber composite with used WEDM wire of 0 weight percentage, 5 weight percentage, 10 weight percentage, and 15 weight percentage. The resultant engineered composite was then subjected to aqua jet machining with the prime purpose of establishing the machinability characteristics of the fabricated hybrid composite based on the three controlling variables of (i) aqua jet pressure (AQp), (ii) standoff distance (SOD), and (iii) Nozzle traverse speed (NTS). The overall machinability of the engineered composite was established for the two quality-affecting responses, namely (i) kerf taper angle (KTA), and (ii) Surface Roughness (Ra), This research study deals with an assessment of the optimum process parameters in the abrasive aqua jet cutting of CFRP + used wire EDM composite. The optimum parameters that provide the best machining quality were found using both the numerical technique and the graphical optimization technique. Results of this exhaustive research study did reveal that increasing the aqua jet pressure, and moderate traverse speed resulted in minimum surface roughness and kerf taper angle, and the mechanical characteristics to include tensile strength, flexural strength, and shore-D hardness were determined. Results of the mechanical characterization study revealed the 10-weight percent use of the wire laminate to have a noticeable improvement in the characteristics to include strength and hardness. Morphological study of the cut surface of the hybrid composite was analyzed using a scanning electron microscope (SEM), and characterization of the reinforced fiber was done using Fourier-transform infrared spectroscopy (FTIR).

Keywords: Carbon Fiber, Abrasive Aqua Jet, Used Wire, wire electric discharge machine (WEDM), Scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FTIR).

Mechanical Response of Hybrid Glass/Kevlar Epoxy Polymer Composite Reinforced with Multi-Walled Carbon Nanotubes: An Experimental Study

A. Arun 1, S. Santosh1,*, P. Kamaraj2 and T.S. Srivatsan3

[1] Department of Mechanical Engineering, Sri Sivasubramaniya Nadar (SSN) College of Engineering, Old Mahabalipuram Road, Kalavakkam 603110, Tamil Nadu, INDIA
[2] Department of Mechanical Engineering, Sri Venkateswaraa College of Technology, Sriperumbudur 602105,Tamil Nadu, INDIA
[3] Department of Mechanical Engineering, The University of Akron, Akron, Ohio 44325, USA
*** E-mail Address of Presenting Author: santoshs@ssn.edu.in*

Abstract

The prevailing situation necessitates the need for lightweight materials that can offer a combination of unaltered qualities. With resources quickly running out in terms of shorter service lives coupled with an inability to reduce, reuse, and recycle, the concept of sustainability is both gaining and becoming increasingly important. This technical presentation will present the results of a recent study aimed at understanding and improving the properties of composite materials through hybrid fiber stacking and the use of nanofillers. The desired composite materials were prepared using a simple hand layup process and subsequently cut using the technique of abrasive water jet machining (AWJM). Mechanical tests, to include tensile, flexural, impact, and hardness, were conducted using the standard machines. The test results revealed both the strength and toughness of the engineered composite material to increase with the inclusion of nanofillers. The observed increase in interlaminar bonding coupled with adhesion between the laminae was caused by the presence of nanofillers. Both load sharing and resistance to failure provided by the composite material were significantly influenced by the presence of distinctive features. All of the experiments did reveal that the 0.3 weight percent (GKC0.3) lower nanofiller concentration has the most significant improvement. Upon comparison with the unfilled ones (GKC0), the flexural strength improved by 11.30 percent, impact toughness improved by 10 percent, and hardness improved by 60 percent with an 18.19 percent improvement in tensile strength. The test findings clearly revealed that, for a given weight of the composite material, adding hybrid layers of glass and Kevlar with multi-walled carbon nanotube (MWCNT) as the reinforcement did improve the characteristics of the engineered composite material. As a result, numerous lightweight applications, including automobiles and unmanned aerial vehicles [UAVs], can benefit from the use of this type of hybrid layered composite material.

Keywords: Glass Fiber, Kevlar fiber, multi-walled carbon nanotube (MWCNT), Mechanical Properties.

Predictive modeling of additive manufactured Ti6Al4V lattice structures design using simulation-based machine learning models

Samala Thirupathi[1*], Pratik Kumar Shaw[1], Amit Rai Dixit[1]

[1]Department of Mechanical Engineering, IIT ISM Dhanbad, Dhanbad, India
**thirupathisamalaa@gmail.com*

Abstract

Light weights with better mechanical properties have shown much interest in additive manufacturing of Ti6Al4V alloy lattice structures in various applications such as aerospace, marine, and biomedical. The strength of the Ti6Al4V lattice structure is greatly influenced by the lattice geometries such as gyroid, diamond, etc. and its parameters such as strut length, and strut size. However, the design process and a complete experimentation with these infill geometries and its parameters is complex, inefficient, as well as time consuming. To tackle the challenge of better strength in a real time scenario, this study proposes a simulation based machine learning approach to optimize the design process of lattice structure for better strength. Initially, 2*2*2 cm3 lattice structures are designed with commonly used gyroid and diamond geometries by varying the strut length as 4mm and 5mm, and strut diameter from 0.7mm to 1.25mm with increment of 0.05mm in a design software. Later, the required data is collected by simulating these designed lattice structures under the compression testing using a computational model under a constant 5KN loading condition. Furthur, this data is utilized in training and testing by developing a machine learning model and predicting the maximum equivalent stress and strain generated in the component. The famous machine learning based linear regression, random forest regressor algorithms are used for predictions and found the relation between the parameters. With the help of a trained model we utilized to optimize the infill geometry and parameters for the component with better strength. During the training and testing, the algorithms have shown 98% accuracy and low predicted error observed with the help of evaluation metrics. Overall, our research showed that the machine learning methods have promise in creating different infill structures with different lattice parameters for better strength efficiently and effectively.

Keywords: Additive Manufacturing, Machine Learning

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Mechanical Response of 3D Printed Reinforced Nylon for Use in Performance-Specific Applications

Anilchandra R. Adamane [1], Jayaram R. Pothnis [2], Sathyapal Hegde [3] and T. S. Srivatsan [4*]

[1] Department of Mechanical Engineering, B.M.S. College of Engineering, Bangalore 560 019, INDIA
[2] Department of Aeronautical Engineering, Dayananda Sagar College of Engineering, Bangalore 560 078, INDIA
[3] Prasanna Technologies, Bangalore - 560 010, INDIA
[4] Department of Mechanical Engineering, The University of Akron, Akron, OHIO, 44325-3903, USA
** srivatsants@yahoo.com*

Abstract

Additive manufacturing (AM) or 3-dimensional (3D) printing is the talk of the day as it has penetrated all walks of life spanning the toy industry, the food industry and even critical components in the aerospace industry. Properties of a 3-D printed material depends on various factors, such as (i) properties of the raw material, (ii) printing parameters, and (iii) post-processing of the 3-D printed material. Onyx® is a nylon material that is reinforced with micro carbon fiber and developed by Markforged® . This material is popular among a few others, such as (i) Polylactic acid (PLA), and (ii) Acrylonitrile butadiene styrene (ABS). In this presentation the results of a recent research study aimed at investigating and understanding the fatigue behaviour of Onyx was determined using uniaxial fatigue tests. During the fatigue test, the infra-red (IR) thermography technique was used to analyze heat signature in the material prior to failure by fracture. This research study does highlight the usefulness of infra-red (IR) thermography as a non-contact measuring system for applications in the area of structural health monitoring and even for the life prediction of Onyx® that is chosen for use in structural applications.

Study on deposition characteristics of Ti6Al4V alloy fabricated through wire arc additive manufacturing using TIG and CMT mode

Kadiri Sai Sidhartha [1], Kaoushik V M[1*], S Natarjan[1] and Kavinaya P[1]

[1] Advanced Precision Manufacturing Technology Development Center,Larsen & Toubro,Coimbatore,India
**Kavinaya.P@larsentoubro.com*

Abstract

The present work aims to study the effect of arc source on the microstructure evolution and tensile properties of Ti6Al4V alloy fabricated using wire arc additive manufacturing(WAAM) through tungsten inert gas (TIG) and cold metal transfer-metal inert gas (CMT-MIG) welding source. The specimens are extracted from X and Z orientation for both the welding methods subsequent to solution annealing at 910° C followed by ageing at 540°C.The results revealed that the as-built microstructure is acicular α which got decomposed after heat treatment. After solution annealing and ageing, the microstructure appears to be lamellar α and β under both welding methods. The size of lamellar α is finer in CMT mode which results in higher tensile properties than TIG mode. The tensile properties are approximately 7.5% more in horizontally extracted specimens and approximately 10 % more in vertically built specimens in CMT mode of deposition.

The development and refinement of WAAM techniques for Ti6Al4V alloy is expected to motivate the exploration for manufacturing of critical parts for space applications with lower cost and with lesser lead time compared to conventional forging routes.

Keywords- wire arc additive manufacturing, Ti6Al4V, lamellar α and β.

Advanced Processing and Optimization of NiOx as a Hole Transport Layer in Perovskite Solar Cells

K Shashank Kumar1, Pradyumna J2

[1] Project Fellow-1, (Dept. of Centre for Sensor Vision Technology, CMTI, Bengaluru)
[2] Scientist-C, (Dept. of Centre for Sensor Vision Technology, CMTI, Bengaluru)
shashankkumar.pro@gmail.com

Abstract

Recent advancements in the field of perovskite photovoltaic devices, charge carrier material for the hole transport layer (HTL) in perovskite solar cells (PSCs) plays a crucial role in the extraction and transport of positive charge carriers (holes) from the perovskite absorber layer to the electrode. Nickel oxide (NiOx) is one of the promising inorganic material for hole transport layer (HTL) in perovskite solar cells (PSCs) due to its desirable optical properties, chemical properties, electronic properties, chemical stability, and compatibility with various perovskite materials. The intrinsic properties of NiOx plays crucial role in enhancing and performance of PSCs, NiOx exhibits high hole mobility and conductivity essential for efficient extraction and transport of holes generated within the perovskite layer. High optical transparency of NiOx in the visible spectrum allows efficient photon absorption and electricity generation. The optimal thickness of the NiOx layer is critical for maximizing the efficiency of PSCs. In this work of NiOx as an HTL, focuses on the processing techniques for NiOx thin films and thickness optimization to enhance the performance of PSCs. In this current work, pure nickel samples were deposited in physical vapour deposition method using electron beam evaporation deposition (EBED) on Glass/ITO substrates layers ranging from 30nm to 50nm.Futher, few deposited Ni samples were subjected heat treatment for Oxidation of pure Ni to NiOx.NiOx are dependent on its composition, the conductivity of NiOx is higher in Ni3+/Ni2+ ratio. Other few samples of Ni thin films having thickness of 30nm to 50nm deposited through electron beam evaporation deposition(EBED) were directly subject to sputtering NiOx creating a bi layers of Ni/NiOx. To study the characteristics of annealed NiOx and sputtered NiOx thin film samples variety of advanced characterization techniques were carried out, structural and morphological properties were analysed using X-ray diffraction (XRD) & scanning electron microscopy (SEM). Optical properties were assessed through ultraviolet-visible (UV-Vis) spectroscopy, photoluminescence (PL) spectroscopy and photoluminescence (PL) quenching. Electrical properties were characterised using techniques such as DC probing and Hall Measurements, followed by chemical properties characterisation using X-ray Photoelectron Spectroscopy (XPS) to asses NiOx chemical composition.

In conclusion, optimization of process parameters with achieving optimum thickness were crucial aspect of NiOx to improve the hole extraction capacity and regulate energy level of NiOx resulting acceleration of the charge separation and transport. Optimized NiOx layer efficiently promotes charge transport, separation and reduce the charge recombination resulting in the enhanced photovoltaic performance of the device. This work focuses on the understanding the underlying charge carrier dynamics for enhancing performance of perovskite solar cells.

Keywords: Perovskite solar cells (PSCs), Hole transport layer (HTL), Nickle Oxide (NiOx), Electron beam evaporation deposition (EBED), Thin Films

Influence of post-weld heat treatment of GTA welded Nickel-Based Superalloy Inconel 718

Ravi G[1*], Jonah[2] and Arulmani R[3]

[1]Assistant Professor(Dept. of Mechanical and Automation Engineering, Sri Sai Ram Engineering College, Chennai-600 044, Tamil Nadu, India)*
[2]Professor (Dept. of Robotics and Automation Engineering, PSG College of Technology, Coimbatore-641 004, Tamil Nadu, India)
[3]Senior Welding Engineer (Cameron Manufacturing India Pvt. Ltd, Coimbatore-641014, Tamil Nadu, India)
**E-mail: ganesanravi.87@gmail.com*

Abstract

Nickel based superalloy Inconel 718 is mainly strengthened by gamma prime γ′ Ni3 (Al, Ti) and gamma double prime γ′′ (Ni3Nb) precipitates resulting from the age-hardening treatment in the temperature ranges from 620°C to 850°C. In the present work Influence of Post Weld Heat Treatment (PWHT) of Gas Tungsten Arc Welding (GTAW) on Inconel 718 was investigated in 6mm thick plates with conventional welding and subjected to the aging process. The mechanical properties have been evaluated by means of bend and microhardness test in aging heat treatment to evaluate the ductility, the samples were heat treated at a temperature of 775°C with different timings are: 1.5hrs, 3hrs, 4.5hrs, 6hrs and the microstructural studies were observed using optical microscope, field emission and scanning electron microscope and elemental analysis and transmission electron microscopy (TEM). From the result, microstructure was change in various stages of heat treatments and morphology has been observed, γ′′ precipitates influence the strengthening of an alloy at a temperature of 775°C. The influence of aging temperature and aging time that bring about the morphology has been investigated, while the aging time increases, suggestively microhardness were increased, so aging time has more significant role on both microhardness and microstructure to improve the strength.

keywords: Inconel 718, Heat Treatment, microstructures, micro-vickers hardness, FESEM / EDAX and TEM.

Comparative Study of Heat Source Models To Analyse Their Effect On Precise Modelling Of Arc Welding Process

Saurav Suman[1], Vijay Mandal[1]

Department of Mechanical Engineering, NIT Mizoram, Aizawl, India[1]

Abstract

In this study, thermo-mechanical elastic plastic 3D finite element analysis has been performed for single pass submerged arc welding of 10mm thick corrosion and oxidation resistant AISI 304 steel plate for square butt joint with no edge preparation. Five different heat source models were employed to model the heat deposition from a moving heat source during welding. Element birth and death techniques were also employed to imitate the addition of a weld molten pool in the weld gap during the welding process. Temperature-dependent mechanical and physical properties were also considered for both the base plate and weld material. The analysis was performed using an FE software package of ANSYS APDL. The thermal effect of all the heat sources was compared by altering their design parameters and comparing them with the experimental results. It was found that the volumetric heat sources show better thermal gradients than the surface heat source models. Moreover, the volumetric heat source model was found more suitable for emulating the phenomenon of the addition of weld material in the weld gap during the actual welding process.

Keywords: FEM; Welding; Modelling; ANSYS; Thermo-mechanical; Elastic- Plastic; AISI 304 steel

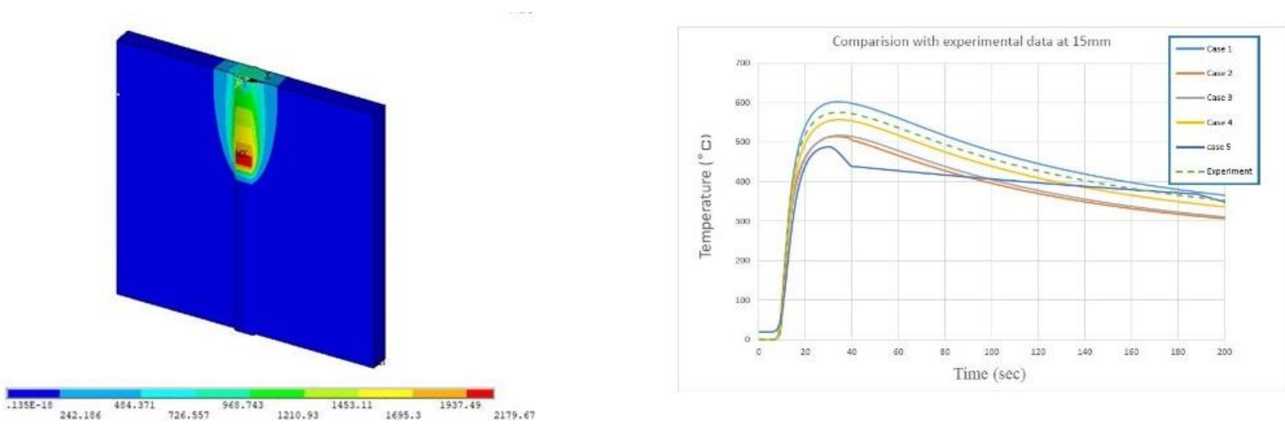

Fig.1 (a) Welding thermal contour using 3D volumetric heat source model, (b) Comparison of thermal profile for different heat source models with experiment result

Selective and transient stealth coating of the liver sinusoidal walls for targeted organ delivery of nanomedicines

Anjaneyulu Dirisala*[1], Satoshi Uchida[1,2], and Kazunori Kataoka[1]

[1] Innovation Center of NanoMedicine, Kawasaki Institute of Industrial Promotion (Kawasaki, Japan)
[2]Tokyo Medical and Dental University (Department of Advanced Nanomedical Engineering, Medical Research Institute, Tokyo, Japan)
**dirisala-a@kawasaki-net.ne.jp*

Abstract

Selective organ targeting of nanomedicines holds great promise for enhancing disease diagnosis and treatment. However, the reticuloendothelial system (RES) organs, especially the liver sinusoidal endothelium, often capture most of the injected nanomedicine dose upon systemic administration. This nonspecific clearance notably reduces the delivery efficiency of nanomedicines to target diseased tissues and can raise toxicity concerns. We addressed this issue by applying an in situ stealth coating to the liver sinusoidal endothelium using poly(ethylene glycol) (PEG)–conjugated oligo(L-peptide) (OligoPeptide), in either a one-armed or two-armed configuration. Both one-armed and two-armed PEG-OligoPeptide specifically adhered to the liver sinusoids, creating a PEG coating while leaving endothelia of other tissues uncoated and, thus, accessible to the nanomedicines. The two-armed PEG-OligoPeptide was gradually removed from the sinusoidal walls and cleared into the bile, whereas the one-armed PEG-OligoPeptide remained longer in the sinusoidal walls, potentially causing prolonged disruption of liver function. The transient and selective stealth coating achieved with two-armed PEG-OligoPeptide effectively prevented the sinusoidal clearance of both nonviral and viral gene vectors—representative of synthetic and nature-derived nanomedicines, respectively—thereby improving their gene transfection efficiency in target tissues (Figure 1).

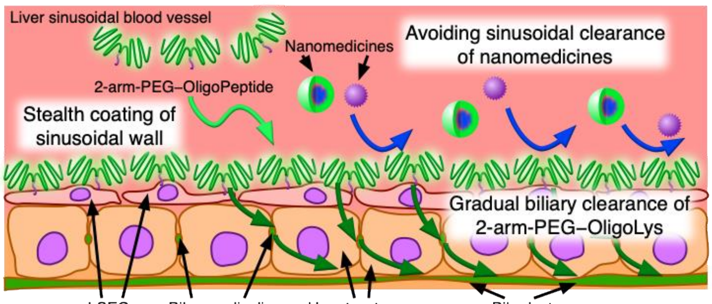

Figure 1. In situ stealth coating of the liver sinusoidal wall using PEG-OligoPeptide. Two-arm-PEG-OligoPeptide selectively binds to the sinusoidal wall to prevent the capture of nanomedicines, such as lipid nanoparticles and adeno-associated viruses, via the stealth property of PEG. Two-arm-PEG- OligoPeptide is gradually removed from the sinusoidal walls to bile, thereby avoiding prolonged disturbance of normal liver physiological functions.

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Mechanical and Microstructure Analysis of AlSi10Mg Alloy Fabricated by Selective Laser Melting Process

Sunita K. Srivastava[1] *, N. Rajesh Mathivanan[1], Sunith Babu L.[2]

[1] Department of Mechanical Engineering, PES University, Bangalore, INDIA
[2] Department of Mechanical Engineering, RIT, Bangalore, INDIA
**Corresponding author email: sunita.shri45@gmail.com*

Abstract

AlSi10Mg alloy is one of the most extensively used aluminum alloys in additive manufacturing because of its exceptional thermal and dimensional stability. However, the fabrication parameters affect the mechanical properties. Understanding the mechanical properties is of prime importance to characterize the material. The research is focused on examining the microstructure and mechanical properties of the AlSi10Mg alloy manufactured using selective laser melting (SLM) in as-built conditions. The sample is fabricated using specific SLM parameters such as 275 W laser power, 2000 mm/s scan speed, 80 µm hatch spacing, and 30 µm layer thickness. To evaluate the material properties, the tensile, hardness, porosity and density measurement tests were performed on the sample. Additionally, SEM (Scanning Electron Microscopy) and EDAX (Energy-Dispersive X-ray Spectroscopy) were employed on the as-fabricated and fractured samples for detailed characterization. The results demonstrate that AlSi10Mg alloy exhibits a tensile strength of 436 MPa, yield strength of 58 MPa, elongation of 9.6%, and hardness of HRB 74 as the sample achieved a relative density of 97.43%.

Keywords: Powder Bed Fusion, Additive Manufacturing, AlSi10Mg, Selective Laser Melting, SEM

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Improved Bandgap Prediction of 2D Materials using Ensemble of Hyperparameter Optimized Boosting Algorithms

Bhuma Chandra Mohan [1], Ch.V.M.S.N.Pavan Kumar[2], and K. Ramanjaneyulu[3]

[1] Department of ECE, Bapatla Engineering College, Bapatla, India
[2] Department of ECE, Bapatla Engineering College, Bapatla, India*
[3]Department of ECE, P.V.P Siddhartha Institute of Technology, Vijayawada, India
*pavankumar.ch@becbapatla.ac.in

Abstract

An improved machine learning algorithm for predicting the bandgap of 2D materials is proposed in this work. After successful characterization of graphene, 2D materials with their excellent physical, and chemical properties associated with unique nano sheet structure are gaining importance in recent times. Electrical and optical properties of semiconductors are characterized by its bandgap. Hence, accurate prediction of the bandgap is essential in understanding the material properties. Computational 2D materials database (C2DB) is used to test the proposed algorithm. C2DB contains two sets of data containing 8 and 9(bandgap without spin orbit coupling is added)dimensional features for 3130 materials.The features considered are density of states at the Fermi energy, Heat formation, Number of Atoms, Sum of atomic masses in unit cell, Total Energy, Maximum Force, Maximum stress on unit cell, Volume of unit cell, Gap without Spin Orbit Coupling (SOC). Minimum bandgap is 0 eV and the maximum bandgap is 6.450904 eV. Three boosting algorithms i.e., Light Gradient Boosting-Machine (LGBM), Extreme Gradient Boosting-Machine (XGBM), and Categorical Boosting (CATBoost) with optimized hyper parameters (using Bayesian Optimization) are used in the regression mode to estimate the bandgap. An ensemble of all the three tree-based algorithms (LGBM, XGBM, CATBoost) is considered wherein, average of the predictions from the optimized three models are considered as final predictions. After adding the bandgap without spin orbit coupling as an additional feature, the Mean Absolute Error (MAE) and Root Mean Square Error(RMSE) in the bandgap prediction are significantly decreased. With a 90% train and 10% test split on the dataset, the coefficient of determination (R^2) value is 0.9864and 0.9989for 8 dimensional and 9 dimensional features respectively. Compared to a recent work on the same dataset, all the regression metrics i.e., R^2, MAE, and RMSE are superior.

Keywords: 2D Materials, Bandgap Prediction, Ensemble of Boosting Algorithms

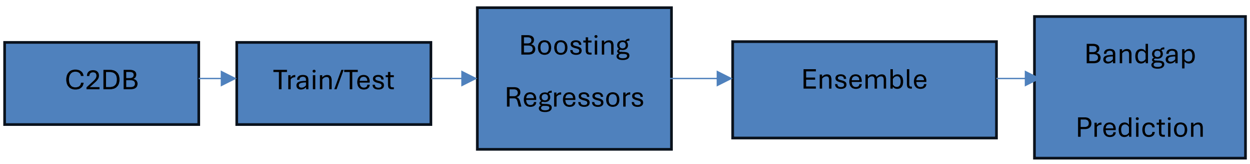

Figure 1. Block diagram of the proposed algorithm

Table 1: Comparison of the proposed work with an existing work

Reference	Feature Space	Model	MAE(eV)	RMSE(eV)	R^2
Zhang et al., (2021)	8 dimensional	GBDT*	0.12	0.24	0.92
	9 dimensional	GBDT*	0.03	0.09	0.98
Proposed	8 dimensional	Ensemble**	0.05	0.11	0.986
	9 dimensional	Ensemble**	0.02	0.04	0.997

*Gradient Boosting Decision Tree, **Ensemble of XGBM, LGBM and CATBoost

Acknowledgments

We thank the Principal, Management of Bapatla Engineering College for encouraging and sponsoring us to participate in this Confence.

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Fusion 360 Based Design of a Composite Leaf Spring

[1]Duriseti Venkata Srikanth, [2]Allam Purushottam

[1, 2]Department of Mechanical Engineering, Sreenidhi Institute of Science and Technology
Ghatkesar, Hyderabad, India

Abstract

The aim of this research is to design and modify the steel leaf spring design by replacing it with composite materials for an extended application in automobiles. The economic advantage and enhanced mechanical properties of materials like carbon epoxy, Aluminum Alloy, Titanium Alloy make them choosy when compared with the conventional steel leaf. The objective is to compare the stresses, deformations and weight saving characteristics of composite leaf springs with those of steel leaf springs. The design constraint was stiffness. The Automobile Industry has great interest for composite leaf springs, as the materials have high strength to weight ratio and good corrosion resistance. The leaf spring was modeled and analysed on Autodesk Fusion 360 Software

Ambient Temperature Humidity Sensing Properties of Polypyrrole – Neodymium Oxide Composite

S. Manjunatha[1*], L.B. Gunjal[2], N. M. Nagabhushana[2], A. Sunilkumar[3], Y. T. Ravikiran[4] P. N. Ravi Shankar[5]

[1]*Department of Physics, Kishkinda University, Ballari, 583104, India*
[2]*Department of Physics, VTU-RC, RYM Engineering College, Ballari, 583104, India*
[3]*Department of Physics, Ballari Institute of Technology and Management, Ballari, 583104, India,*
[4]*Department of Physics, Government Science College, Holalkere, 577526, India*
[5]*Department of Chemistry, B.M.S. College of Engineering, Bengaluru, 560 019, India*
**E-mail: manjusballari@gmail.com*

Abstract

In-situ chemical polymerization was used to make polypyrrole-neodymium oxide (PPy/Nd_2O_3) composites with different weight % of Nd_2O_3 (10, 30, and 50). Crystalline characteristics of the composites was revealed by XRD spectra. The homogeneous distribution of Nd_2O_3 in the matrix of PPy with reduced grain size was deduced from SEM images of the PPy/ Nd_2O_3 – 50% composite. TEM studies also validated the crystalline nature of the composite by embedding Nd_2O_3 in the PPy matrix. FTIR spectra revealed the interfacial interaction of PPy and Nd_2O_3 and the formation of the composite. The humidity sensing capabilities of the composites were investigated in the range of 10–97% relative humidity. PPy/Nd_2O_3-50% composite exhibited good linearity (0.976), sensitivity, and limit of detection, as well as quick response and recovery times of 40 and 40 seconds, respectively.

Transport, EMISE and Humidity Sensing studies of Polyaniline-Cobalt Ferrite Nanocomposites

Raghavendra Naik[1], Revanasiddappa M[1*], Manjunatha S[2], Ravikiran Y T[3]

[1]Department of Chemistry, PES University, Electronic City Campus, Bangalore 560100, India
[2]Department of Physics, Kishkinda University, Ballari, 583104, India
[3]Department of Physics, Government Science College, Holalkere, 577526, India
**E-mail: revanasiddappam@pes.edu*

Abstract

Polyaniline-CoFe2O4 nanocomposite thin films and pellets were prepared by incorporating varying amounts of CoFe2O4 in the matrix of polyaniline (PANI) through an in-situ polymerization technique. Morphology of the composites were examined using SEM, XRD studies exhibited crystalline nature of the composites and FTIR analysis revealed cobalt ferrite was homogeneously mixed in the matrix of PANI. AC Conductivity, dielectric and electric modulus studies exhibited the regular behaviour of PANI composites were studied in the range 10 Hz – 7 MHz. Thin films of PANI- CoFe2O4 nanocomposites when exposed to a broad frequency range of 2 GHz to 3 GHz showed electromagnetic interference in the range of -4 dB to -9 dB, indicating effective attenuation of electromagnetic energy and serving as evidence for EMI shielding. Conductivity measurements were investigated and showed that PANI exhibits a more effective conducting mechanism in CoFe2O4-PANI composites. The humidity sensitivity experiment revealed a variation in resistance in response to relative humidity when the pellets were exposed to a broad humidity range from 11% to 97% RH.

Process-Microstructure Linkages using Physics Informed Neural Operator (PINO)- a Machine Learning Approach

Gaijinliu Gangmei[1],[3], Kishalay Mitra[2*], Bernard Rolfe[3], Santu Rana[4], and Saswata Bhattacharyya[5]

[1]*Center of Interdisciplinary Program, Indian Institute of Technology Hyderabad, Kandi, India*
[2]*Department of Chemical Engineering, Indian Institute of Technology Hyderabad, Kandi, India*
[3]*School of Engineering, Deakin University, Geelong, Australia*
[4]*Applied Artificial Intelligence Institute, Deakin University, Geelong, Australia*
[2]*Department of Materials Science and Metallurgical Engineering,*
Indian Institute of Technology Hyderabad, Kandi, India
**kishalay@che.iith.ac.in*

Abstract

Phase-field equations, which are solved numerically, can be used to describe the process-microstructure relations of a material. However, numerical solvers are computationally expensive since it needs to discretize the space and time into very fine grids and solve a great number of equations on the grids to achieve good accuracy. As a result, researchers are recently developing physics informed machine learning methods that can learn partial differential equations such as physics-informed neural networks(PINNs) and physics-informed neural operator(PINOs) which are mesh independent. In this study, we trained PINO for surrogate modeling of process-microstructure linkage by learning the solution operator of a family of PDEs, as PINNs require training a separate neural network for each instance of the PDEs.

In particular, we have demonstrated the capability of PINO to learn the dynamics of precipitate in 1D which is a coupled physics problem. The coupling is of second order and fourth order dynamic PDEs namely Allen-Cahn equation and Cahn-Hilliard equation. Furthermore, PINO was able to accurately predict the evolution of the precipitates with different composition and seed value which were not seen during training.

Manufacturing of hollow parts with light weight for automotive industry: A case Study

Yogesh Dandekar[1*], Sanjay Aloni[2], and Udayan Pathak[3]

[1] Assistant Professor (Cummins College of Engineering for Women, Nagpur)
[2]Assistant Professor (Cummins College of Engineering for Women, Nagpur)
3Executive Director (Udayan Patahk & Associates, {Pune)
**yogesh.dandekar@cumminscollege.edu.in*

Abstract

Automotive industry is restlessly working on reducing the vehicle weight. Several automotive parts are subjected to torsional load. Challenge is to redesign these parts to hollow. Already many of such parts like in transmission system components are hollow in the cross section. There are manufacturing constraints to make these parts from bar stocks or through forging route. Many components yield as low as to 30%. The raw material for these parts is low carbon alloy steels like DIN 20Mn5Cr5, SAE 8620, JIS SCM415 typically. Succeeding to machining, all of these parts undergo Case Carburizing-Hardening-Tempering heat treatments. These heat treatment processes, relieve the stresses accumulated during machining but result in unpredictable distortions in the components. This is apart from the wastage formed in swarf generation. The possible manufacturing option is forging and machining prior to the case carburizing. This method shows great improvement in mechanical properties and avoids accumulation of machining stresses, but is a costly affair. Also leading to lower raw material yield.

The case study in this paper typically involves retaining of the mechanical properties of forging and at the same time get better yield with avoiding accumulation of machining stresses. The process involves seamless tubing improving the mechanical properties and eliminating possible unpredictable distortion during heat treatment process. Two innovative options were implemented- first, the redesigning of the parts and second, the innovative manufacturing route, using seamless tubes.

Keywords: Hollow parts, Transmission parts, Seamless tubing, Case Carburising, Shifter sleeves, splined hollow shafts, splined couplings, welded hollow shafts, spacers.

Modelling and Analysis of Essential Parameters in Green Sand Process to Minimize Shrinkage Porosity in Grey Iron Components

Sanjay Aloni [1*], Yogesh Dandekar[2], and Udayan Pathak[3]

[1] Assistant Professor (Cummins College of Engineering for Women, Nagpur)
[2] Assistant Professor (Cummins College of Engineering for Women, Nagpur)
[3]Executive Director (Udayan Pathak & Associates, {Pune)
**sanjay.aloni@cumminscollege.edu.in*

Abstract

The rejection of casting components because of most challenging defects such as shrinkage porosity which are persisting in complex gray iron components used in automotive is the major issue across the green sand foundries in India. The shrinkage porosity defect which is persisting in cylinder head castings produced in gray iron using green sand casting process is difficult to avoid. In pursuing for the identification of most influential parameters which are responsible for occurrences of such defect, total 19 potential parameters associated with principal operations are selected and experiments are performed as per the plan given by the suitable Taguchi array, L36 OA. Based on the results obtained, the linear and exponential mathematical model is formulated for identification of influential parameters. The study also concluded with reliability and sensitivity analysis which ensures the suitability of the models to predict and avoid the rejections because of variation in respective parameters.

Keywords: Green sand process, persisting casting defects, process parameters, Taguchi orthogonal array, Linear and Exponential Model

Case Study on Repair Welding of Nickel Aluminium Bronze Alloy Casting (BS1400 AB2) using Tungsten Inert Gas Welding Process

Bhavesh R. Rana[1*], Avinash C. Pandey[2] & Hemal M. Desai[3]

[1] Sr. Engineer, Larsen & Toubro PES IC (Welding Engg. & Metallurgy, Surat)
[2] Manager, Larsen & Toubro PES IC (Welding Engg. & Metallurgy, Surat)
[1] Sr. DGM, Larsen & Toubro PES IC (Welding Engg. & Metallurgy, Surat)
** bhavesh.rana@larsentoubro.com*

Abstract

Nickel Aluminium bronze (BS1400 AB2) is a copper-based alloy with excellent combination of mechanical strength, pitting corrosion resistance, superior wear resistance along with ease of machinability & weldability. These properties make it outstanding choice for marine, chemical processing, and other industries involving sea water applications. The investigation is focused on centrifugally casted bearing bush of BS 1400 AB2 alloy, where the volumetric defect and lamination were observed on considerable circumferential area, after machining. The defects subtraction was performed using mechanical grinding. The standard BS1400:1985, does not allow repair of casted material. On the other hand, ASME BPVC. II. B-2023 standard for alternate material ASTM B148 C95800, allows and restricts the repair of defected area to 20 % of the casting section or wall thickness or 4 % of the casting surface area. The mapping of defects indicates; the volumetric defects were present across the cross section of casting thickness. With customer confirmation, the repair of casting across the thickness is allowed. However, the welding procedure need to be established for ensuring that the mechanical and metallurgical properties at transition area i.e. from casted to welded portion shall have similar properties to as casting. The welding of cast BS 1400 AB2 alloy is challenging, when using Gas Metal Arc Welding processes and flux-based arc welding process. The Tungsten Inert Gas welding being a clean and friendly process to perform welding, hence the process was used. This research tries to elaborate issues emerges, while using TIG welding process and focused on developing repair welding procedure to retain the properties of casted bearing bush. The objective of this case study was to successful establish repair welding procedure of Nickel Aluminium bronze alloy casting, focusing on the development of welding parameters (including current, voltage, and travel speed), techniques and the resultant weld quality, to meet designed properties as casted structure. Microstructural analysis and mechanical testing assessments vis-a-vis casted product were conducted to establish smooth transition between cast to weld portion. This research contributes to a better understanding of BS 1400 AB2 welding processes, benefiting industries that rely on this material for critical applications.

Keywords: Repair welding, Nickel Aluminium Bronze (BS 1400 AB2), Tungsten Inert Gas Welding (TIG), Metallurgical Analysis, Mechanical Analysis, crack formation

Development of IoT Based Real Time Weld Defect Monitoring System for GMAW

Harshitsinh Padhiyar[1*], Avinash Pandey[2] & Hemal Desai[3]

[1] Sr. Engineer, Larsen & Toubro PES-IC (Welding Engineering & Metallurgy, Surat -Gujarat, India)*
[2] Manager, Larsen & Toubro PES-IC (Welding Engineering & Metallurgy, Surat -Gujarat, India)
[3] Sr. DGM, Larsen & Toubro PES-IC (Welding Engineering & Metallurgy, Surat -Gujarat, India)
**harshitsinh.padhiyar@larsentoubro.com*

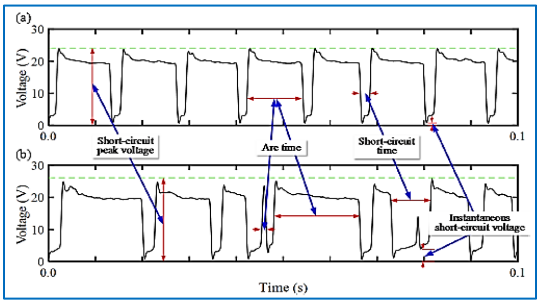
Abstract

Welding is a critical process in various industries, and the quality of the weld is essential to ensure reliability of the final product. The weld quality monitoring, as it stands today, is mainly done by various NDE techniques. These techniques are applied after completion of welding. In case, any weld defects are missed out in Non-destructive test, can lead to catastrophic failures, resulting in significant economic losses and safety hazards. Therefore, to enhance the quality of weld and improve productivity, detection of defects at each weld pass, without involvement of any NDE method will helps to ensure the quality of welded structures.

The real time weld defects monitoring system is based on the concept that different weld defects create unique electrical current and voltage patterns that can be identified through pattern recognition techniques using advancement in data analysis and prediction methodology based on AI/ML. The system uses machine learning algorithms to process the electrical signal patterns and categorize the welds defects. It proposes a unique approach to detect and monitor weld defects such as porosity and lack of fusion in real-time by processing the electrical signal patterns, generated during welding using Gas Metal Arc Welding (GMAW) process.

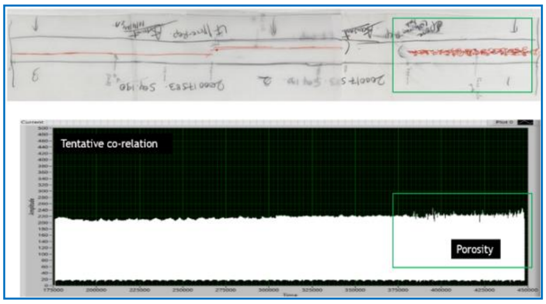
The system comprises of a sensor, data acquisition hardware and software for data processing and analysis. The sensor is used to generate data of the electrical signal i.e. current and voltage during welding, the data acquisition hardware acquires the data from sensors and software based on algorithm of AI/ML is used to processes & analysis the data, to identify and classify any defects in the weld. The pilot system allows prompt detection and identification of defects in each weld pass.

Fig1: A typical example of change in welding parameter



(a) No Porosity signal and (b) Porosity Signal

Fig 2: Co-relation of welding signature with weld defect



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Dielectric energy storage properties of $BaTiO_3$ ceramics prepared by reactive cold sintering using a novel transient flux

Montek Mohapatra, Arvind Pandey and Partha Sarathi Mondal*

National Institute of Advanced Manufacturing Technology, Ranchi 834003, India

**Email: psmondalmbox@gmail.com*

Abstract

Cold sintering process (CSP) is an innovative technique that has gained a considerable attention for its ability to densify ceramics and its composites in an energy-efficient way [1]. In this study, a well-known ferroelectric, $BaTiO_3$ (BT) ceramics were consolidated via CSP with $Ba(OH)_2.8H_2O$ as a transient solid-state flux. The CSP was carried out at constant optimized temperature (T= 200°C) and optimized pressure (P=350 MPa), whereas the dwell time was systematically varied from 30 minutes to 24 hours. The BT ceramics produced by CSP achieved a maximum relative density of 90%. and a relative permittivity of 2500 at room temperature, both of which are comparable to the BT samples prepared by the conventional solid-state sintering method [2]. Additionally, P-E hysteresis loops were measured by applying various electric field at 10 Hz, and the energy storage efficiency was calculated, reaching a maximum efficiency of nearly 53% at 15 kV/cm applied electric field. A presence of $BaCO_3$ was detected in the as-prepared CSP samples as an impurity which is known to be thermally unstable. To remove the undesired phase, the samples were heat treated at high temperature (1000°C for 2 hrs) and compared dielectric and energy storage properties of samples before and after the heat treatment. The experimental results indicates that CSP can be used as an alternative energy-efficient route to consolidate BT ceramics and can be used for energy storage application.

Keywords: Ultralow-temperature sintering, Cold sintering process, Ferroelectricity, Dielectric energy storage, Fatigue

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Sustainable Synthesis of Cu-doped ZnO Nanoparticles Using *Bixa orellana* L. Leaf Extract for Antimicrobial and Cytotoxic Investigations.

Thejeswini P G[1*],Monica K J Nidhi[1], Nagaraja H[1] and Uma Reddy B[1]

[1]Department of Studies in Botany, Vijayanagara Sri Krishnadevaraya University, Ballari 583105, India

**E-mail:tigertejat567@gmail.com*

Abstract

This study reports the sustainable synthesis of copper (Cu)-doped zinc oxide (ZnO) nanoparticles using *Bixa orellana* L. leaf extract as a reducing and stabilizing agent. The green synthesis approach offers an eco-friendly alternative to conventional chemical methods, minimizing the use of harmful substances. The synthesized Cu-doped ZnO nanoparticles were characterized by UV–Vis spectroscopy, FTIR, XRD, and SEM, confirming the formation of crystalline, spherical nanoparticles with Cu incorporation. The antimicrobial efficacy of the nanoparticles was tested against a range of Gram-positive (*Bacillus subtilis, Enterococcus faecalis, Staphylococcus aureus*) and Gram-negative bacteria (*Pseudomonas aeruginosa, and Escherichia coli*), as well as fungal strain (*Aspergillus niger*), revealing significant inhibition of microbial growth. Additionally, the cytotoxic properties of the Cu-doped ZnO nanoparticles were assessed on human cancer cell lines using the MTT assay, demonstrating potent cytotoxicity with dose-dependent effects. Furthermore, the results of the hemolytic, coagulation assays and DPPH assays indicate the potent haemocompatibility, and antioxidant nature of these NPs. The dual action of antimicrobial and anticancer activities in addition to their hemocompatibility and antioxidant properties of these NPs highlights the potential of Cu-doped ZnO nanoparticles as multifunctional agents in biomedical applications. This work also upholds the potential use of *B. orellana* L. in the fabrication of biocompatible nanoparticles for therapeutic applications.

Keywords: Bixa orellana L., Antimicrobial, Antioxidant, Hemocompatability, Cytotoxicity

Acknowledgments

The finical support from " Backward Classes Welfare Department,GOVT OF KARNATAKA" is gratefully acknowledged. The physico-chemical characterization portion of the research was performed using facilities at CeNSE, Indian Institute of Science, Bengaluru, Centre for Excellence for Multidisciplinary Advanced Research Facility, Vijayanagara Sri Krishnadevaraya University, Ballari. The authors thank to Dr. Gajendra Varma, VIMS, Ballari for gifting the ATCC bacterial strains, and Dr. Shringeswara A N, Mahatma Gandhi Botanical Garden, University of Agricultural Sciences , Gandhi Krishi Vigyana Kendra, Bangalore for plant identification, and authentication.

Optimization on Wear Test Parameters of Al7075 Based Hybrid Metal Matrix Composites Using Taguchi Approach

I.Vimal Kannan[1&*], N.Gnana Prasanna[2], P.Thangapandian[3], S.Ramanathan[4], S.A.Siddeshwar[5]

[1,4,5] *Department of Mechanical & Automation Engineering, Sri Sairam Engineering College, Chennai 600044, India*

[2] *Department of Mechanical Engineering, Jayamatha Engineering College, Aralvaimozhi, 629301, India*

[3] *ADepartment of Mechanical Engineering, Rathinam Technical Campus, Coimbatore, 641201, India*

**E-mail: ivimalkannan@gmail.com*

Abstract

An HMMC is ideally suited for transportation applications thanks to its superior strength, corrosion resistance, and wear resistance. This study reinforces Al7075 with 15 weight percent titanium carbide (TiC) and 0 to 6 weight percent molybdenum disulfide (MoS2) in the step of 1.5 wt % to increase its mechanical and tribological characteristics. A stir-casting process produces Al7075 HMMCs. A combination of Al7075/15wt.%TiC/4wt.%MoS2 exhibits superior characteristics. EDAX and SEM validate a matrix and reinforcements to determine the distribution of reinforcements within the matrix. Al7075/TiC/MoS2 HMMC wear test parameters are optimized using Taguchi and ANOVA. This optimization uses wt.% MoS2, sliding distance, sliding velocity, and applied load as input parameters. This optimization considers wear loss as the response parameter. The confirmation test specimen for enhanced Al7075-based composites shows the lowest wear loss of 8.5 mg.

Keywords: AA7075, Titanium carbide, Molybdenum Disulfide, Stir-casting, Optimization, Wear test.

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Drilling Analysis of Coir Fiber/Pine Needle Powder Reinforced Hybrid Epoxy Composite

Rishu Kesharwani[1], Satyavrat[1], Ankit[1] and Dungali Sreehari[1*]

[1] Department of Mechanical Engineering, NIT Uttarakhand, Srinagar, Pauri Garhwal, Uttarakhand, India
**Email: sreehari@nituk.ac.in*

Abstract

Pine Needles are abundantly available in the Himalayan region – Northern region of India and it is a huge forest waste material. The coconut shell (coir fiber) is also a waste material which is huge in the Southern region of India. Considering the two natural waste materials, a coir fiber/pine needle powder reinforced hybrid epoxy composite was fabricated. Drilling is the most common process for joining two materials for structural applications. However, delamination is one of the major concerns in drilling fiber-reinforced composites due to multilayer and multiphase materials. Therefore, in the present study, investigations were carried out to study the effect of input factors of drilling operation on the delamination factor of the developed composite. The most influencing parameters such as drill diameter, spindle speed and feed rate were considered the input factors at three different levels of each factor. The output factor is the delamination factor. A randomized full factorial was considered to design and perform the experiments. A regression model was generated between the input factors and the output factor. ANOVA was used to analyze the results with 95% confidence interval. It was observed that the feed rate is the most significant and influencing factor on the delamination factor among the three input factors.

Keywords: Pine needle, coir fiber, drilling, delamination factor, ANOVA.

Investigating the Impact of Applied Current and Chevron Pattern Groove on Slot Entry Hybrid Conical Journal Bearings

Krishnkant Sahu[1*], Adesh Kumar Tomar[2], and Satish C. Sharma[3]

[1]Mechatronics Engineering Department, Sharad Institute of Technology College of Engineering, Yadrav, Ichalkaranji-416121, MH, India
[2]Mechanical Engineering Department, Graphic Era (Deemed to be University), Dehradun, 248002, Uttarakhand, India
[3]Tribology Laboratory, Mechanical, and Industrial Engineering Department, Indian Institute of Technology, Roorkee, 247667, India
Corresponding Author:*krish.sahu7060@gmail.com

Abstract

This paper investigates the influence of chevron pattern groove angle and magnetorheological fluid behavior on slot entry 'hybrid conical journal bearing system' (HCJBs). The slot entry restrictor is employed to supply the lubricant in the clearance space of HCJBs. Various groove orientation angles of the groove over the surface of conical bearings have been employed. Further, the MR lubricant behavior on the behavior of grooved slot entry HCJBs have been analyzed. The finite element method (FEM) and the successive iteration-based Gauss-Seidel method have been used to solve the modified Reynolds equation. The results drawn from the present study show different effects on the bearing performance for different orientations of Chevron pattern grooves. The results presented that increasing applied current, the value of minimum fluid film thickness, stiffness coefficient, damping, and stability improves for both grooved and non-grooved bearings.

Keywords: Chevron groove, Slot-entry, Semi-cone angle, Reynolds equation, Finite element analysis, Conical bearing.

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Tribological performance of a novel AA6061 based high strength composite reinforced with TiAl – a metallurgical investigation on the combined effect of precipitation and grain refinement

Ilyas Hussain, and R. Jose Immanuel*

Advanced Materials Development and Characterization Groupd, Department of Mechanical Engineering,
Indian Institute of Technology Bhilai, Durg, Chhattisgarh, INDIA
** Presenting Author, E-mail id: jose@iitbhilai.ac.in*

Abstract

In the present investigation, the effect of artificial ageing on the tribological behaviour and mechanical characteristics of Titanium Aluminide (TiAl) particulate reinforced AA6061 aluminium composite developed through the friction stir processing (FSP) is studied. FSP process facilitated homogeneous incorporation of the reinforcing TiAl particles within Al matrix using two distinct pin tool geometries: a square (Sq) pin and a taper threaded (TT) pin. A two-pass approach was employed, with the initial pass utilizing the TT pin for deeper material penetration and the subsequent pass employing the Sq pin to achieve a more uniform distribution and grain refinement through its high-pulsating action. To further enhance the refinement and distribution of the reinforcement particles, the plates were rotated by 180° between the FSP passes, effectively reversing the direction of processing. After FSP, artificial ageing treatment was conducted at 175°C on both reinforced and unreinforced samples to induce fine precipitation. Microstructural characterization of the FSPed samples was performed using scanning electron microscopy (SEM) and X-ray diffraction (XRD) techniques. A comprehensive evaluation of the mechanical properties was undertaken, encompassing wear resistance, microhardness, tensile strength, and compressive strength. Wear analysis of the specimens adhering to the ASTM-G99 standard was performed, employing a pin-on-disc wear testing methodology.

Experimental findings revealed that the two-pass FSP approach utilizing the combined action of Sq and TT pin tools, coupled with the subsequent ageing treatment, resulted in a significant microstructural refinement and uniform distribution of TiAl particles in Al matrix. The microstructural change demonstrably enhanced the overall strength of the composite. High temperature induced during FSP led to dissolution of precipitates, which could be re-precipitated through post-FSP aging. Synergetic effect of grain refinement, TiAl particle induction and fine precipitation resulted in superior wear resistance and mechanical properties. The observed performance enhancement is analysed systematically in this paper with the help of microstructures and post-deformation analysis to bring out the underlying mechanisms.

Study on the effects of properties to polypropylene blends with the addition of recycled material

Abstract

Polypropylene (PP) is the most widely used general plastics in automotive, packaging, furniture, and domestic appliances due to their low cost, environmental friendliness, recyclability, and excellent strength per weight ratio. Today, plastic recycling and reusage is a hot topic with growing concerns about carbon footprint reduction to save the environment. The polymer recycling process involves various stages such as plastic sorting, cleaning, and reprocessing. This whole recycling process potentially influences the material structure and properties. This work mainly deals with the effect of introduction of recycled polypropylene into the virgin polypropylene composition blends and its effect on various properties such as physical properties, mechanical properties, and thermal properties. Analyzed multiple virgin and recycled polypropylene polymer blend by increasing the recycled content up to half of the original mass of the virgin material and characterized their properties changes. Additionally, aimed to establish the correlation between recycled percentage and properties of the recycled blend which may be used as a standard guide or standard operating procedure for characterizing the blends.

The knowledge gained from this study will not only contribute to the fundamental insights into the behavior of recycled polypropylene but also support the development of sustainable materials with improved performance for a wide range of industries. Ultimately, bridging the gap between virgin PP and recycled PP properties will facilitate the adaptation of recycling practices and further promote the circular economy, leading to a more environmentally responsible and resource-efficient automotive industry.

Phase separated Cu-Fe bulk metastable alloys prepared by mechanical alloying and spark plasma sintering

Santhi Ba, Arvindha Babu Db, Vajindar Singhb, Deepak Kumarb, and Uma Maheswara Rao Seelama,*

[a] *Department of Metallurgical and Materials Engineering, National Institute of Technology, Warangal 506004, Telangana, India.*
[b] *Defence Metallurgical Research Laboratory, Hyderabad 500058, Telangana, India.*

Abstract

The equilibrium-insoluble Cu and Fe metals with a composition of Cu100-xFex (x = 30, 50 and 70 at%) were mechanically alloyed (MA) for 20 h in a high energy Spex ball mill, resulting in a metastable face-centered cubic (FCC) supersaturated solid solution (γS). The alloy powders were consolidated by spark plasma sintering (SPS) at temperatures 0.5Tm, 0.6Tm, 0.7Tm and 0.8Tm, where Tm represents the linear-interpolated melting point of the respective Cu-Fe alloys. Scanning electron microscopy (SEM), X-ray diffraction (XRD), differential scanning calorimetry (DSC) analyses, and electron backscatter (EBSD) analyses were conducted on the MA powders and the consolidated SPS bulk samples. Compressive stress-strain, and hardness tests were conducted on the SPS samples to evaluate the mechanical properties. The characterization results showed that upon SPS, the γS phase decomposed into Cu-rich γ (FCC) and Fe-rich α (BCC) phases by phase separation. The phase separated microstructures exhibited a continuous/discontinuous γ-network phase surrounding an ultrafine γ+α mixture. During compressive testing, the lower SPS temperatures, the samples manifested a brittle fracture due to crack propagation along the continuous γ-network phase upon mechanical loading. In contrast, at higher SPS temperatures, the γ-network phase was discontinuous, which inhibited the crack propagation, thereby increasing the ductility. Additionally, the high temperature SPS samples possessed a bimodal grain size distribution, with the coarser γ-network phase grains of about 1-2 µm size surrounding an ultrafine γ and α grains of 200-500 nm size, leading to an excellent combination of strengths between 1000 and 1400 MPa and ductility up to 25% in the bulk metastable Cu-Fe alloys.

*Dr. Uma Maheswara Rao Seelam, corresponding author
Email ID: uma.seelam@nitw.ac.in
Ph: 9441326641

Development of Multimaterial DLP-Based 3D Printing Process to fabricate 3D ceramic electronics using ceramic matrix and metal conductors

Swapnil Doke*, Jyoti Kondhalkar, Swapnil Narkhede, Pravin Bailmare, Rajendra Panmand,

Janardhan Rao Gadde, Vijaya Giramkar, and Shany Joseph#

[1] Electronic Packaging Division, Centre for Material for Electronics Technology (C-MET), Pune 411 008, INDIA

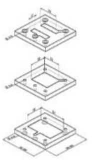
**E-mail Address of Presenting Author: swapnilsdoke@gmail.com,*

Abstract

Printed ceramic electronics are gaining a substantial share in the electronic fabrication market due to advantages in high-throughput production, customizability, and excellent material properties. However, current additive manufacturing (AM) techniques have limited material selection and difficulties in fabricating geometrically complex structures. Printing ceramic–metal parts increase the number of applications in AM technology, but printing different materials on the same object with different mechanical properties will increase the complexity of printing. Multi-material AM technology is a solution. In literature, many researchers tried Multi-material AM using hybrid methods.[1,2] This study presents first of its kind a novel multimaterial DLP-based 3D printing process for creating complex multilayer 3D electronic components followed by a multistage cleaning procedure. Multistage cleaning is involved in the multimaterial 3D printing process to reduce cross-contamination due to resin switching during material change. The experimental results show that both slurries have good bonding strength, with a weight ratio of powder to resin of 60:40. The composition of ceramic (like low-temperature co-firec ceramics, LTCC) and metal (like Ag, Ag-Pd) slurries is optimized to enable printing without delamination. A detailed preparation procedure is outlined, encompassing material synthesis, printing parameter optimization, and post-processing techniques. The developed process enables the seamless integration of diverse materials with varying electrical and mechanical properties, facilitating the creation of intricate 3D electronic architectures.[3,4] The influence of structural and dimensional properties of functional materials on composite preparation and their ensembled effect on printing parameters, such as layer thickness, curing time, and material composition, on the printed components' structural and electrical properties, are systematically investigated. This process is proposed to print a wide range of ceramics and metals. Through this technique, complex multi-material structures (with metal–ceramic, ceramic–ceramic combinations) can also be created. Overall, the present work gears up the rapid prototyping and manufacturing of intricate 3D electronic components, bridging the gap between conventional 2D electronics and innovative, cost-effective 3D systems.

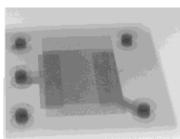
3D design

(exploded view)



3D printed product

(Dielectric base)



3D image of the product

Figure 1: Fabrication of multimaterial 3D ceramic electronics using DLP-Based 3D printing technique

Acknowledgments

Financial assistant from Ministry of Electronics and Information Technology (MeitY), Gov. of India (File no. GG-11/21/2019-EMCD-MeitY)

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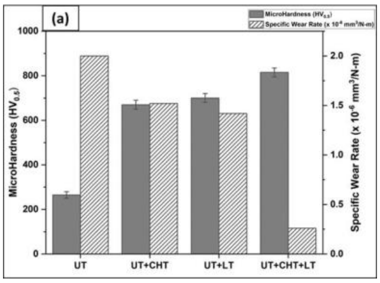
Effect of Spheroidization on Laser Surface Hardening and Sliding WearPerformance of Bearing Steel

E. Anusha[1,2,3*], A. Kumar[3], S.M Shariff[2]

[1]Centre for Additive and Special Manufacturing Processes, Central Manufacturing Technology Institute, Bangalore, India; Work conducted while at [2]International Advanced Research Center for Powder Metallurgy and New Materials,(ARCI), Hyderabad, India.
[3]Department of Mechanical Engineering, National Institute of Technology Warangal, India.
**anusha.epparla@gmail.com*

Abstract

The present research studied the individual and combined effects of spheroidization, conventionally hardening and tempering treatment, and laser surface hardening treatments on the resulting microstructural and wear behavior of AISI 52100 bearing steel and compared results with non-spheroidized and its subsequent heat treatments. The wear tests werecarried out on a conventional ball-on-disc sliding configuration under lubrication conditions. Also, the microstructure, micro-hardness profiles and worn tracks were examined. The role of spheroidized carbides and prior treatment on improving the wear resistance of laser surface hardened 52100 bearing steel has been studied and compared with non-spheroidized samples. In the sliding wear tests, the spheroidized and conventionally heat treated only resulted in higher wear resistance of 52100 bearing steel when compared with non-spheroidized and conventionally heat-treated specimens. The wear performance of the spheroidized and conventionally heat-treated sample was enhanced after receiving the laser surface hardening treatment. Finally, spheroidized prior treated laser hardened 52100 bearing steel resulted in enhanced microstructural refinement with formation of nano alloy carbides in treated layers as compared to other conditions. By observing the worn surfaces, the laser hardened regions could effectively inhibit the formation of delaminated layers and facilitated in lowering of contact stress due to its high strength microstructure. In addition, the spheroidized substrate with low hardness in laser hardened and prior treated 52100 bearing steel may provide enhanced strength and rolling contact fatigue resistance for bearing engineering components.



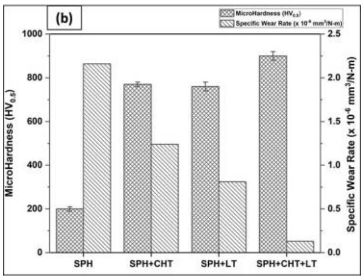


Fig. Hardness v/s Sliding wear resistance of (a) non-spheroidized samples (b) spheroidized samples under different heat treatment conditions (as-received hot-rolled (UT) bearing steel samples; Spheroidization treated (SPH); conventionally heat treated (CHT) andLaser treated (LT))

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Study on the effects of properties to polypropylene blends with the addition of recycled material

Mr Santu Panja
TVS Motor Company Limited, Hosur

Abstract

Polypropylene (PP) is the most widely used general plastics in automotive, packaging, furniture, and domestic appliances due to their low cost, environmental friendliness, recyclability, and excellent strength per weight ratio. Today, plastic recycling and reusage is a hot topic with growing concerns about carbon footprint reduction to save the environment. The polymer recycling process involves various stages such as plastic sorting, cleaning, and reprocessing. This whole recycling process potentially influences the material structure and properties. This work mainly deals with the effect of introduction of recycled polypropylene into the virgin polypropylene composition blends and its effect on various properties such as physical properties, mechanical properties, and thermal properties. Analyzed multiple virgin and recycled polypropylene polymer blend by increasing the recycled content up to half of the original mass of the virgin material and characterized their properties changes. Additionally, aimed to establish the correlation between recycled percentage and properties of the recycled blend which may be used as a standard guide or standard operating procedure for characterizing the blends.

The knowledge gained from this study will not only contribute to the fundamental insights into the behavior of recycled polypropylene but also support the development of sustainable materials with improved performance for a wide range of industries. Ultimately, bridging the gap between virgin PP and recycled PP properties will facilitate the adaptation of recycling practices and further promote the circular economy, leading to a more environmentally responsible and resource-efficient automotive industry.

Poster

Presentation +

Flash Talks

Micro-segregation behaviour of γ-γ' Precipitate Hardened Additively Manufactured Nickel Based Superalloy

Abhishek Shukla*, E. Hemaprabha, Gandham Phanikumar

Department of Materials and Metallurgical Engineering
Indian Institute of Technology, Madras, Chennai, 600036, India
**Email ID: mm20d018@smail.iitm.ac.in*

Abstract

Precipitation hardened additively manufactured nickel-based superalloys are important class of materials for high temperature applications such as aero-engines, auto-mobile sector, land-based gas turbines and ultra super critical power plants. Processing of these class of materials by additive manufacturing is already well established as it offers many advantages: complex geometry, weight reduction, short lead times. However, additive manufacturing provides higher cooling rate during solidification, thereby leading to strong elemental segregation. For instance, heavy elements like Cobalt, tungsten have a tendency to segregate in the dendritic regions which solidify first in pure γ phase while light elements like Aluminium, Titanium usually segregates in the interdendritic regions which is low melting point eutectics. This class of alloy having a particular kind of precipitation which is γ' precipitate Ni_3 (Al,Ti), having FCC arrangement with L12 ordered structure, are responsible for the excellent performance at high temperature environment. The strength of the alloys is primarily based on the size, fraction, morphology, and distribution of the γ' phase.

The present study investigates micro-segregation behaviour of various elements present in multicomponent Haynes γ-γ' nickel-based superalloy and their effect on the performance of the materials in as received and heat-treated conditions.

Keywords: Ni based superalloy, Additive Manufacturing, Segregation, γ' precipitate

An ICME approach to investigate the process-structure-property co-relation of aluminium alloys

Arpita Priyadarshani Samal[1*], Ranjit Bauri[2], Gandham Phanikumar[3]

[1,2,3] Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Madras, India

**Email: mm22d004@smail.iitm.ac.in*

Abstract

Aluminum alloys offer lightweighting applications for the automotive and aerospace industries to improve fuel efficiency and reduce greenhouse gas emissions. Altering alloy chemistry significantly reduces the carbon footprint and results in novel alloys with the desired microstructure and a reasonable level of strength. The corelation between the processing condition of an alloy, phase formation or microstructure and mechanical properties is influenced by the cooling rate and thermal gradients. This is due to the formation of intermetallic precipitates and the lengthscale of the secondary dendritic arm spacing (SDAS).

Further, the conventional approach to producing alloys of required composition, grain structure and mechanical properties is time-consuming and expensive. To digitally predict the microstructure without actual experiments, it is crucial to understand the relationship between the as-cast microstructure and the associated cooling rate. This is accomplished by using a comprehensive Integrated Computational Materials Engineering (ICME) approach which allows modification of alloy composition and controlling the cooling rate similar to that of experiments.

Phase-field modelling (PFM) emerged as an efficient predictive tool for microstructure evoution without explicitly tracking the solid-liquid interface. Simulations are fastened with the use of GPU computing techniques and parallel computing which increases its applicability. These simulations coupled with thermodynamic databases to understand the relationship between specific alloy chemistries and their microstructure / phase formation. The current study presents a use case of an ICME strategy at various length scales utilising already-accessible models and literature for developing and implementing new generation Al alloys for lightweight applications.

Keywords: Al alloy, Cooling rate, Microstructure, PFM, ICME

Synthesis of Superabsorbent Polylactic acid- Dextran Composites

Bhavya Surendran, Sudeshna Samantaray, and Althuri Avanthi*

Department of Biotechnology, Indian Institute of Technology (IIT) Hyderabad, Kandi, Sangareddy, Telangana-502285, India
**Correspondance: a.avanthi@bt.iith.ac.in*

Abstract

The functional polymers which can absorb and retain a large amount of water are known as superabsorbent polymers (SAP). Most of the commercially available SAPs are of synthetic origin. The deterioration of mechanical strength at the swollen condition is a major drawback in the long term usage of SAP. Properties of a polymer material is a function of physical, chemical and structural characteristics of a single polymer chain. In this regard, the present work attempts to design and synthesize a composite polymer with high mechanical strength and water holding properties. Polylactic acid (PLA) is an established biodegradable polymer as an alternative for synthetic plastic due to its transparent, hydrophobic, mechanical, and thermal characteristics. The exopolysaccharide dextran, is known for its water absorbing capacity and biocompatibility. The present work focuses on synthesizing a composite polymer of PLA and dextran which has amphiphilic properties. PLA has been synthesized from microbial LA produced in-house through single pot process. Two different types of PLA were synthesized- low molecular weight and high molecular weight and used in composite to analyse the effect of molecular weight on the properties of the composite. Dextran is being functionalized by oxidation to improve the water absorbency. The effect of concentration of individual polymers, concentration of crosslinker, and the effect of reaction conditions on the formation and properties of the SAP composite are being profiled for structural (FT-IR and LC-MS), thermal (TGA and DSC), rheological (viscosity) and functional characterizations (water absorbency, absorbency under load, and swelling kinetics). The properties of the composite film are being evaluated with respect to the film casting methods; manual and automatic solvent casting in terms of surface morphology (SEM), mechanical, hydrophilic (water absorbency), and hydrophobic properties (contact angle measurement) of SAP films.

Keywords: hybrid polymers, green synthesis, sustainable production, water absorbent

Acknowledgments
Authors acknowledge the Ministry of Education (MoE), India fellowship, Science and Engineering Research Board (SERB) India(SERB-EEQ/BT/F304/2023-24/G667), and the Director, Indian Institutes of Technology (IIT), Hyderabad for providing the seed grant (SG/IITH/F304/2022-23/SG-135) and other necessary facilities.

Optimization of Kerf Taper, Material Removal Rate and Surface Roughness of POLYOXYMETHYLENE in in Abrasive Waterjet Machining

K.Karthik[1], A.Mani sankar[2], B.Atchaya[3], P.Mahalakshmi[4],U.Manoj[5],and N.Sathish kumar[6]

[123456] Department of Mechanical Engineering, Coimbatore Institute of Technology, Tamil Nadu, India, 641014

71762202086@cit.edu.in

Abstract

Abrasive water jet machining (AWJM) is an advanced machining technique. It swiftly removes material from extremely hard and brittle substances without inducing distortion or altering the microstructure, using a blend of high-pressure water and abrasive particles. As a result, it has quickly established itself as one of the most prominent manufacturing technologies. The effects of various AWJM input parameters on POM removal rate (MRR), kerf angle, and surface roughness (SR) have been investigated in this study. On POM material, Design of experiments (DOE) -approved experiments are carried out by adjusting input parameters like traverse speed (TS), abrasive flow rate (AFR), and water pressure (WP). The data collected is optimized by Grey Relational Analysis, Response Surface Methodology and aggression optimization. All these are carried out using MINITAB software

Enhancing Polyoxymethylene (POM) Strength for Gearing Applications through Alumina Reinforcement and Comprehensive Testing

K. Karthik[1], A N Kaarthik[2], Atchaya B[3], Mahalakshmi P[4], Manoj U[5], Sathish Kumar N[6]

[123456] Department of Mechanical Engineering, Coimbatore Institute of Technology, Tamil Nadu, India, 64101471762202076@cit.edu.in

Abstract

One of the most important parts of mechanical power transmission systems is the gearing. Plastic gears have a number of advantages for drive designers, such as reduced noise, flexible design, and lubrication-free operation. Additional advantages consist of reduced weight and cost, increased effectiveness, and chemical resistance. Even though plastics having many advantages the major drawback is the strength when compared to the metals. So our objective is to improve the strength of Polyoxymethylene (POM) thermoplastic by adding Alumina (ceramic filler) of 5 & 10% to the POM and analyzing the variations in the property by conducting various tests such as tensile, flexural, hardness, wear test and FESEM. After that design and analysis of spur gear pair is done on ANSYS software for the obtained property to study the variations among the materials. If the obtained variation in the properties suits our objective then we can use the material for gearing applications such as Gear Pumps etc..

Keywords : Polymer, Alumina, Analysis, Gears.

The Influence of Isothermal Surface Oxidation on the Microstructure and Mechanical Properties of NiTiCo Shape memory alloy.

Maalolan B[1], Santosh S[1] and Srivatsan TS[2]

[1] Department of Mechanical Engineering, Sri Sivasubramaniya Nadar College of Engineering, OMR, Kalavakkam -603110
[2]Department of Mechanical Engineering, The University of Akron, Akron, Ohio 44325, USA
**maalolan2010545@ssn.edu.in*

KEYWORDS

NiTiCo; Isothermal oxidation; SEM; Microstructure; Mechanical Properties

Abstract

Shape Memory Alloys (SMAs) are shape memory materials that retain their original form when exposed to external stimuli such as thermomechanical or magnetic changes. Ni-Ti commercially called Nitinol is preferred owing to its high recoverable strain, wear resistance, large deformation and mechanical performance. To reduce the martensite start temperature of Ni-Ti alloy, Cobalt is added. A passive oxidation layer formed on the surface of NiTi alloys at room temperature. However, at higher temperatures the passive oxidation layer formation depends on both the composition and surface treatment of materials due to surface oxidation. NiTi alloys react with oxygen in the air vigorously at elevated temperatures to form oxides. Isothermal oxidation tests were carried out in the alloy by heating it in a furnace at temperatures 450, 550, 650 and 750ºC for 60 minutes to examine the oxide structures. Microstructures of NiTiCo specimens after oxidation were analysed by scanning electron microscope (SEM). The results of SEM and inferences are explained in the paper.

Optimizing Friction Stir Processing Parameters to Enhance Microstructure and Mechanical Properties of Aluminum Plates: An Experimental Approach

Sujata Sahoo[1*], Somashekara M A[2], and Anbukkarasi Rajendran[3]

[1] Department of Mechanical, Materials and Aerospace Engineering (MMAE), IIT Dharwad, Karnataka, India
**sujatasahooias@gmail.com*

Abstract

Friction Stir Processing (FSP) is a solid-state technique used to refine the microstructure and enhance the mechanical properties of materials, especially aluminum alloys. By employing a non-consumable tool to generate frictional heat, FSP facilitates plastic deformation and dynamic recrystallization of the material, resulting in improved grain refinement and mechanical performance. This study aims to optimize FSP parameters to enhance the microstructure and mechanical properties of in-house prepared aluminum plates through an experimental approach. The research investigates the effects of key processing parameters, including rotational speed, traverse speed, and axial force, on the microstructural characteristics and mechanical behavior of aluminum plates. Extensive experimental analysis was conducted to determine the optimal parameter combinations that maximize grain refinement, hardness, tensile strength, and ductility. The results demonstrate a significant correlation between optimized FSP parameters and the improved performance of the aluminum plates. Microstructural evaluations, performed using optical and scanning electron microscopy, revealed a uniform distribution of fine grains, which substantially contribute to enhanced mechanical properties. This study highlights the effectiveness of an experimental approach in optimizing FSP parameters, providing a solid foundation for achieving superior material performance. The findings have important implications for various industries, such as aerospace, automotive, and marine, where aluminum alloys are essential. Current studies contribute to the development of lightweight, high-strength materials for challenging modern engineering by advancing Friction Stir Processing (FSP) capabilities.

Keywords: Friction Stir Processing, aluminum alloys, microstructure, mechanical properties, optimization, experimental approach.

Assessment of the linear reciprocating tribological (LRT) performance of Graphene nanoplatelets (GnPs) loaded Polyamide-6,6 (PA-6,6) composite under dry sliding contact

[1]Ranjan Kumar, [1]Sujeet Kumar Mishra, [*2]Sudeepan J, [3]Rakhi Kumari, and [4]Kamlendra Vikram

[1,2]Department of Mechanical Engineering, Birla Institute of Technology, Mesra -835215, Ranchi, INDIA.
[2]Department of Chemical Engineering, Birla Institute of Technology, Mesra -835215, Ranchi, INDIA
[3]Department of Production Engineering, Birla Institute of Technology, Mesra -835215, Ranchi, INDIA
[4]Functional and Biomaterials Engineering Lab, Department of Mechanical Engineering, College of Engineering and Technology, SRM Institute of Science and Technology, Chennai–603203, Tamil Nadu, INDIA.
**Corresponding Author E-mail: ranjan.mech1990@gmail.com;*

Abstract

This study represents a novel approach toward developing self-lubricating composite materials for harsh service environments, paving the way for future advancements in this field. The objective of this study is to examine the friction and wear characteristics of PA-6,6 material that has been strengthened with different weight percentages (1, 3, 5, and 10 wt.%) of Graphene nanoplatelets (GnPs). The friction and wear tests were carried out at frequency levels of 5 and 25 Hz and under typical load circumstances of 10, 30, and 50 N. The material underwent twin screw extrusion processing, followed by injection molding using the melt-mixing technique. The tribological performance was evaluated in ambient conditions using a linear reciprocating tribology (LRT) configuration test. The morphology of the abraded surfaces was examined using Field Emission Scanning Electron Microscopy (FESEM), which provided detailed insights into the wear mechanisms of the composite. The plausible wear mechanism contributing to the composite's wear behavior was explained in detail. Additionally, the materials were thoroughly characterized for their tribological and physical properties. The experiments found significant improvement in friction and wear-resisting properties up to 5 wt.% of filler loadings. Additionally, transfer film formation on the steel ball counterface for PA-6,6/GnPs composite was analyzed to gain a better understanding of the tribological behavior of the composite system.

Keywords: Coefficient of friction, PA-6,6, Graphene nanoplatelets, linear reciprocating tribological.

Steady-State Thermal analysis of Inconel Material Based on 3D Metal Printed Exhaust valve for IC Engines : An innovative approach

Sarabjit Singh[1], Harmesh Kumar Kansal[2*],Rajesh kumar[3]

[1]Research Scholar, UIET Panjab University, Chandigarh
[2]Professor, UIET Panjab University, Chandigarh*
[3]Associate Professor, UIET Panjab University, Chandigarh
**Corresponding Author Email: harmeshkansal@gmail.com, Phone: +91 9417270363*

Abstract

This effort investigates the use of metal additive manufacturing, specifically laser powder bed fusion (LPBF) for the automotive and defense industries by demonstrating its feasibility to produce working internal combustion (IC) engine components. The exhaust valve of a commercially available diesel engine is the subject of this study, which focuses on Steady-State Thermal analysis of 3 D metal printed exhaust valve. Using a video measuring machine, the exhaust valve model was prepared using Inconel 718 material. In steady state conditions, a diesel engine's exhaust valve was thermally analyzed. The ANSYS software has been used to create the model in order to perform steady-state thermal analysis via Finite Element Method (FEM). The simulation has been performed and the results of thermal analysis carried out on the exhaust valve under steady-state conditions. It has been observed that the highest temperature occurs on the exhaust valve head, while the minimum temperature is near the valve's stem tip. The lowest and highest total heat flux observed for Inconel 718 material are 0.0016767 W/mm2 and 0.22504 W/mm2. It has been observed that the area around the head of the exhaust valve and near the engine's exhaust valve stem tip experiences the least total heat flux. Conversely, the lower section of the valve stem experiences the maximum total heat flux. The lowest and highest directional heat flux are 0.22312 W/mm2 and 0.00217 W/mm2. It has been observed that the area around the head of the exhaust valve and near the stem tip experiences the maximum directional heat flux. Conversely, the lower section of the valve stem experiences the minimum directional heat flux.

Keywords: Exhaust Valve, Internal combustion engine, Inconel 718, Thermal analysis

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Dynamic Mechanical and Tribological Properties of Multimaterial Hydrogel Films Under Physiological Solutions for Biomedical Applications

Devara Venkata Krishna[1*], Palivela Bharagav Chandan[2], and Mamilla Ravi Sankar[3]

[1,2,3] Department of Mechanical Engineering, Indian Institute of Technology Tirupati, India
**E-mail: me21d501@iittp.ac.in*

Abstract

Hydrogels are progressively familiar for their potential in biomedical applications due to their biocompatibility and customizable properties [1]. Developing hydrogel films with tailored mechanical and tribological properties is critical for their successful application in biomedical fields, such as tissue engineering and wound healing. Numerous studies have reported hydrogel films for articular cartilage and wound healing applications. For instance, Huang et al.[2], Bhardwaj et al.[3], Yang et al.[4], Mohammad et al.[5], etc. However, prior studies are lacking in assessing the performance of the hydrogel film under physiological solutions that mimic the biological environment. The present study evaluates the dynamic mechanical and tribological properties of the quarternary blended multimaterial hydrogel under different physiological solutions such as fetal bovine serum (FBS), ringer lactic solution (RLS), and artificial synovial fluid (ASF). The dynamic mechanical behavior of the developed hydrogel film was assessed through the variation of the storage and loss modulus of the film under the oscillatory strain and frequency test. Additionally, creep and stress relaxation behaviors were evaluated. Tribological analyses were carried out concurrently to appraise the hydrogel film surface wear and frictional characteristics, which are crucial for applications requiring prolonged contact with biological tissues. The outcomes highlight the feasibility of these multimaterial hydrogel films for use in biomedical devices and implants by showing that they maintain mechanical stability and have low friction coefficients in various physiological fluids. This thorough analysis of hydrogel films in various physiological settings advances the development of materials intended for biomedical use.

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Investigating the Integration of Hydrogen and Biomass in Iron Ore Pellet Reduction Process

B Lakshman Kumar, Sri Pushpa, Ramesh Kumar, Ashok Kamaraj, S Bhattacharya

[1]Material Science & Metallurgical Engineering, Indian Institute of Technology Hyderabad, Sangareddy, India
[2]Material Science & Metallurgical Engineering, Indian Institute of Technology Hyderabad, Sangareddy, India
[3]Material Science & Metallurgical Engineering, Indian Institute of Technology Hyderabad, Sangareddy, India
[4]Material Science & Metallurgical Engineering, Indian Institute of Technology Hyderabad, Sangareddy, India
[5]Material Science & Metallurgical Engineering, Indian Institute of Technology Hyderabad, Sangareddy, India
ms23resch11002@iith.ac.in

Abstract

The iron and steel industry are a major contributor to global greenhouse gas emissions gas emissions primarily due to the use of carbon-based reducing agent. The World Steel Association estimates that the industry contributes between 7 to 9% of the world's CO2 emissions. Additionally, the decline in fossil fuel reserves further necessitates the search for alternative reducing agent. With the goal of decreasing the carbon footprint associated with conventional steel making process, the present research investigates the potential of a mixture of hydrogen and biomass as a reducing agent for the direct reduction of iron ore in search of sustainable alternatives process. First, reduction will be conducted on high-grade iron ore pellets in a horizontal tubular furnace at temperatures ranging from 700-900oC. Comprehensive characterisation utilizing scanning electron microscopy (SEM) and X-ray diffraction (XRD) will come next. These techniques will make it easier to comprehend the phase changes and microstructural changes that occur during the reduction and cooling procedures that follow. While SEM will give detailed images and analysis of the microstructure to highlight morphological changes, XRD will be used to identify the phases present. The reduction process will be examined by a thorough kinetic analysis that will be conducted after the characterisation. This investigation will aid in the undertaking of reaction processes and rate determining steps, as well as provide insight into the efficiency and practicality of using hydrogen and biomass mixture as reducing agent. The results of this study will help create a more environmentally friendly method of producing steel by using a mixture of hydrogen and biomass as a competitive substitute for conventional full pledged carbon-based reducing agents.

Dielectric behaviour and AC Conductivity of Polypyrrole –Neodymium oxide Composites

L.B. Gunjal[1*], S. Manjunatha[2], N. M. Nagabhushana[1], *Y. T. Ravikiran[3], P. N. Ravi Shankar[4]*

[1]Department of Physics, VTU-RC, RYM Engineering College, Ballari, 583104, India
[2]Department of Physics, Kishkinda University, Ballari, 583104, India
[3]Department of Physics, Government Science College, Holalkere, 577526, India
[4]Department of Chemistry, B.M.S. College of Engineering, Bengaluru, 560 019, India
**E-mail: lavanyagunjal@gmail.com*

Abstract

Neodymium oxide (Nd2O3) embedded in polypyrrole (PPy) composites with varying compositions were synthesized using the chemical polymerization technique. To analyze the morphology of the pure PPy and PPy/Nd2O3 composites, several characterization techniques were employed, including scanning electron microscopy (SEM), transmission electron microscopy (TEM), and selected area electron diffraction (SAED). Structural properties were examined through X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR) studies. AC conductivity of these composites was measured at room temperature across a frequency range of 50 Hz to 5 MHz. Results indicated that the AC conductivity increased with a higher weight percentage of Nd2O3, which is attributed to the enhanced hopping of polarons within the material. Notably, PPy/Nd2O3 composite with 10 wt% Nd2O3 exhibited a conductivity of 2.69×10^2 S/cm at 100 Hz, outperforming the other compositions. The dielectric properties of these composites were interpreted through Maxwell–Wagner polarization, while the dielectric loss curves were analyzed using the Rezlescu model. Given their electrical and dielectric properties, these composites show potential for applications in the design of low to mid-frequency electronic devices.

Mathematical Modeling of Motion of Carrier Gas and Mg Particle in the Top Lance during Hot Metal Desulphurization Process

Syed Furqan Bukhari[1*], Sarbendu Sanyal[2], Ramkarn Patne[3] and Ashok Kamaraj[4]

[1] Center for Interdisciplinary Programs, Indian Institute of Technology Hyderabad, Kandi, Sangareddy, Telangana 502285, India,
[2] JAMIPOL Limited, Jamshedpur, Jharkhand 831007, India,
[3] Department of Chemical Engineering, Indian Institute of Technology Hyderabad, Kandi, Sangareddy, Telangana 502285, India,
[4] Department of Materials Science and Metallurgical Engineering, Indian Institute of Technology Hyderabad, Kandi, Sangareddy, Telangana 502285, India
**E-mail: id22resch11008@iith.ac.in*

Abstract

The desulphurization (DeS) reaction efficiency in the hot metal (HM) bath mostly depends on the Mg bubble-hot metal interactions. The behavior of gas and particles in the external DeS unit top-lance has been investigated. In the present work, different forces acting on the Mg particle and carrier gas while traveling in the lance and into the hot metal bath have been studied using a mathematical model. The newly developed mathematical model accounts for forces like the effect of lance-wall drag and pressure loss at the bend of the T-shaped nozzle, in addition to the conventional forces. The effect of lance geometry has been taken care of by considering various types of cross-sectional lances, such as circular, ellipse, pentagon, and hexagonal-shaped lances. Moreover, composite heat transfer from the HM to the particle is studied considering the skull formation/dissolution on the outer surface of the lance immersed in the bath. The results include estimating the temperature profile from the liquid bath through the skull layer, refractory shell, steel pipe, and carrier gas to the Mg particle. Subsequently, the temperature & velocity of gas and solid Mg particles inside the lance have also been calculated. In addition, penetrability analysis for the gas jet at the lance tip and the behavior of the Mg particles has been investigated. The results from the developed model can be utilized to design a lance for the physical model, and subsequent results can be validated in the future.

Fault Tree Analysis of FDM 3 D Printer for improved maintainability

[1]Ms. Sayli M. Jadhav, [2]Dr. Vinay Kulkarni

[1,2] Mechanical Engineering Department, D. Y. Patil College of Engineering, Akurdi,

Maharashtra, India.

email: jsaylichinu@gmail.com, email: vakulkarni@dypcoeakurdi.ac.in

Abstract

Additive manufacturing, particularly FDM 3D printing, has potential for the manufacturing industry. However, Problem of nozzle clogging is a major issue in using FDM Printers and it reduces production. Lack of early warning systems emphasizes the importance of efficient maintenance solutions for using FDM Printers. In Industry 4.0. Real-time monitoring and online process control are critical to increasing productivity of FDM Printers. This paper involves Fault Tree Analysis of FDM printers performed during working. A graphic representation of the system's main flaws and their root causes is provided. In order to assess Fault Tree (FT) diagrams and derive the governing reliability models for FDM printers Evaluation of Fault Tree Diagrams can be done by boolean algebra. Maintainability and real time maintenance improves the effectiveness of FDM printers. Real time maintenance improves adaptability to industries and mass manufacturing systems in industry 4.0 It lowers operational, maintenance, support, and production loss costs.

Keywords: Fault Tree Analysis, FDM Printers, Nozzle Clogging

Transport properties and EMI SE studies of Silver decorated Polyaniline-Banana carbon ternary nanocomposites

K.R.Hemantha Kumar[1*], M. Revanasiddappa[2], S. Manjunatha[3],

Y. T. Ravikiran[4], S.B. Naidu Krishna[5], V. Srinivasa Murthy[1a]*
[1]Department of Chemistry, School of Engineering, Dayananda Sagar University, Bangalore, India, 5600068
[2]Department of Chemistry, PES University, Electronic city campus, Bangalore, India, 560100
[3]Department of Physics, Kishkinda University, Ballari, 583104, India
[4]Department of Physics, Government Science College, Holalkere, 577526, India
[5]Institute for Water and Wastewater Technology, Durban University of Technology, Durban-4000, South Africa.
**E-mail: hemanthdhanya@gmail.com*

Abstract

Green tea extract and banana peels, a natural ingredients were used in the synthesis of Silver-PANI-Banana carbon (Ag-PANI/BC) ternary composites. In-situ chemical polymerization method was adopted with incorporating varied weight percentage composition of banana carbon (BC). Characeristic vibrational requency bands evidence the formation of composite with the help of FTIR spectroscopy obtained for 10 wt.% composite. Amorphos nature of PANI and Ag-PANI, semicrystalline form of Ag-PANI/BC ternary composite was clearly detected from diffraction pattern of pXRD spectal data. Surface morphology of the Ag-PANI-BC (10%) from SEM data reveals granular non uniform spherical like structures with inhomogeneous surfaces of size measuring 90 to 175 nm. The composite shown comparable AC conductivity 10-6 to 10-4 S/cm for 6, 8, & 10 wt.% composites measured in the frequency range 20 Hz to 10 MHz. 6 and 8 wt.% composites have exhibited excellent EMI shielding effectiness of around 25 to 26 dB measured in s-band which suits pertinent practical applications in electronic and electrical devices funtioning in frequency range (2.1 to 3 GHz).

Slag Free Eccentric Bottom Tapping in Electric Arc Furnace by Physical Modelling Studies

Uppaluru Guru Srikanth Reddy, Tejaswi Tekumalla, Syed Furqan Bukhari, Ashok Kamaraj

Uppaluru Guru Srikanth Reddy -pursuing an MTech degree in MSME department at IIT Hyderabad 502 285.

Tejaswi Tekumalla - pursuing a BTech degree in MSME department at NIT Warangal.

Syed Furqan Bukhari is a research scholar in MSME and chemical department at IIT Hyderabad 502 285.

Ashok Kamaraj is an assistant professor at IIT Hyderabad in MSME Department.

Email: ms23mtech11016@iith.ac.in

Abstract

Electric Arc Furnaces (EAF) are one of the transformative trajectories in industrial practice, where steel scrap and DRI are taken as inputs and produce quality steel. The EAF has higher energy efficiency and lower environmental impact which is the aim of ongoing research and development. However, slag carryover during tapping is one of the main challenges which EAFs are facing in producing the ultra-high-quality steel. Very few studies investigated about the eccentric bottom tapping in EAF and hardly any research about slag carryover in EAF tapping is studied. The present study focuses on the slag carryover which is mainly due to vortex and drain sink formation. The complex shape of EAF along with various parameters which affect the vortex and drain sink formation are studied to predict the inception period of vortex and drain sink while tapping. A physical model which is geometrically scaled down of an industrial EAF is constructed with Perspex material. The tapping experiments were conducted in the physical model with water because of its similar kinematic viscosity to molten iron at its melting point. The drain curve analysis of water with varying nozzle diameter, initial liquid heights and dwell time between filling and tapping are studied. The critical heights for vortex and drain sink formation are predicted by using dimensional analysis, which is followed by the mathematical formulation, that gives the time of vortex and drain sink formation. The observation suggests that the heights of vortex and drain sink formation are clearly influenced by the nozzle diameter and dwell time between filling and tapping processes. The proposed mathematical equation can give the appropriate time of vortex formation which can be employed in the industrial scale to prevent slag carryover during tapping.

Duplex treatment of Nitriding and PVD coating – An Insight

V.K.Bupesh Raja[1*], Abel J Francis2, P D Jeyakumar3, S.Premnath[4], Sathish Kannan[5],

Dinesh.P[6],Sabari.C7,D.Lohithanathan[8]

[1,6,7,8]School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, India
[2]Eltechnologies, Chennai, India
[3]Department of Automobile Engineering, B S A Crescent Institute of Science and Technology, Chennai, 600 048, India.
[4]Department of Automobile Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, 602117, India.
5School of Engineering Architecture and Interior Design, Amity University, Dubai.
**Corresponding author: bupesh.v.k@gmail.com*

Abstract

This review explores the benefits of duplex surface treatment, combining plasma nitriding and Physical Vapor Deposition (PVD) coating, to enhance the performance of metal components, particularly titanium alloys. Plasma nitriding, a thermochemical process, introduces nitrogen into the surface to form hard, wear-resistant nitrides, improving hardness, roughness, friction, and corrosion resistance. PVD coating deposits thin film coatings, such as titanium nitride or chromium nitride, to further enhance surface hardness and reduce friction. The duplex treatment influences the strengths of both methods, resulting in superior surface properties, including improved wear resistance, corrosion protection, and extended component life. This approach is particularly advantageous in applications requiring enhanced wear resistance, corrosion protection, and extended component life, such as in aerospace, automotive, and tooling industries. The combined treatment has shown improved wear resistance, load-bearing capacity, and fatigue resistance, making it a promising solution for various industrial products, especially in aerospace applications.

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Diamond - Like Carbon Coating – Tribological applications

V.K.Bupesh Raja[1*], Abel J Francis[2], K.Duraivelu[3], S.Premnath[4], Sathish Kannan[5],

D.Lohithanathan[6] ,Sabari.C7,Dinesh.P[8]

[1,6,7,8]School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, India [2]Eltechnologies, Chennai, India

[3]Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai, India

[4]Department of Automobile Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, 602117, India.

[5]School of Engineering Architecture and Interior Design, Amity University, Dubai.

**Corresponding author: bupesh.v.k@gmail.com*

Abstract

Diamond-like carbon (DLC) coatings are a metastable form of amorphous carbon with unique properties, including excessive mechanical hardness, chemical inertness, optical transparency, low friction coefficients, high wear resistance, and biocompatibility. DLC coatings can be deposited on various substances using techniques such as Plasma-enhanced chemical vapor deposition (PECVD) and Pulsed laser deposition (PLD), and their properties can be tailored by incorporating elements like nitrogen, hydrogen, silicon, and metals, which have an effect on their hardness, residual strain, and tribological properties. They have been successfully used in various industrial applications, including tribology, optics, electronics, automotive, biomedical, and aerospace, and have shown promising results in reducing abrasion and wear. However, their performance can be affected by factors like lipids, immune cells, and environmental factors, and can be improved by doping, controlling deposition conditions, and surface modification. DLC coatings are self-lubricating, resistant to erosion, abrasion, and corrosive wear, and offer promising solutions for demanding medical applications.

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Identifying the advancements of Friction Stir Welding: Innovations in Numerical Modeling and Simulation

Urmila H. Dakave[1] , Dr. Vivek V. Kulkarni[2]

Research Scholar, Mechanical Engg. Dept., Sanjay Ghodawat University, Atigre, Maharashtra
Professor, Mechanical Engg. Dept., Sanjay Ghodawat University, Atigre, Maharashtra

Abstract

Numerical modeling has played a pivotal role in advancing Friction Stir Welding technology, enabling process optimization, predicting weld quality, and enhancing our understanding of material behavior. This paper provides an overview on the advancement of numerical modeling techniques employed in FSW of various materials. It offers a comprehensive analysis of various modelling approaches, emphasizing their strengths, limitations, and recent advancements. The review assesses the challenges faced by numerical modeling in FSW, such as the complexity of physical phenomena, the need for robust validation, and computational demands. It emphasizes the role of numerical modeling in addressing these challenges and driving innovation in FSW technology. A critical aspect of the review is the exploration of material-specific modeling, simulation software's approaches considering the distinct behaviors of different materials. It underscores the importance of these techniques in advancing FSW technology, reducing costs, and promoting sustainability. By recognizing the evolving trends and challenges, this review provides a foundation for future research and development efforts in pursuit of even more precise and efficient FSW processes for joining of different materials

Keywords: FSW, Numerical modelling, Simulation software's, FEM, Materials, FSW challenges

Effects of Antimony vacancies and nanostructuring on thermoelectric properties of n-type InSb

Usharani Valaparla, and Suresh Perumal*

Laboratory for Energy and Advanced Devices (LEAD), Indian Institute of Technology, Hyderabad, Kandi 502284, Telangana, India.
**E-mail: suresh@msme.iith.ac.in*

Abstract

The escalating global energy demand and stringent environmental regulations have necessitated exploring alternative energy conversion technologies. Thermoelectric (TE) technology has emerged as a promising route for energy harvesting as it can directly convert thermal energy into electrical power and vice versa, by harvesting the waste heat from various sectors, such as thermal power plants, automotive exhausts and industries [1]. The efficiency of TE materials is conventionally quantified by the dimensionless figure of merit $zT = S^2\sigma T/(\kappa_{ele}+\kappa_{lat})$, which is related to inter-dependent parameters of Seebeck coefficient (S), electrical conductivity (σ), lattice (κ_l) and electronic (κ_e) thermal conductivities with absolute temperature, T. To enhance the zT, it is indeed important to decouple the electronic and thermal properties, which is a challenging task due to its interdependency. Nevertheless, some classes of materials, such as Bi_2Te_3, PbTe, GeTe, and SiGe, exhibit significantly large TE performance; however, they are less attractive because of their toxic and expensive nature [2].

Further, most of the high-performance TE materials are p-type semiconductors which urges us to explore the counter n-type materials for device fabrication. Here, we have prepared eco-friendly, cost-efficient, and earth-abundant n-type nanostructured Sb-deficient InSb for intermediate-temperature TE applications[3]. Phase confirmation and microstructural analyses were done using XRD and SEM. It is noticed that Sb vacancies notably increases the electrical conductivity and thereby increases the power factor. Further, nanostructuring results in low lattice thermal conductivity due to grain boundary-assisted phonon scattering. In this study, we shall present the effects of Sb-vacancies and nanostructuring on the thermoelectric properties of n-type InSb with experimental and theoretical insights.

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AC Conductivity and Humidity Sensing behaviour of PTh-Nanoclay composites

Devindrappa Patil[1*], Manjunatha S[2], Madesh Kumar M[1], Ravikiran YT[3] Revanasiddappa M[4],

[1]School of Applied Sciences, REVA University, Bangalore, Karnataka 560064 India.
[2]Department of Physics, Kishkinda University, Ballari, 583104, India
[3]Department of Physics, Government Science College, Holalkere, 577526, India
[4]Department of Chemistry, PES University, Electronic City Campus, Bangalore 560100, India
**E-mail: devupatil77@gmail.com*

Abstract

Polythiophene (PT) – Nanoclay, composites were synthesized by in situ polymerization method in the varying compositions of nanoclay of 2, 4, 6 and 8 wt% using $FeCl_3$ as an oxidizing agent. Morphological and structural characterization were performed using FT-IR, XRD (X- Ray Diffraction), SEM (Scanning Electron Microscopy). AC conductivity studies were carried out in the frequency range 50 Hz – 1 MHz and humidity sensing studies were conducted in the relative humidity range 11% RH – 97% RH at room temperature. Among all the composites 6 wt% composite exhibited a higher conductivity of increase in two orders compared to pristine polythiophene and 8 wt% composite demonstrated an appreciable humidity sensing behaviour with good sensitivity, linearity, LOD and stability.

One-Step Biofuel-Assisted Flame Treatment for Fabricating Flexible, Durable, and Transparent Superhydrophobic Films

Reshab Pradhan, and Harpreet Singh Grewal#

Surface Science and Tribology Lab, Department of Mechanical Engineering, Shiv Nadar Institution of Eminence, Gautam Budh Nagar, UP, India

**Presenter's Email: rp943@snu.edu.in*

Abstract

The performance of various engineering systems, including solar panels, flexible electronics, and optical devices, is often hindered by atmospheric contamination. Pollutant and salt-laden aerosols and rain significantly reduce the functionality of these systems. In this study, we developed flexible, semi-transparent, and durable superhydrophobic films designed for complex geometrical surfaces. We demonstrated that a simple and environmentally friendly biofuel-based flame treatment can be effectively optimized to create durable superhydrophobic polydimethylsiloxane (PDMS) films in under a minute, without the need for any pre-treatment. This treatment induces the formation of a coral-like wrinkled morphology, adorned with in-situ synthesized functionalized silica nanoparticles. By carefully tuning the processing conditions, we achieved a hierarchically structured surface that exhibits excellent water repellency ($\theta > 160°$) and repellency to other liquids, including blood, with low hysteresis (<5°) and sliding angles (<5°). The adhesion to water is extremely low (~2 µN), outperforming even the Lotus leaf (~10 µN). These extreme dewetting and low adhesion properties are attributed to the coral-like structures formed by agglomerated silica nanoparticles, which generate negative capillary pressure exceeding 14 MPa. The films displayed outstanding resistance to harsh physical and chemical environments, withstanding over 20,000 droplet impacts and more than one year of weathering without significant damage. The developed superhydrophobic, flexible, durable, and semi-transparent films hold great potential for use in non-wettable, self-cleaning structures, even those with intricate shapes.

High-Temperature Mechanical properties of Haynes 282® Nickel base superalloy processed through Laser Powder Bed Fusion Additive Manufacturing Process

Harinarayan Namdev a, Purnendu Das a,b, Nithin B [a]

[a] *Department of Materials Science and Metallurgical Engineering, Indian Institute of Technology Bhilai, Chhattisgarh 491001*

[b] *Department of Mechanical Engineering, Indian Institute of Technology Bhilai, Chhattisgarh 491001*

Abstract

In order to increase an efficiency and reduce the emission of greenhouse gases, there is an urge to increase the operating temperature of advanced ultra-supercritical (AUSC) power plants. Currently, Ferritic/martensitic dual-phase steels are the material of choice for such applications. However, the dual phase steel has temperature limitations, and so in order to further increase the operating temperature of AUSC, the development of alternative materials with high-temperature capabilities is critical. Nickel base superalloys are possible alloy classes that can be used in an A-USC power plant. Among available nickel-based superalloys, Haynes 282® is an ideal candidate for the A-USC application. Haynes 282® is a precipitate-strengthened nickel-base superalloy (combination of L12-ordered coherent γ′ precipitates and carbides) and exhibits better creep and oxidation resistance along with good processability (Thermo-mechanical processing and welding). At present, this alloy is processed through conventional casting followed by thermo-mechanical heat treatment. Some parts in A-USC have intricate shapes and require precision dimensional clearance, which is difficult to achieve through conventional processes. In this study, we explored the Laser powder bed fusion additive manufacturing (LPBF-AM) of Haynes 282® nickel-base superalloy. The process parameters were optimized based on the distribution of defects and microstructural evolution. The heat treatment parameters were optimized based on the distribution of precipitates in the matrix and the mechanical properties. The creep behavior for the optimized heat treatment cycle was further explored in the temperature range of 560-760°C and stress values of 300,400 and 500 MPa. The active deformation mechanisms during the creep were discussed based on the obtained Norton's creep exponent (n) and activation energy (Q) values and are correlated with the crept microstructure. The detailed microstructural analysis was carried out using a correlative EBSD-TEM and APT analysis. Further, the effect of varying load, speed and distance on wear behavior at elevated temperatures was studied and a detailed comparison with conventional Haynes 282® nickel superalloy is made.

Keywords: Nickel base superalloys, Creep, Additive Manufacturing, correlative microscopy techniques.

Bio-inspired Synthesis of Metal oxide Nanoparticles from Neltuma juliflora (Sw.) Raf. Leaf Extract for Antimicrobial and Anticancer applications."

Nagaraja H[1*], Monica K.J. Nidhi[1], Hanumanthagouda B[2], Kotresh M G[2], Uma Reddy B[1]

[1]Department of Botany, Vijayanagara Sri Krishnadevaraya University, Ballari - 583105, Karnataka, India.
[2]Department of Physics, Vijayanagara Sri Krishnadevaraya University, Ballari - 583105, Karnataka, India.
**Email: nagarajah@vskub.ac.in*

Abstract

The current study presents a bio-inspired method for synthesizing metal oxide nanoparticles using Neltuma juliflora (Sw.) Raf. leaf extract as a reducing and stabilizing agent. This green synthesis method offers a sustainable substitute to conventional chemical techniques, minimizing the reliance on harmful chemicals. The nanoparticles were characterized using UV-Visible spectroscopy, FTIR, X-ray diffraction, and scanning electron microscopy, confirming their Optical, chemical, and physical characteristics. The antimicrobial activity of the nanoparticles was evaluated against Gram-positive (Enterococcus faecalis, Staphylococcus aureus), and Gram-negative (Pseudomonas aeruginosa, and Escherichia coli) bacterial strains, demonstrating significant inhibition of microbial growth. Further, the haemolytic and coagulation tests, combined with DPPH analysis, demonstrated that the NiO nanoparticles had excellent biocompatibility and robust antioxidant activity. Thus, Additional, cytotoxicity of NiO was assessed on cancer cell lines using the MTT assay, showing a dose-dependent cytotoxic effect. These findings emphasize the potential of these metal oxide nanoparticles as multifunctional agents in biomedical applications and underscore the suitability of N. juliflora (Sw.) Raf. for the eco-friendly fabrication of biocompatible nanoparticles with therapeutic potential.

Keywords: Nickel oxide Nanoparticles, Antimicrobial, Antioxidant, Anticancer

Acknoweledgments
The financial support from "NFST Fellowship by Ministry of Tribal Affairs, GOVT OF INDIA", and "KSTEPS, DST, GOVT. OF KARNATAKA" is greatly acknowledged. The physico-chemical characterization portions of the research were performed using facilities at CeNSE, Indian institute of Science, Bengaluru, Centre for Excellence for Multidisciplinary Advanced Research Facility, Vijayanagara Sri Krishnadevaraya University, Ballari. The authors thank to Dr. Gajendra Verma, VIMS, Ballari for gifting the ATCC Bacterial strains, and Dr. Shringeswara A N, Mahatma Gandhi Botanical Garden, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bangalore for plant identification, and authentication.

A novel green manufacturing route for developing metal powders for additive manufacturing: An experimental investigation of IN718 alloy

Manish Kumar Tiwari*, and R. Jose Immanuel

Advanced Materials Development and Characterization Group, Department of Mechanical Engineering, Indian Institute of Technology Bhilai, Durg, Chhattisgarh, INDIA
** Presenting Author, E-mail id: manishkt@iitbhilai.ac.in*

Abstract

In the subtracting manufacturing process, a large amount of raw material is converted to waste chips which are traditionally recycled back through the primary manufacturing process. However, recent studies revealed that these chips offer a suitable green alternative in powder metallurgy. This work is an attempt to explore the potential of machining chips towards stock powder for metal additive manufacturing (AM). Compared to conventional, energy-intensive powder development processes such as gas/water atomization, reusing recycled chips to produce powders reduces the environmental impact, conserves resources, and saves the cost of powder production.

The present work aims at producing powders from recycled machining chips and investigating the feasibility of using the developed powders in additive manufacturing. Inconel-718 alloy is chosen as the material for the intended study. Machining chips were generated through the face milling process, where different milling parameters were used to generate chips of different morphologies. The generated chips were characterized for their phase purity, oxide formation, etc. Generated chips were subjected to a two-step chemical cleaning process. High energy ball milling process is used for powder generation. The milling chips were classified into various sizes through mechanical sieving before ball milling. A process window consisting of various ball-milling parameters to generate AM-quality powders is developed for chips of various morphologies. The developed powders were characterized for their shape, size distribution, and elemental composition using Scanning Electron Microscopy and X-ray Diffraction methods. Results indicate that a high-energy ball-milling process can suitably convert machining chips to powders. With a required particle size distribution ranging between 15 to 50 m, the obtained powders were found to possess near-spherical morphology with retained chemical integrity. A sample AM build was done using the developed through Laser Powder Bed Fusion (LPBF) and the build quality was assessed and compared with AM print from commercial powder.

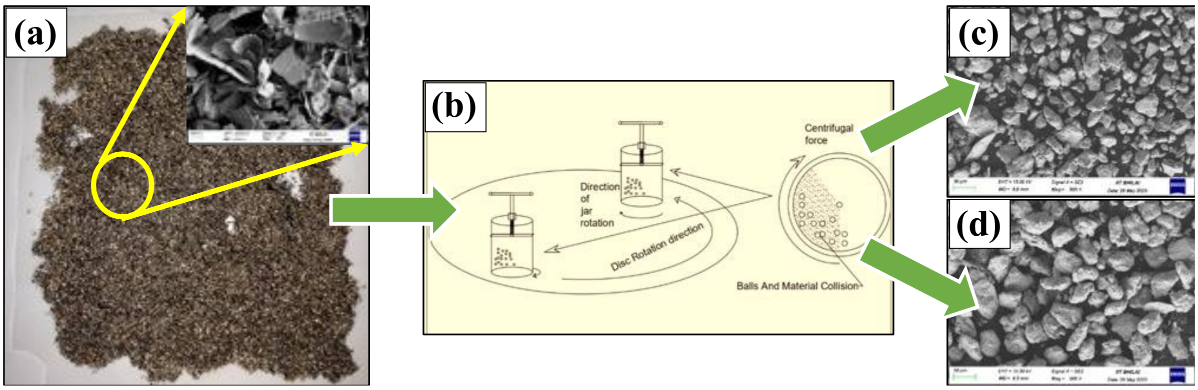

Figure 1 (a) pictograph of machined chips with the inset revealing their morphology, (b) Schematic diagram of high-energy ball-milling process, (c) & (d) SEM micrographs of developed powders.

Adjustable Prosthetics Design of Feet for the Age Group 5-10.

Khushi H. Sharma[1], Aryan S. Nandgaonkar[2], Arin A. Thale[3],
Ankita J. Sartape[4], Sunny Sarraf[5], Afzal Ansari[6]
[1, 2, 3, 4, 5, 6] Department of Mechanical Engineering, Fr. C. Rodrigues Institute of Technology, Vashi, India.
sharmakhushihemant@gmail.com

Abstract

Traditional prosthetic feet have mostly failed the physical and developmental demands that active children place on these prostheses, often resulting in frequent replacements due to wear, tear, and growth. This has been a persistent problem that seriously hinders the possibility of comfort, functionality, and adaptability in paediatric prosthetics in the long run. One promising development is the design of adjustable prosthetics that are designed to grow with a child and withstand a great deal more activity. These new prosthetics are reinforced with 3D printing technology and provide a unique blend of customization, resilience, and adaptability, which makes them highly suitable for children from 5 to 10 years old. This research is targeted at the design for and development of light, tough, prosthetic feet that can accommodate rapid growth and active lifestyles common in children.

To this end, the prosthetic devices will be made from biocompatible materials, easily adjusted and modified as the child grows to reduce replacement frequency. Along with toughness, comfort is a paramount factor to ensure the long-term usability of the prosthetic. With the addition of 3D printing technology, these devices can be highly customized to a child's specific anatomic and biomechanical requirements, fitting much closer with less discomfort and irritation. The initial test results are promising, with prototypes doing very well in all three areas: durability, comfort, and functionality during rigorous physical activity. Although in their infancy of development, the data would seem to indicate that 3D-printed prosthetic feet represent a potential solution for improving paediatric patient quality of life. Future research will be directed at further optimization of materials, refinement of the adjustable mechanisms, and long-term usability studies that ensure these prosthetics meet the demands of growing children over time.

Keywords: paediatric prosthetics, 3D printing, biocompatible materials, growth accommodation, lightweight design, adaptability, comfort, active children.

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Patterning of Colloids by Freeze Drying

Sagarika Bhattacharjee[1*], Pratik K. Ray[1], and Madivala G. Basavarj[2]

[1] Department of Metallurgical and Materials Engineering, Indian Institute of Technology Ropar, Rupnagar, Punjab, India

[2] Department of Chemical Engineering, Indian Institute of Technology Madras, Chennai, Tamil Nadu, India

**sagarika.20mmz0006@iitrpr.ac.in*

Abstract

Self-assembly of colloids is a versatile tool to create two or three dimensional functional solid surfaces. The arrangement of particles in such self-assembled materials can be tuned by exploiting colloidal interactions or by the application of external fields. In this study, we consider the use of freeze drying to tailor the deposition of particles on solid substrates. Freeze drying, or lyophilization is a dehydration technique that is typically employed to preserve a substance by removing its water content. We consider freeze drying dispersions of model spherical and ellipsoidal particles of varying sizes, aspect ratio and concentration. Optical microscopy along with some advanced characterization techniques such as scanning electron microscopy (SEM) and X-ray diffraction (XRD) are employed to evaluate the effect of particle shape on the arrangement of particles and structural integrity of the particulate deposits formed by freeze drying of colloidal dispersions. Findings reveal significant variations in particle organization and structural properties based on the shape and surface charge of the particles. Additionally, studies have been carried out by varying pH across the isoelectric point of particles. This comprehensive study provides critical insights into the role of particle dimensionality on scalable soft-patterning techniques such as colloidal lithography.

Establishing a process map of microstructural and phase changes through molten pool thermal history for ex-situ and in-situ laser cladding of TiN/ Inconel 625 MMC

Dolagobinda Sethi*, Prabhat Kumar, Suvradip Mullick

School of Mechanical Sciences, Indian Institute of Technology Bhubaneswar, India
**a24me09003@iitbbs.ac.in*

Abstract

This study aims to develop a process map based on the thermal history of the molten pool to predict the formation of specific phases along with microstructural changes under varying process parameters for laser cladding of TiN/Inconel 625 Metal Matrix Composites (MMCs). TiN/Inconel 625 MMCs were deposited onto SS304 substrates using preplaced laser cladding technique through ex-situ and in-situ deposition methods. For the ex-situ process, a pre-mixed layer of 30% TiN and 70% Inconel 625 (by weight) was irradiated with a continuous-wave (CW) Yb-fiber laser with 220 W power. In the in-situ process, 5% Ti and 95% Inconel 625 (by weight) preplaced powder layer was subjected to laser irradiation in a nitrogen gas environment, leading to the in-situ formation of TiN during deposition. The depositions were carried out under variable line energy conditions by varying the scan speed, with the operational line energy range being 83-110 J/mm for the ex-situ process and 110-146 J/mm for the in-situ process, reflecting the different reaction mechanisms in these conditions. Under ex-situ conditions, line energy played a crucial role in the decomposition of TiN and consequent formation of intermetallic Ti-Ni compounds and TiN during solidification. Conversely, in the in-situ process, the nitrogen gas flow rate influenced the amount of TiN formed, while line energy affected Ti-Ni phase formation. The microstructural characteristics and phase formations were correlated with thermal history profiles obtained via infrared pyrometer. Temperature profiles revealed distinct solidification shelves at different temperatures, indicative of specific phase formations. The solidification shelves at 1670-1800°C and 950-1100°C corresponded to TiN re-solidification and Ti-Ni phase formation respectively. Further a specific phase of Fe-Ni was identified and a corresponding solidification shelf was observed at 1420-1500°C in case of ex-situ deposition under specific conditions. Thus, the development of process map can help to identify phase formation based on these solidification shelves and hence minimizing the need for post-processing analysis. The microstructural characteristics and formation of phases were analysed in the current study through SEM, EDS and XRD.

Keywords: ex-situ, in-situ, MMCs, Inconel 625, Titanium Nitride, thermal history

Wire Arc Additive Manufacturing based alloy development approach for Copper: A comparison study on the pure copper and Cu-Ni alloy against Vacuum Arc Melting method.

Shivraj Gahir[1*], M Hemachandra[2], Shivraman Thapliyal[2] and R. Jose Immanuel[1]

[1]Advanced Materials Development and Characterization Groupd, Department of Mechanical Engineering, Indian Institute of Technology Bhilai, Durg, India
[2]Mechanical Engineering Department, National Institute of Technology Warangal, India
** Presenting Author, E-mail id: shivrajgahir@iitbhilai.ac.in*

Abstract

Copper-based alloys exhibit a unique combination of electrical and mechanical properties, making them versatile for various applications. However, attempts in improving the mechanical properties have often led to detrimental effect on the electrical properties. Additive manufacturing (AM) technologies have opened up novel ways for rapid material development that includes developing alloys, functionally graded materials, composites, etc. Versatile AM techniques employing LASER as energy source has its own disadvantage when it comes to printing of copper alloys owing to their higher reflectivity and lesser energy absorption.

In this work an attempt is being made to explore the potential of wire arc additive manufacturing (WAAM) in the alloy development for copper-based system. A parametric study on printing commercially pure copper and Cu-2Ni alloy using WAAM is presented here. Process optimization is done based on build quality, porosity, etc. Metallurgical and mechanical performance of the printed material is compared against the same material cast using conventional vacuum arc melting process. Detailed analysis on the mechanical performance is performed through tensile testing along build, scanning and traverse directions. Microstructural correlation and texture components were also presented for the developed materials establishing a structure-property correlationship for WAAM developed Copper and its alloy.

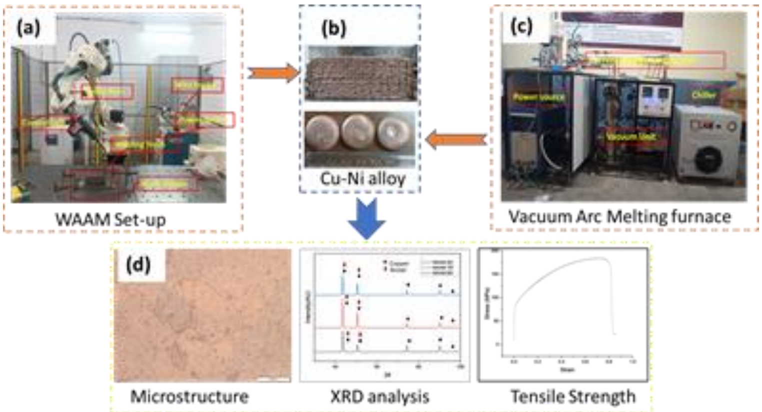

Figure 6: (a) WAAM set-up; (b) Developed Cu-Ni alloys; (c) Vacuum arc melting furnace set-up; (d) characterization of developed alloys.

Fabrication and analysis of dual hardness steel through laser DED

Sidhartha Sankar Swain*, Rohan Ranjan Shandilya, Prabhat Kumar, Suvradip Mullick

School of Mechanical Sciences, Indian Institute of Technology Bhubaneswar, India
**23mf06020@iitbbs.ac.in*

Abstract

Dual hardness steel, characterized by varying hardness levels, provides enhanced performance for industrial applications. However, traditional manufacturing methods, such as roll bonding and hot forging, often lead to defects including pinholes, voids, and poor interfacial bonding, which can result in cracking, delamination, and compromised structural integrity. Alternative methods like weld cladding and interlayer diffusion bonding have not proven effective for large-scale industrial applications. This study investigates the feasibility of fabricating dual hardness steel through the laser direct energy deposition (DED) technique. SS316l and SS420 are chosen as high corrosion and hardness materials respectively suitable for defence applications. The primary objective is to establish an operational window to achieve void-free multilayer deposits of the individual materials and subsequently, the fabrication of dual hardness steel. DED is also observed to produce voids during the fabrication of dual hardness steel; however, optimization of process parameters, including line energy and powder feed rate, as well as the implementation of melt pool interlayer vibration and inter pass laser re-melting, significantly reduced defects. The optimal parameters under laser power of 220 W with a powder feed rate of 7 g/min and line energy of 132 J/mm for SS316L, combined with inter inter-pass re-melting strategy minimize the voids and enhance surface smoothness. For SS420 a slightly reduced power and increase in line energy with remelting gives better results. The highest recorded hardness ranged between 600-700 HV. Further the application of post-processing a minor compromise in hardness is observed. Ongoing research is focused on evaluating additional mechanical strength, and surface properties. These findings are expected to advance the fabrication techniques for dual hardness steel, facilitating its broader application in demanding industrial environments.

Keywords: Dual hardness steel, Laser direct energy deposition, ultrasonic vibration, re-melting, interfacial bonding, structural integrity.

Focal Offset Distance as a Key Enabler for Microstructure Control in Additively Manufactured Ti-6Al-4V during High Power LPBF

Sahil Dhiman[1, 2]*, Milan Brandt[3], Daniel Fabijanic[4], Wei Xu[2], Viswanath Chinthapenta[1]

[1] Micro-Mechanics Lab, Department of Mechanical and Aerospace Engineering, Indian Institute of Technology Hyderabad, NH-65, Sangareddy, Kandi, Telangana 502285, India
[2] School of Engineering, Deakin University, Geelong, VIC, 3216, Australia
[3]Centre for Additive Manufacturing, School of Engineering, RMIT University, Melbourne, VIC 3000, Australia
[4]Institute of Frontier Materials, Deakin University, Geelong, VIC, 3216, Australia
** id21resch11020@iith.ac.in; dhimansah@deakin.edu.au*

Abstract

Laser powder bed fusion (LPBF) is a premier additive manufacturing (AM) process capable of making intricate metallic parts with short lead time, but its widespread industrial acceptance is still limited due to its low build rate in producing high-quality near-net-shape parts. Herein, we have demonstrated the capability of focal offset distance (FOD, distance between laser's focal point relative to the surface of the powder bed) during high laser power LPBF for the manufacture of quality Ti-6Al-4V at a much-increased build rate, combined with decent dimensional accuracy, and suitable microstructure. For a given high laser power of 600 W, a small focal offset distance imparts a thermal environment with reduced cooling rates to facilitate the formation of globular α and equiaxed prior-β grains at a much lower critical energy density than that under low power. In contrast, increased FOD leads to the formation of lamellar α+β and α' martensite having elongated prior-β grains along the build direction. The findings in this work advance our understanding of optimizing the LPBF process in the high-power regime towards sustainable and efficient manufacturing of quality Ti-6Al-4V components with regulated microstructures.

Graphite oxide embedded polyaniline hybrids for high frequency electromagnetic wave attenuation and EMI shielding

Girisha T N[a], Thulasi R[a], Maruthi N[b], Narasimha Raghavendra [c] and Muhammad Faisal [a]*

[a]*Research Center-Physics, PES University-Electronic City Campus, Bangalore- 560100, Karnataka, India*
[b]*Department of Physics, Faculty of Engineering and Technology, Jain University, Bangalore -562112, Karnataka, India.*
[c] *Department of Chemistry, K.L.E Societies P.C. Jabin Science College Hubballi-580031, Karnataka, India*
*Correspondence author: E-mail: *muhammadfaisal@pes.edu (Muhammad Faisal)*

Abstract

With the ever-increasing use of smart electro/electrical devices and systems, electromagnetic interference (EMI) has become highly sensitive issue and needs to be suppressed. The adverse effects of, EMI, the silent invisible pollution cannot be underestimated as it is associated with the operational efficiency of the devices and also the living beings. In this study composites of conducting polyaniline (PAni) dispersed with graphite oxide (GO) have been synthesized by in-situ chemical oxidative polymerization and tested for broadband electromagnetic (EM) wave attenuation and EMI shielding. These composite hybrids have been characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy and high-resolution transmission electron microscopy (TEM) for structural and morphological features. SEM and TEM results showed modified morphological features of conducing network of PAni matrix in the presence of dispersant GO. The EM wave attenuation and EMI shielding properties have been investigated using transmission line waveguide technique in the frequency range of 8 to 12 GHz (microwave X-band). The composite samples have shown EMI shielding efficiency (EMI SE) in the range of -39 dB to -47 dB which demonstrates that more than 99% of the incident EM energy has been attenuated. The observed absorption coefficient was in the range of 60 to 70% clarifying that polyaniline-coated graphite oxide composites can be optimized as potential broadband electromagnetic wave absorbers and shields. These EMI shielding results can be primarily attributed to the modified complex dielectric permittivity of polyaniline in the presence of graphite oxide. These composites combine the morphological and electrical properties of both polyaniline (PAni) and graphite oxide (GO), and can effectively absorb electromagnetic waves across a wide frequency range with very high EMI SE.

Enchancing energy absorption characteristics of modified Euplectella aspergillum-inspired lattice structure

Pabitra Kumar Sahu* and Somaskekhar S Hiremath

Department of Mechanical engineering, IIT Madras, Chennai, India
** pabitrasahu1994@gmail.com*

Abstract

In this study, new lattice structures are developed by modifying the Euplectella aspergillum-inspired lattice structure. Five modified lattice structures are designed and printed using thermoplastic polyurethane (TPU) via the fused filament fabrication (FFF) method. The experimental and numerical analysis of structures under uniaxial quasi-static compressive load was carried out to investigate the mechanical properties like specific energy absorption, elastic modulus, and mean plateau stress. The deformation behaviour of modified structures is also investigated. It was observed that adding additional struts to the structure improved the energy absorption capacity. The four-corner and tri-diagonal strut Euplectella aspergillum-inspired lattice (EA5) structure showed higher mechanical properties than others. The deformation behaviour and higher energy absorption properties of modified Euplectella aspergillum-inspired lattice structures are presented.

Keywords: Lattice strutures, Energy absorption, 3D printing, Fused filament fabrication

Eco-friendly Electropolishing of SS304L Stainless Steel for Nuclear Fusion Applications

Uday Kumar[1,2*], Rizwan Ahmad Qureshi[3], Jhansi Kokkiligadda[1], Hitensinh Vaghela[2], Amit Arora[2] and Parasuraman Swaminathan[1]

[1] Department of Metallurgical and Materials Engineering, IIT Madras, Chennai, India
[2] ITER-India, Institute for Plasma Research, Ahmedabad, India
[3]Indian Institute of Technology Gandhinagar, India
**E-mail: mm20s033@smail.iitm.ac.in, uday.kumar@iterindia.in,*

Abstract

Stainless steel SS304L is extensively used as a construction material for cryogenic systems due to its high mechanical strength and ductility, low thermal expansion coefficient, and excellent corrosion resistance. One of the most critical design criteria is the low thermal emissivity of SS304 for regulating radiative heat transfer among components of cryogenic and superconducting systems utilized in nuclear fusion engines like the ITER tokamak. It is advantageous to reduce the overall operational cost by reducing the heat load on the cryogenics system. The parasitic radiation heat transfer can be effectively reduced by lowering the emissivity of stainless steel. The emissivity of a material is a surface property that strongly depends on its surface quality, such as roughness, oxidation, and impurity. Mechanical polishing, followed by electropolishing, is an established material processing method in industry for enhancing surface quality to reduce emissivity. Electropolishing is usually conducted in concentrated sulfuric acid, phosphoric or perchloric acid, and their mixtures. However, the strong corrosive property of concentrated sulfuric acid is hazardous for operators, readily corrodes experimental apparatus and is detrimental to the environment. Furthermore, the sulfuric acid electrolyte employed in the process of electropolishing itself is classified as hazardous waste. The environmentally detrimental effects of electropolishing byproducts, including hazardous residue electrolytes and heavy metals, may threaten aquatic organisms. In this work, sulfuric acid-free electropolishing of SS304L was performed by using phosphoric acid and glycerol with an equal volume ratio of 1:1. The emissivity of polished samples was measured using a portable emissometer following the ASTM C1371 standard. To reduce the surface roughness and emissivity of SS304L, the as-received samples (Ra:3 - 4.5µm and $\in_h$: 0.36) were mechanically polished to a submicron level before electropolishing. The results show the surface roughness (Ra) and emissivity ($\in_h$) reduced to 0.073 ± 0.014 µm and 0.12 ± 0.01, respectively. It is observed that the experimental emissivity of the electropolished SS304L at room temperature is marginally higher than the theoretical value owing to the existence of certain surface irregularities and the development of a passive oxide layer on the outermost surface

Influence of tool profile on temperature distribution and residual stress development during friction stir processing of aluminium 7068 alloy

Rahul Singh Patel[1*], Jose Immanuel R.[1]

[1] Advanced Materials Development and Characterization Group, Department of Mechanical Engineering, Indian Institute of Technology Bhilai, India
** Presenting Author, E-mail id: rahulpatel@iitbhilai.ac.in*

Abstract

Al-7068, a precipitate hardenable alloy from the 7xxx series, is a relatively recent addition to the aerospace sector, exhibiting superior hardness and strength compared to its closest competitor, Al-7075, from the same series. Despite several research aimed at advancing friction stir processing (FSP) technology, the impact of FSP on the mechanical and microstructural characteristics of Al-7068 alloy needs additional exploration. The connections among tool profile, mechanical properties, and microstructural features of Al 7068 alloy remain inadequately comprehended. Precise correlations are essential for effective process optimization. This study used three distinct tool pin profiles (tapered threaded cylindrical, triangular, and square) with shoulder diameters of 20 mm to process Al-7068. A 6 mm thick Al-7068 solution-treated plate has undergone FSP to investigate the resulting microstructure and its impact on mechanical characteristics. A tool rotational speed of 1000 rpm and a traverse speed of 50 mm/minute was used for processing. The creation of the friction stir zone and grain refinement resulting from severe plastic deformation (SPD) has been examined macroscopically using a field emission scanning electron microscope (FESEM). The mechanical characteristics of the friction stir processed materials have been assessed and associated with the creation of the FSP zone utilizing a universal testing machine (UTM) and hardness testing. The occurrence of dynamic recrystallization throughout the process, as well as the presence of different orientations inside the stir zone and across the transition zone, has been examined using electron backscattered diffraction (EBSD). The temperature produced during FSP significantly influences the microstructure and characteristics of the treated plate, as well as the tool's longevity. A thermal imaging camera has been used to assess the temperature distributions of Al-7068 plates during FSP. This setup employs two infrared detectors to mitigate emissivity and facial effects, operating at a 40 Hz acquisition rate. The relationship between temperature variations and process parameters, together with their impact on the final microstructure, has been examined. FSP applies heat energy and mechanical force to the material, resulting in metallurgical transformations and a complicated residual stress state. X-ray diffraction (XRD), a non-destructive technique for assessing the residual stress in crystalline materials, has been used to detect residual stress in both longitudinal and transverse directions. Residual stresses were ascertained from the diffraction data by computing the strain from the diffraction peak locations via the sin2ψ method.

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Ramesha B S
Head - Academic Initiatives
rambs@altair.com
+91-9177770258

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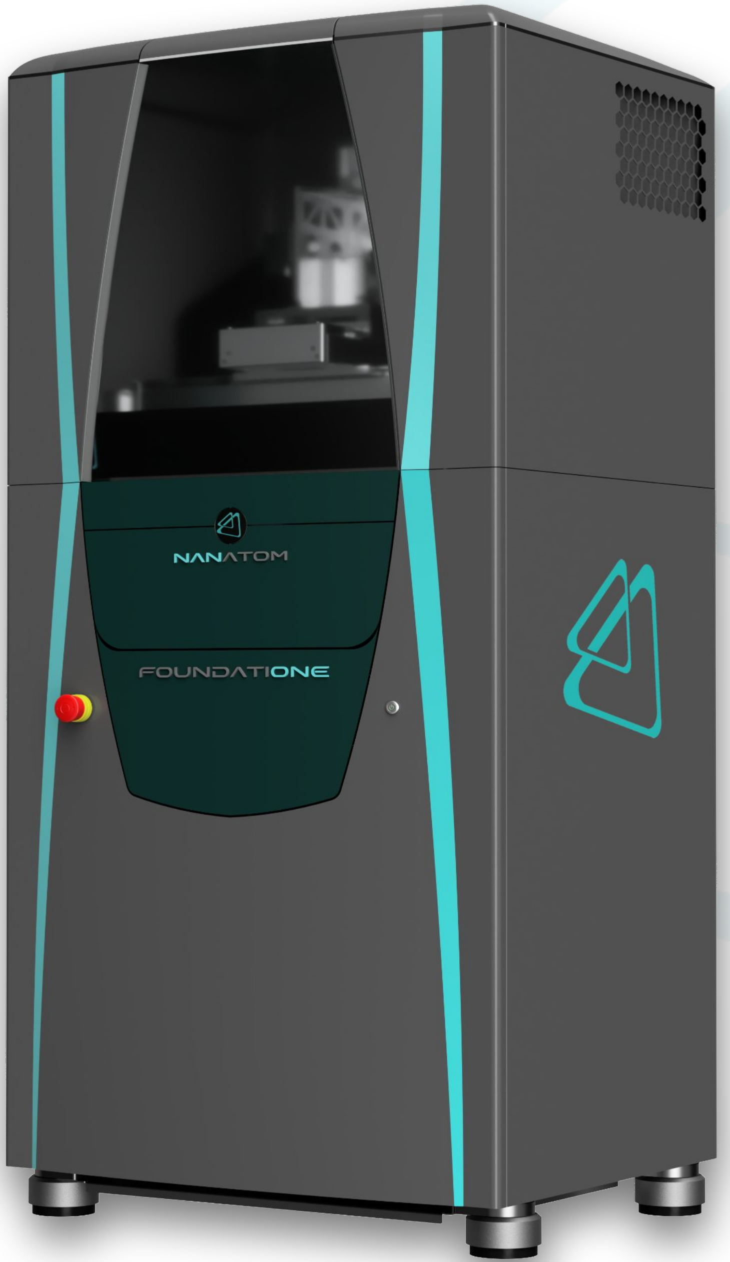
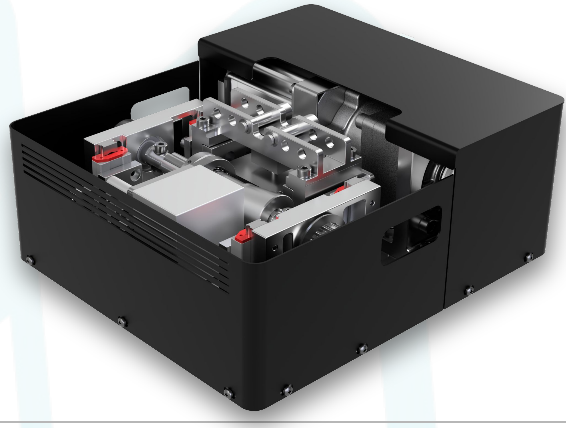


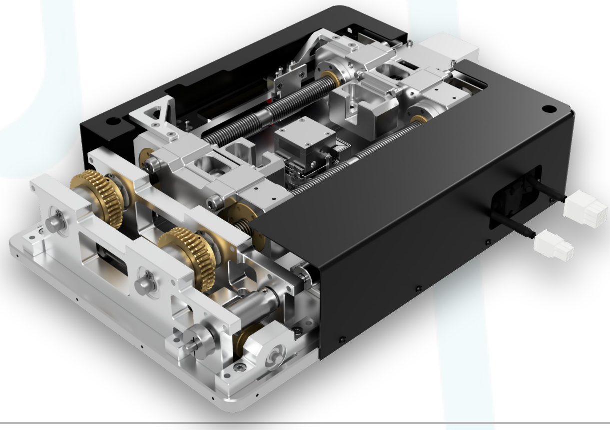
CYCLOPX

'In-situ' Micro Mechanical Test Stage



TRAVIX

'In-situ' Three point bend Fatigue analysis



HTHT

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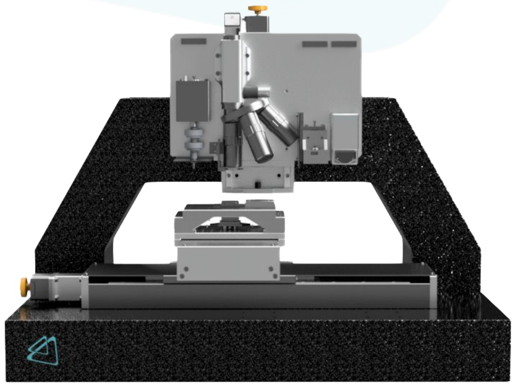

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