ITRS 2021

2nd Virtual International Tribology Research Symposium

8th to 10th December 2021

Book of Abstracts

Editors

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Jointly Organized with

National Institute of Technology Karnataka Surathkal, Karnataka, India

Centre for Advanced Studies Dr. A P J Abdul Kalam Technical University (CAS-AKTU) Lucknow, UP, India

Shri Mata Vaishno Devi University (SMVDU) J&K, India

Madanapalle Institute of Technology & Science, AP, India

Universiti Technologi MARA, Malaysia (UiTM)

University of Salerno, Italy (UNISA)

2nd Virtual International Tribology Research Symposium

Theme: Tribology for Sustainability And Reliability

8th December to 10th December 2021

Jointly Organized
National Institute of Technology Karnataka Surathkal, Karnataka, India
Centre for Advanced Studies Dr. A P J Abdul Kalam Technical University (CAS-AKTU) Lucknow, UP, India
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2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

Session 1 **Session Coordinator: Prof. T V V L N Rao** **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**	**Time**
Inauguration	9:00 AM – 10:00 AM
Plenary 1 (Inaugural Talk) Prof. Ali Erdemir, TEES Eminent Professor, Texas A&M University USA **Title:** Engineered Tribological Interfaces for a Green and Sustainable Future	10:00 AM-10: 40 AM (IST) 10:30 PM to 11:10 PM (UST) (7 Dec 2021)
Keynote 1 Prof. Dr. Hakan KALELİ Yildiz Teknik Universitesi, Makine Fakultesi, Turkey **Title:** Tribological Investigation of the Effect of (rGO) Reduced Graphene Oxide Nanoparticle Additive Added to Ship Diesel Engine Oil on Engine Cylinder Wear	10:40 AM-11:25 AM (IST) 8:10AM-8:45 AM (Turkey Time)
Break (5 Minutes)	
Session 2 (11:30 AM – 01:42 PM) **Session Chair:** Dr. T V K Gupta, VNIT Nagpur **Session Coordinators:** Dr. Ranjeet Kumar Sahu NIT Karnataka Surathkal **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**	

Paper ID	**Invited/Oral Session**	**Time**
Dr. O P Khatri, CSIR-IIP Dehradun, India **Title:** Role of Tribology in Energy Efficiency and Environmental Conservation		11:30 AM-11:54 AM
ITRS325	Metallic Titanium Nanoparticles as Potential Anti-wear additive Vinay Saini, Jayashree Bijwe*, Sarita Seth & SSV Ramakumar Indian Institute of Technology Delhi, India	11:54 AM-12:06PM
ITRS323	Effect of Surfactants on Dispersion Stability and Tribological Behavior of Olive oil containing Graphene Nanoparticles. Amir Ashraf*, Mir Irfan Ul Haq, Ankush Raina, Wani Khalid Shafi *Shri Mata Vaishno Devi University, Katra, J& K, India	12:06 PM-12:18 PM
ITRS315	Lubrication behaviour of Rice bran and Sesame Greases using different nanoparticles Pranav Dev Srivyas, Mir IrfanUl Haq, Ankush Raina, M S Charoo, Seikh Amir Farooq *National Institute of Technology Trichy, TamilNadu.	12:18 PM-12:30 PM
ITRS314	Effect of Alumina and Titanium di oxide nanoparticles on Lubrication behaviour of Rice bran and Sesame Grease. Pranav Dev Srivyas, Mir Irfan Ul Haq, Ankush Raina, M S Charoo, Ovais Gulzar *National Institute of Technology Trichy, Tamil Nadu	12:30 PM-12:42 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

ITRS293	Study and Comparison of Thermal Conductivity, Interfacial Tension, and Wettability of Cutting Fluid on Different Unidirectional Surface Roughness of Ti67 Lalit Dehariya*, Ambesh singh, Suvin P.S, Vimal Edachery, Satish V Kailas *National Institute of Technology Karnataka, Surathkal	12:42 PM-12:54 PM
ITRS256	Sustainable Cutting Fluids: A Review Gauthamkrishna S*, M Harikumar, Maria Palacherril, Muhammed Razi, P S Suvin *National Institute of Technology Karnataka, Surathkal	12:54 PM- 01:06 PM
ITRS251	Effects of Viscosity Variation on Frictional force of a Triangular Plates Lubricated with Couple Stress Fluid Faizan Ahmed M and Sujatha E* *SRM Institute of Science and Technology, Kattankulathur	01:06 PM -01:18 PM
ITRS250	Effects of Viscosity Variation on Frictional Force of an Elliptic plate using Squeeze Film Technique Johny A and Sujatha E * *SRM Institute of Science and Technology, Kattankulathur	01:18 PM- 01:30 PM
ITRS273	THEORETICAL ANALYSIS AND CFD SIMULATION ON THE CERAMIC MONOLITH HEAT EXCHANGER Arun Singhvi, P. Baskara Sethupathi, J. Chandradass, A. Eakambaram and R. Silambarasan Department of Automobile Engineering, SRMIST, Kattankulathur	01:30 PM-01:42 PM
Session 3 (11:30 AM – 01:42 PM) **Session Chair:** Dr. Vipin Das, IIITDM, Kurnool **Session Coordinators:** Dr. P S Suvin, NIT Karnataka Surathkal **Link:** https://meet.google.com/vjp-hsxv-bcb		
Paper ID	**Invited/Oral Session**	**Time**
Prof. M F Wani, NIT Srinagar, India **Title: TBA**		11:30 AM-11:54 AM
ITRS236	Experimental Investigation of SAE20W40 Lubrication Bearing Under Different Loading, Speed and Pressure Parameters Avinash Tukaram Panchal* *G H Raisoni Institute of Business Management Jalgaon.	11:54 AM-12:06PM
ITRS233	The influence of nano- additives on the steady state performance of journal bearing. Deepak Byotra and Sanjay Sharma Shri Mata Vaishno Devi University Katra, J&K, India	12:06 PM-12:18 PM
ITRS227	Tribological Behaviour of Copper Ferrous Spinel Nanoparticles as an additive in Lubricant SN 500. Neelapu Avinash Reddy, Dharmender Singh Saini, Surendra Pal Singh Matharu* *National Institute of Technology, Raipur (C.G), 492010, India.	12:18 PM-12:30 PM
ITRS222	Synergistic effect of surface texturing and nano graphene platelets based nano-lubricant on the tribological improvement of spark plasma sintered aluminum-silicon alloy Pranav Dev Srivyas*, Ankush Raina, M. S. Charoo, Mir Ifran Ul Haq *National Institute of Technology Trichy, Tamil Nadu	12:30 PM-12:42 PM
ITRS219	An Experimental Investigation on Tribological Behaviour of Polyalphaolefin(PAO4) Oil Modified With Cu / MnS Nanocomposites MV Varalakshmi, V Venugopal Reddy* JNTU Anantapur, Andhra Pradesh, India.	12:42 PM-12:54 PM
ITRS209	Performance of porous surface hydrostatic thrust bearing operating with non-Newtonian lubricant	12:54 PM- 01:06 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

	Pushpendra K Kushwaha, Vivek Kumar, Vinay Vakharia and Satish C Sharma *Netaji Subhas Technical University (NSUT), New Delhi.	
ITRS206	Analysis of rough surface multi-lobe journal bearings operating in turbulent regime Kuldeep Narwat, Vivek Kumar, Simran Jeet Singh, Abhishek Kumar, Satish C Sharma *Netaji Subhas University of Technology (NSUT), New Delhi	01:06 PM -01:18 PM
ITRS204	Tribological Properties of Bio-degradable Lubricants Containing Graphene and Bacterial Nanocellulose Zahrul Fuadi*, Dieter Rahmadiawan, Rudi Kurniawan, Farid Mulana, Mohammad Khalid *Universitas Syiah Kuala, Banda Aceh, Indonesia	01:18 PM- 01:30 PM (IST) 2:48 PM -3:00 PM (Indonesia Time)
ITRS201	Role of surface waviness on the performance of hydrodynamic journal bearing Arun Bangotra* and Sanjay Sharma *Shri Mata Vaishno Devi University (SMVDU) J&K, India.	01:30 PM-01:42 PM
Session 4 (11:30 AM – 01:42 PM) **Session Chair:** Dr. Ram Krishna, MITS **Session Coordinators:** Dr. T V V L N Rao, MITS **Link:** https://meet.google.com/yxf-iyrr-nfv		
Paper ID	**Invited/Oral Session**	**Time**
Assoc. Prof. Koay Mei Hyie, Universiti of Technologi MARA **Title:** Surface Roughness and Hardness Investigation on Nickel-Cobalt-Iron coating at different surface pretreatment		11:30 AM-11:54 AM (IST) 2:00 PM -2:24 PM (MYT)
ITRS202	Effect of Friction Modifiers Compositions on Tribological Properties of Al/Al_2O_3 Brake Composite Material Amit K Chaurasiya, T V K Gupta, Jitendra Kumar Katiyar*, P Ramkumar Indian Institute of Technology Madras, Chennai India	11:54 AM-12:06PM
ITRS203	Bio-tribological Performance of Heat Treated and DLC Coated Ti6Al4V for Edge and Average Loading Conditions of Hip Implant Vivek Kashyap and P. Ramkumar* *Indian Institute of Technology Madras, Chennai India	12:06 PM-12:18 PM
ITRS205	Dry Sliding Tribological Behavior of AZ31-B 4 C Nano Composites Vikram P.Titarmare*, Sudip Banerjee, Prasanta Sahoo *Jadavpur University, Kolkata, India	12:18 PM-12:30 PM
ITRS207	Evaluation of Frictional Behavior of AA 2024 based Hybrid composites and Prediction using ANN model Nitish Singh Jammoria, Mir Irfan Ul Haq, and Ankush Raina* *Shri Mata Vaishno Devi University, Katra, J&K, India	12:30 PM-12:42 PM
ITRS208	A SCHEMATIC APPROACH FOR TOOL WERA OF 440C STEEL IN INCREMENTAL SHEET METAL FORMING Manish Oraon*, Vinay Sharma Birla Institute of Technology, Mesra, Ranchi, India	12:42 PM-12:54 PM
ITRS210	Electrical discharge coating of MoS 2 +SiC powder for enhanced wettability and tribological performance. Rashi Tyagi*, Ashutosh Tripathi, Nitish Kumar, Harish Bishwakarma, Alok Kumar Das, Amitava Mandal * Chandigarh university, India	12:54 PM- 01:06 PM
ITRS211	Study of Sinter Return Fines Generation and Their Effective Utilization: A Comprehensive View for Sinter Making in Rourkela Steel Plant Anup Kumar Dutta, Prasanta Kumar Padhi, Souvagya Mohanty, Jyoti Prakash Das, M. Sreenivas Rao, Santanu Mahanto	01:06 PM -01:18 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

	*Rourkela Steel Plant, Steel Authority of India Limited	
ITRS212	Research on Tribological Performance of Piston Ring/Liner Conjunction Considering Non-Gaussian Roughness and Cavitation Deepak K. Prajapati* Department of Mechanical Engineering, IIT Delhi, India	01:18 PM- 01:30 PM
ITRS213	Investigation of Wear behaviour of Hybrid LM30 Metal Matrix Composites (MMCs) Fabricated through Stir Casting Rout Vivek Joshi, Leeladhar Nagdeve, Harish Kumar*, J K Katiyar *National Institute of Technology, Delhi, 110040 India.	01:30 PM-01:42 PM
Session 5 (11:30 AM – 01:42 PM) **Session Chair:** Dr. Prabhudev M. S., Government Polytechnic Kalgi **Session Coordinators:** Dr. Mir Irfan Ul Haq, SMVDU, J&K **Link:** meet.google.com/odf-irfs-zvm		
Dr. Jitendra Kumar Katiyar, SRMIST **Title:** Tribo-mechanical Study of Solid Fillers Reinforced Friction Materials		11:30 AM-11:54 AM (IST)
ITRS218	Industrial Application of Tribology on Aluminium Rolling Mill (Hot Rolling Process) for Sustainable Hazardous Waste Management Rashmi Ranjan Mohapatra, Hindalco Industries Limited, India	11:54 AM-12:06PM
ITRS215	Crack detection in a shaft-rotor-bearing system based on frequency domain responses C. Shravankumar*, P. Uday, J. Prabu, K. Jegadeesan and TVVLN Rao *SRM Institute of Science and Technology, Kattankulathur.	12:06 PM-12:18 PM
ITRS221	A Comparative Investigation on Wear Characteristics of Polymer and Biopolymer Gears Ahmad Azimi Rahimi Bin Rahim, Daing, Mohit Jain, Santosh Patil* *Manipal University Jaipur, Jaipur, 303007, Rajasthan, India	12:18 PM-12:30 PM
ITRS223	Study on Tool Wear and Tool Life during Milling on Unidirectional CFRP Siti Fatirah, R*, Nor Khairusshima, M.K, Suhaily, M , Aishah Najiah,D and Natasha, A.R *International Islamic University Malaysia	12:30 PM-12:42 PM (IST) 3:00PM-3:12 PM (MYT)
ITRS224	Modelling and optimization of wear performance of AISI 1040 steel using AI-GA methodology and investigation of corrosion resistance Rohit Agrawal* and Arkadeb Mukhopadhyay *Birla Institute of Technology, Mesra, Ranchi,India	12:42 PM-12:54 PM
ITRS226	Assembly interface design for high contact performance Yicong Zhou, Qiyin Lin * and Jun Hong * Xi'an Jiaotong University, Xi'an, China.	12:54 PM- 01:06 PM (IST) 3:24PM-3:36 PM (China)
ITRS230	Advancement in Chemical Mechanical Planarization (CMP) Equipment for Tribological Research and Analysis. Wan Nazrul Imran Wan Kamaruzaman, Ahmad Majdi B A Rani* *Universiti Teknologi PETRONAS, Bandar Seri Iskandar, Malaysia.	01:06 PM -01:18 PM (IST) 3:36 PM-3:48 PM (MYT)
ITRS234	Effect of heat treatment on the dry sliding wear properties of solid lubricated hypereutectic aluminum alloy based composites (AMCs) Varun Singhal, Aayush Gupta and O. P. Pandey*	01:18 PM- 01:30 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

	Thapar Institute of Engineering and Technology, Patiala India.	
ITRS235	Synergic effect of CuS/TiO_2 nanostructures for enhanced photocatalytic activity K. Santhi, S. Harish, M. Navaneethan, S. Ponnusamy*, C. Muthamizhchelvan *SRM Institute of Science and Technology, Kattankulathur	01:30 PM-01:42 PM
Lunch (1:42 PM – 2:30 PM)		
Session 6 (2:30 PM – 4:54 PM) **Session Chair:** Dr. Nitin Sharma NIT Jalandhar **Session Coordinators:** Dr. Jitendra Kumar Katiyar, SRMIST **Link: Link:** https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09 **Meeting ID: 948 3346 0480** **Passcode: 398493**		
Prof. Dr. Hakan KALELİ Yildiz Teknik Universitesi, Makine Fakultesi, Turkey **Title:** Experimental Investigation of the Effects of Engine Cylinder Honing as Tribological Aspect on Performance, Wear and Lubrication		2:30 PM- 2:54 PM (IST) 12:00PM-12:24 PM (Turkey Time)
ITRS232	Implementation of an elasto-hydrodynamic non-newtonian lubrication numerical solver Alessandro Sicilia*, Alessandro Ruggiero *University of Salerno Via Giovanni Paolo II, 132, Fisciano (SA), Italy	2:54 PM- 3:06 PM (IST) 10:24 AM-10:36 AM (Italy Time)
ITRS238	Wear and Hardness of Multiwalled Carbon Nanotubes Reinforced Copper Nanocomposites: An Experimental and Statistical Analysis Mahesh, Vishwanath Koti*, Kalyan Kumar Singh, Rabesh Kumar Singh * M. S. Ramaiah Institute of Technology, Bangalore	3:06 PM- 3:18 PM
ITRS240	A novel conjugate heat transfer (CHT) approach to determine the temperature distribution in single point cutting tool under different conditions Rishish Mishra, Rabesh Kumar Singh*, Anuj Kumar Sharma, Jitendra Kumar Katiyar *Dr. A.P.J. Abdul Kalam Technical University, Lucknow-India	3:18 PM- 3:30 PM
ITRS242	USE OF ALGAE IN SEVERAL FIELDS Navita, Leeladhar Nagdeve , Harish Kumar National Institute of Technology, Delhi, India	3:30 PM- 3:42 PM
ITRS243	Reciprocating wear characteristics of AISI 1040 steel at varying relative humidity and operating temperature. Kumar Vaibhav*, Rohit Agrawal, Sudeepan Jayapalan, Arkadeb Mukhopadhyay, Abhinandan Kumar * Birla Institute of Technology, Mesra, Ranchi India	3:42 PM- 3:54 PM
ITRS329	Wear analysis of carbide cutting insert in MQL turning of AISI 304 steel Vineet Dubey *, Anuj Kumar Sharma , J. Ramkumar and Jitendra Kumar Katiyar Centre for Advanced Studies, Lucknow, Uttar Pradesh	3:54 PM- 4:06 PM
ITRS245	Dry Sliding Wear Behavior of Magnesium Metal Matrix Composites: A brief review Babar Pasha Mahammod, G. Chitti Babu, R. Narasimha Rao, Syed Ismail National Institute of Technology Warangal, Warangal, India.	4:06 PM- 4:18 PM
ITRS246	Tribocorrosion of Magnesium and its alloys in Biomedical Applications: Overview and Current status Babar Pasha Mahammod, R. Narasimha Rao, Syed Ismail National Institute of Technology Warangal, Warangal, India.	4:18 PM- 4:30 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

ITRS247	Insitu imaging to identify scratch damage of BCR 692 reference DLC coating Sravan Josyula , Prasad Kangralkar , Anshuman Dube, Debdutt Patro Global Applications Lab, Ducom Instruments, India	4:30 PM-4:42 PM
ITRS252	MICROSTRUCTURE AND MECHANICAL PROPERTIES OF DOUBLE-SIDE FRICTION STIR WELDED AA7075-T651 V. Kiran Kumar, Sk. Abdul Munaf, S.R. Koteswara Rao, T. Srinivasa Rao Vasireddy Venkatadri Institute of Technology, Nambur	4:42 PM-4:54 PM
Session 7 (2:30 PM – 4:54 PM) **Session Chair:** Dr. Sanjay Sharma, SMVDU **Session Coordinators:** Dr. Mir Irfan Ul Haq, SMVDU **Link:** meet.google.com/odf-irfs-zvm		
Prof. Zahrul Fuadi, Syiah Kuala University, Indonesia, **Title: TBA**		2:30 PM- 2:54 PM (IST) 4:00 PM to 4:24 PM (Indonesia Time)
ITRS253	Fatigue performance of the Al-Mg/MgAl 2 O 4 in-situ composites synthesized through MnO 2 and CuO reinforcement P Chandramohan*, R Raghu, Peter Apata Olubambi, M. Selva kumar* , T. Ram kumar * Sri Ramakrishna Engineering College, Coimbatore, India	2:54 PM- 3:06 PM
ITRS254	The role of process parameters on laser cladded Stellite 6 geometry: A statistical approach Nikhil Thawari, Chaitanya Gullipalli, Prayag Burad, T. V. K. Gupta* *Visvesvaraya National Institute of Technology, Nagpur, India.	3:06 PM- 3:18 PM
ITRS255	Nanoindentation Simulation of Gallium Nitride Film Grown in Different Orientations on a Sapphire Substrate using Finite Element Method. Abhishek Prashant Singh, Anoop Kumar Mukhopadhyay, Dhaneshwar Mishra* * Manipal University Jaipur	3:18 PM- 3:30 PM
ITRS257	Tribological performance evaluation and ANN-assisted prediction of halloysite, montmorillonite, and wollastonite filled friction composites Debarghya Saha and Bhabani K. Satapathy* *Indian Institute of Technology Delhi, New Delhi	3:30 PM- 3:42 PM
ITRS258	Improvement of Wear Resistance for Marine Steel using SiC and TiB 2 Ceramic Coating with HVOF technique Abhijeeth Nagaraj, Dr. Adarsha H Jain (Deemed to be University), Bangalore, Karnataka	3:42 PM- 3:54 PM
ITRS259	EXPERIMENTAL INVESTIGATION ON IMPACT OF SIO_2, TIO_2AND Al_2O_3 AS NANO ADDITIVES IN TRIBOLOGICAL PROPERTIES OF SN500 BASE OIL AND OPTIMIZATION OF ADDITIVES COMPOSITION BY TAGUCHI TECHNIQUE Sankar E and Duraivelu K, SRM Institute of Science and Technology	3:54 PM- 4:06 PM
ITRS260	Wear characteristics of Hot Dip Aluminized of Mild Steel Ramesh G*, S. Surendarnath *Rajiv Gandhi University of Knowledge Technologies, Kadapa	4:06 PM- 4:18 PM
ITRS261	Effect of post processing on microstructure and mechanical properties of additive manufactured Inconel 718 Prayag Burad, Chaitanya Gullipalli, Nikhil Thawari, T.V.K. Gupta	4:18 PM- 4:30 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

	Visvesvaraya National Institute of Technology, Nagpur, India	
ITRS262	Effect of laser surface texturing on the tribological behaviour of aluminium-silicon (Al-Si/Al_2O_3) advanced composite under dry and lubricating conditions Pranav Dev Srivyas, Ankush Raina, M. S. Charoo, Mir Ifran Ul Haq National Institute of Technology Trichy, Tamil Nadu.	4:30 PM-4:42 PM
ITRS263	Prediction of abrasion wear properties of eggshell powder filled polymer composite using Taguchi design integrated with quadratic regression modelling and desirability approach Subhrajit Ray, Pravat Ranjan Pati*, Gaurav Gupta * Institute of Aeronautical Engineering, Hyderabad	4:42 PM-4:54 PM
Session 8 (2:30 PM – 4:54 PM) **Session Chair:** Dr. Kishor Kumar Gajrani, IIITDM Kancheepuram **Session Coordinators:** Dr. T V V L N Rao, MITS **Link:** https://meet.google.com/yxf-iyrr-nfv		
Prof. Juliette Cayer-Barrioz, University of Lyon, LTDS, Ec École Centrale de Lyon, **Title:** An Innovative Approach to Reduce Friction from Boundary to Hydrodynamic Lubrication		2:30 PM- 2:54 PM (IST) 10:00 AM -10:24 AM (France Time)
ITRS264	High temperature dry sliding Wear behaviour of cold sprayed Inconel 738 coating B. V. Padmini*, Digvijay G. Bhosale, H. B. Niranjan, Mahantayya Mathapati, P. Sampathkumaran, R. Seetharamaiah, Anand Kumar *Sambhram Institute of Technology, Bengaluru, Karnataka, India.	2:54 PM- 3:06 PM
ITRS265	Microstructural and Sliding Wear Investigation of Co-based Microwave Cladding on Stainless Steel C Durga Prasad* *RV Institute of Technology and Management Bengaluru, Karnataka, India.	3:06 PM- 3:18 PM
ITRS267	Wear characteristics of red brick dust-sisal fiber epoxy composites: A parametric analysis using response surface method and neural networks Gaurav Gupta, Pravat Ranjan Pati*, Alok Agrawal, Sandip Kumar Nayak, Subhrajit Ray, Abhishek Sharma * Institute of Aeronautical Engineering, Hyderabad	3:18 PM- 3:30 PM
ITRS269	Physical, Mechanical and Dry Sliding Wear Characterization of Kota Stone Dust and Fly Ash Filled Hybrid Epoxy Composites Virendra Rajput, Alok Agrawal*, Gaurav Gupta, Pravat Ranjan Pati *Sagar Institute of Research & Technology, Bhopal-India	3:30 PM- 3:42 PM
ITRS271	Superconducting Magnetic Energy Storage (SMES) Supercapacitor application using Magnetic Graphene Oxide (MGO) R. Aiswarya, T.Kalaivani* *SRM Institute of Science and Technology, Kattankulathur	3:42 PM- 3:54 PM
ITRS274	Optimization of influencing parameters on friction and wear behaviour of AZ91D–B4C–Gr hybrid composite under dry sliding conditions Aatthisugan I* and Murugesan R *SRM Institute of Science and Technology, Kattankulathur	3:54 PM- 4:06 PM
ITRS276	Development of Core-shell Nanomagnetic Zn @ Fe 3 O 4 Material for Energy Application R. Aiswarya, T. Kalaivani*	4:06 PM- 4:18 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

	SRM Institute of Science and Technology, Kattankulathur	
ITRS277	Investigation on Surface Roughness and Mechanical Performance with Numerical Analysis of Friction Stir Welded AA6082-T6 Alloys Lopamudra Mohanty, Mantra Prasad Satpathy*, Sambit Kumar Mohapatra, Pravat Ranjan Pati * KIIT Deemed to be University, Bhubaneswar	4:18 PM- 4:30 PM
ITRS326	Laboratory Wear Test Using Jaw Crusher Daiane Münch, Bárbara Diniz Nins Universidade Federal de Ouro Preto. Brazil	4:30 PM-4:42 PM (IST) 8:00 AM-8:12 AM (Brazil Time)
ITRS279	Improvement of Wear Resistance for Marine Steel using SiC and TiB_2 Ceramic Coating with HVOF technique Abhijeeth Nagaraj*, Dr. Adarsha H *Jain (Deemed to be University), Bangalore	4:42 PM-4:54 PM
Session 9 (2:30 PM – 4:54 PM) **Session Chair:** Dr. Ankush Raina, SMVDU **Session Coordinators:** Dr. Rabesh Kumar Singh, CAS-AKTU **Link:** https://teams.microsoft.com/l/meetup-join/19%3ameeting_ZDg3ZjE1ZmYtNTk3MS00MTVlLThkNWEtZWQ1NjEzNmI3MjAw%40thread.v2/0?context=%7b%22Tid%22%3a%22a0b6ea85-9e1b-4d0e-af80-e542011afc9a%22%2c%22Oid%22%3a%22497402c5-935d-4ccf-8225-05d48d4173f8%22%7d		
Dr. Catalin I Pruncu, UK **Title:** Towards net zero emission: Metal Forming and Tribology		2:30 PM- 2:54 PM (IST) 9:00 AM- 9:24 AM (GMT)
ITRS280	Investigation on Tribological behaviour of AA7075 Reinforced with SiC & TiC Composites for Automobile Applications S. Surendarnath*, T. Ramachandran#, G. Ramesh, R. Dharmalingam * Sri Venkateswara College of Engineering & Technology (A), Chittoor	2:54 PM- 3:06 PM
ITRS282	Exploration of cottonseed oil as an ecologically sustainable and new generation rust and oxidation inhibited type spindle oil lubricant Ponnekanti Nagendramma*, Sayed Khadija Bari, and Anjan Ray *CSIR-Indian Institute of Petroleum, Dehradun- India	3:06 PM- 3:18 PM
ITRS283	A Complete Elastic-Plastic Spherical Asperity Contact Model with the Effect of Linear Kinematic Strain hardening K S Hanumanth Ramji, AMegalingam 2 *Bannari Amman Institute of Technology, Sathyamangalam, TamilNadu	3:18 PM- 3:30 PM
ITRS284	Comparison between tribological performance of nano additive lubricants containing SiO2 and Cu particles Syed Junaid*, Nitya Nand Gosvami Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India	3:30 PM- 3:42 PM
ITRS285	Bio-Tribo-Behaviour of Ti6Al4V: A Review Jibin T Philip*, Ananthakrishnan R, Rubin Binu Roy, Atul Sundaresan, and Robin Santhan *Amal Jyothi College of Engineering, Kanjirappally, Kerala, India	3:42 PM- 3:54 PM
ITRS287	Digital technologies in tribology and envisage towards future: A contemporary review	3:54 PM- 4:06 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 1 (8-12-2021)

	Jubair Ahmed, Jarabala Ranga, Priyadharshini M*, V Bhuvaneswari, Balaji Devarajan#, L Rajeshkumar * VIT-AP University, India	
ITRS288	Investigation on the mechanical, wear and corrosion behavior of Titanium-Titanium boride composites for biomedical applications M. Selva kumar *, T. Ramkumar, M. Mohanraj *Dr. Mahalingam College of Engineering and Technology, Pollachi	4:06 PM- 4:18 PM
ITRS289	Taguchi's DOE and Artificial Neural Network analysis for the prediction of tribological performance of graphene nano-platelets filled glass-fiber-reinforced epoxy composites Nikhil Sharma, Santosh Kumar, K. K. Singh Indian Institute of Technology (ISM) Dhanbad, India	4:18 PM- 4:30 PM
ITRS290	Characterization study on the mechanical behavior of composite honeycomb sandwich panels Saurabh Rathod, Gaurav Tiwari Visvesvaraya National Institute of Technology, Nagpur, INDIA	4:30 PM-4:42 PM
ITRS291	Experimental Investigation on Vibrational Properties of Natural Fiber Reinforced Epoxy Composite Dattatray P. Kamble, Shivaji V. Gawali, Manmohan M. Bhoomkar Savitribai Phule Pune University, Pune Maharashtra, India.	4:42 PM-4:54 PM
Session 10 (2:30 PM – 4:54 PM) **Session Chair:** Dr. Vimal Edachery, IISc Bangalore **Session Coordinators:** Dr. P S Suvin, NITK **Link: https://meet.google.com/vjp-hsxv-bcb**		
Prof. Mayank Tiwari, IIT Patana, India **Title: TBA**		2:30 PM- 2:54 PM
ITRS324	Recent progresses in surface texturing for machining applications: A review Dheeraj Lal Soni*, Jagadish *National Institute of Technology Raipur, India.	2:54 PM- 3:06 PM
ITRS320	Tribological Study of Additively Manufactured Polymers for Simple to Complex Features: A critical review. Jaspreet Singh, Shanmuka Srinivas M, M Mahaboob Basha, Ravi Sankar M* *Indian Institute of Technology Tirupati, India	3:06 PM- 3:18 PM
ITRS029	Optimization of surface roughness and wear rate during sliding of tribopair using GA Mohammad Hanief NIT Srinagar, J&K	3:18 PM- 3:30 PM
ITRS030	Effect of Low Weight Fraction of TaC Ultra High Temperature Ceramic on Wear Properties of Mg-AZ91D Lightweight Alloy A. Gnanavelbabu*, K.T. Sunu Surendran , K. Rajkumar *CEG Campus, Anna University	3:30 PM- 3:42 PM
ITRS037	Finite Element Method Based Transient Wear Modelling Using Constant Extrapolation Technique for Steel-On-Steel Dry Sliding Contact Vedant Joshi, Penchaliah Ramkumar* IIT Madras, India	3:42 PM- 3:54 PM
ITRS038	The Effect Of Scandium (Sc) Onto Mechanical Properties And Wear Properties Of Al- 7 Wt.% Si Alloy N.N.A.Basir, M.M.Mahat, S. M.Yahaya , R. Rosmamuhamadani Universiti Teknologi MARA, Maylasia	3:54 PM- 4:06 PM (IST) 6:54 PM-7:06 PM (MYT)
ITRS039	A comprehensive review on abaca fiber reinforced	4:06 PM- 4:18 PM

	polymer composites Rittin Abraham Kurien*, D Philip Selvaraj, M Sekar, Chacko Preno Koshy, Cherian Paul Saintgits College of Engineering, Kottayam, Kerala	
ITRS040	Effect of Rare Earth Oxides (REOs) on Tribological Behaviour of Aluminium Hybrid Composites: Experimental Investigations and Predictive Modelling Vipin Kumar Sharma, Vinod Kumar, Ravinder Singh Joshi Thapar Institute of Engineering and Technology Patiala, India	4:18 PM- 4:30 PM
ITRS043	Friction and wear response of tri-ceramic reinforced copper-based hybrid composites under dry sliding condition Manvandra Kumar Singh*, Rakesh Kumar Gautam Amity University Madhya Pradesh, India	4:30 PM-4:42 PM
ITRS190	Swirling jet erosive wear progression on AISI 310 stainless steel at 400 ° C J. Zaragoza-Granados, E.A. Gallardo-Hernández *, M. Vite-Torres, C. Sedano-de la Rosa, D.E. Ramírez-Arreola Grupo de Tribología, Col. Lindavista, C.P. 07738 Ciudad de México, México	4:42 PM-4:54 PM (IST) 5:12AM-5:24AM (Mexico Time)

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

Session 11 **Session Coordinator: Dr. Jitendra Kumar Katiyar, SRMIST** **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**	**Time**
Keynote 2 Prof. Michael Khonsari, Louisiana State University, Louisiana **Title:** Science of Degradation	**9:00 AM to 9:35 AM (IST)** **9:30 PM-10:05 PM (CST Time) (8 Dec 2021)**
Keynote 3 Prof. Hong Liang, Texas A&M University, USA **Title:** TBA	9:40 AM-10: 20 AM (IST) 10:10 PM to 10:50 PM (UST) (8 Dec 2021)
Keynote 4 Prof. Ashlie Martini, University of California, Merced **Title:** TBA	10:20 AM-11:00 AM (IST) 8:50 PM-9:30 PM (Merced USA) (8 Dec 2021)
Plenary 2 Prof. Jean Michel Martin, University of Lyon, LTDS, Ecole Centrale de Lyon **Title:** Achieving liquid superlubricity at the macroscale	11:00 AM-11:40 AM (IST) 6:30 AM-7:10 AM (France Time)
Break (5 Minutes)	
Session 12 (11:45 AM – 02:09 PM) **Session Chair:** Dr. Pranav Dev Srinvas, NIT Trichy **Session Coordinators:** Dr. Vijayraghawan, SRMIST **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**	

Paper ID	Invited/Oral Session	Time
	Dr. Nityanand Goswami, IIT Delhi, India **Title:** TBA	11:45 AM-12:09 PM
ITRS306	Wear, Corrosion and Tribocorrosion Mechanisms of Offshore Mooring Chains Sabri Alkan Bandırma Onyedi Eylül University, Turkey	12:09 PM-12:21 PM (IST) 9:39AM-9:51AM (Turkey Time)
ITRS050	Mechanical and Tribological Characterization on Light weight AZ91D/WS2 composites processed via Stir-Squeeze casting S. Ayyanar, A.Gnanavelbabu*, K. Rajkumar and P. Loganathan CEG Campus, Anna University, Chennai-600025, India.	12:21 PM-12:33 PM
ITRS054	Investigation of Tribological Characteristics of Copper-Titanium Alloys Processed by Multi-Axial Cryo-Forging	12:33 PM-12:45 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

	Ramesh S*, Shivanada Nayaka, Gajanan M Naik , Gajanan Anne National Institute of Technology Karnataka, Surathkal	
ITRS056	Dry sliding wear behavior of surface-modified Al 6061-T6 alloy with WS2 solid lubricant through electric spark deposition technique R.Rajeshshyam, R.Venkatraman and S.Raghuraman SASTRA Deemed to be University, Tirumalaisamudram, Thanjavur	12:45 PM-12:57 PM
ITRS057	Effect of Equal Channel Angular Extrusion on Wear and Corrosion resistance of Mg-9%Al-0.5%Zn light weight alloy Gajanan M Naik, Ramesh S, Sadashiv B, Anjan B N RV Institute of Technology and Management, JP Nagar, India	12:57 PM- 01:09 PM
ITRS061	Effect of Surface Mechanical Attrition Treatment (SMAT) through surface topography modification on Tribological properties of Inconel X-750 superalloy Moin Khan P *, Vimal Edachery , Aashish John, P S Suvin National Institute of Technology Karnataka, Surathkal	01:09 PM -01:21 PM
ITRS065	Investigation on tribological properties of aluminum alloy A356 coated with Alumina Renjish Vijay, Baiju Sasidharan, Arif Mohammed, S Rani*, V N Aju Kumar College of Engineering Trivandrum - 695016, Kerala, India	01:21 PM- 01:33 PM
ITRS066	Investigation of wear performance for corn hub husk particle- nano graphene filler reinforced epoxy composite at different load conditions Santosh Kumar, Abir Saha National Institute of Technology Silchar, Silchar, Assam, India	01:33 PM-01:45 PM
ITRS071	On Wear Behaviour of Different Grades of Spheroidal Graphite (SG) Cast Iron Mohd Nadeem Bhat, S. Mushtaq IUST Awantipora, Kashmir 192122, India	01:45 PM-01:57 PM
ITRS073	Influence of heat treatment on progressive scratch behaviour of Fe-Cr-C hardfaced alloy N.Ch. Kaushik*, J. Ajay Vamsi, T. Sai Krishna, A. Tarun Satya, M. Sitaram Chowdary , S.Pramod Mani, Debdutt Patro BML Munjal University, Sidhrawali Gurugram, Haryana, India.	01:57 PM-02:09 PM

Session 13 (11:45 AM – 02:09 PM)
Session Chair: Dr. Sanjay Mohan, SMVDU
Session Coordinators: Dr. Rabesh Kumar Singh, CAS-AKTU
Link: https://teams.microsoft.com/l/meetup-join/19%3ameeting_YTlhYTViY2UtYmNhZS00YzU4LTljYjktNjgxYzZiMDJhMTk1%40thread.v2/0?context=%7b%22Tid%22%3a%22a0b6ea85-9e1b-4d0e-af80-e542011afc9a%22%2c%22Oid%22%3a%22497402c5-935d-4ccf-8225-05d48d4173f8%22%7d

Paper ID	Invited/Oral Session	Time
Prof. A. Elayaperumal, Anna University, India **Title:** Crabshell: A Biomaterial and Its Tribo-mechanical Aspects		11:45 AM-12:09 PM
ITRS214	Performance Evaluation of Wire-EDM process of EN-31using multiple electrode material Akash Gupta, Leeladhar Nagdeve, Harish Kumar* *National Institute of Technology, Delhi, India	12:09 PM-12:21 PM
ITRS220	Hybrid models for optimization of process parameters influencing the quality of multi-stage, deep-drawn cylindrical cups from uni-directionally rolled copper strips.	12:21 PM-12:33 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

	S.P. Sundar Singh Sivam*, R. Rajendran * SRM Institute of Science and Technology, Kattankulathur	
ITRS074	Characterization of Wear Resistance and Corrosion during Magnetorheological Fluid Assisted Finishing (MFAF) of Ti-6Al-4V and Duplex Stainless Steel for enhanced biocompatibility Atul Singh Rajput, Manas Das, and Sajan Kapil Indian Institute of Technology Guwahati, India	12:33 PM-12:45 PM
ITRS076	Magnetorheological Fine Finishing of Steering Rack Bar for Improving its Functional Operation Manpreet Singh Baba Farid College of Engineering and Technology, Bathinda	12:45 PM-12:57 PM
ITRS079	Effect of two different sulfide coated steel fiber in a disc brake pad towards tribo performance – An interface study A.Eakambaram*, M.A.Sai Balaji, S.Rasool Mohideen, P.Baskara Sethupathi B S Abdur Rahman Crescent Institute of Science & Technology, Chennai, India	12:57 PM- 01:09 PM
ITRS080	Surface Roughness and Hardness Investigation on Nickel-Cobalt-Iron Coating at Different Surface Pretreatment Koay Mei Hyie, Nor Azirah Mohd Fohimi, Salina Budin, Normariah Che Maideen, M. S. Osman, Shafiq Suhaimi Universiti Teknologi MARA, Malaysia	01:09 PM -01:21 PM (IST) 3:39PM-3:51 PM (MYT)
ITRS083	Surface Coatings For Protection of Concrete in Marine Environment - Performance Evaluation Through Laboratory Evaluations Gaurav Tehlan Department of Ship Technology, CUSAT - Kochi	01:21 PM- 01:33 PM
ITRS084	Influence of Organo-Sulfur Compounds with Overbased Calcium Compounds on Lubrication in Cold Forming Shrijith Suresh Central Institute of Petrochemical Engineering and Technology, Guindy	01:33 PM-01:45 PM
ITRS085	Enrichment of hardness and wear behavior of severely deformed AA 5083: Prediction of wear response using supervised machine learning technique Ananda BabuVaradala* Swami Naidu Gurugubelli, SateeshBandaru Vignan's Institute of Engineering for Women, Visakhapatnam,	01:45 PM-01:57 PM
ITRS086	Effect of heat treatment on wear behaviour of carbide-based coatings Akshay R. Govande, B. Ratna Sunil, Ravikumar Dumpala Visvesvaraya National Institute of Technology, Nagpur	01:57 PM-02:09 PM
Session 14 (11:45 AM – 02:09 PM) **Session Chair:** Dr. Mir Irfan Ul Haq SMVDU **Session Coordinators:** Dr. Anuj Kumar Sharma, CAS-AKTU **Link:** meet.google.com/odf-irfs-zvm		
Paper ID	**Invited/Oral Session**	**Time**
Dr. Muhammad Ilman Hakimi Chua Bin Abdullah, Universiti Teknikal Malaysia Melaka **Title:** Effect of Different Internal Geometries of Fused Filament Fabrication 3D Printed Abs on Tribological Behaviour		11:40 AM-12:04 PM (IST) 2:10 PM -2:24 PM (MYT)
ITRS104	Magnetorheological Finishing of Internal Tapered Flat End Blind Hole Type Circular Mould-Cavity and its Performance Analysis	12:09 PM-12:21 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

	Ankit Aggarwal and Anant Kumar Singh* Thapar Institute of Engineering and Technology, Patiala, India	
ITRS106	Artificial Neural Network technique to assess the tribological performance of GFRP composites incorporated with graphene nano-platelets Nikhil Sharma, Santosh Kumar, K. K. Singh Indian Institute of Technology (ISM) Dhanbad, 826004, India	12:21 PM-12:33 PM
ITRS109	An Investigation of Magnetorheological Finishing on Tribological and Functional Performance of Polymer Gears Kunal Arora and Anant Kumar Singh Thapar Institute of Engineering and Technology, Patiala, India	12:33 PM-12:45 PM
ITRS116	The Use of Artificial Intelligence in Tribology—A Perspective S.Hariram Central Institute of Petrochemicals Engineering and Technology (CIPET), Guindy	12:45 PM-12:57 PM
ITRS117	Evaluation of tribological characteristics of alumina coated aluminum alloy using Finite Element Method Renjish Vijay*, V N Aju Kumar, A Sadiq TKM College of Engineering Kollam – 691005, Kerala, India	12:57 PM- 01:09 PM
ITRS119	Impact of Various Surface Friction Conditions on Joint Performance During Ultrasonic Welding Between Al-SS Sheets Soumyajit Das, Mantra Prasad Satpathy*, Bharat Chandra Routara, Diptikanta Das KIIT Deemed to be University, Bhubaneswar, Odisha, India	01:09 PM -01:21 PM
ITRS059	The correlation of Tool Wear and Surface Roughness under Sustainable Cryogenic CO2 Condition Nurul Hayati Abdul Halim, Che Hassan Che Haron*, Jaharah A. Ghani, Muammar Faiq Azhar Universiti Teknologi MARA, 40450 Shah Alam, MALAYSIA	01:21 PM- 01:33 PM (IST) 3:51PM-4:03PM (MYT)
ITRS053	Numerical Studies on Roller Bearings Using Empirical Model and Response Surface Method V. G. Salunkhe *, R. G. Desavale RIT, Rajaramnagar-415414, Sangli, Maharashtra, India	01:33 PM-01:45 PM
ITRS047	High-Temperature Calcium Fluoride (CaF2) Solid Lubricant Material: A Review Suneeth Sukumaran, Francis Xavier L, Deepanraj Jyothi Engineering College, Thrissur,679531, Kerala, India.	01:45 PM-01:57 PM
ITRS032	Traction, Stribeck and scuffing characteristics of lubricants in rolling-sliding contacts using twin disc Sravan Josyula, Prasad Kangralkar, Anshuman Dube, Debdutt Patro Ducom Instruments, India	01:57 PM-02:09 PM
Session 15 (11:45 AM – 02:09 PM) **Session Chair:** Dr. Ankush Anand **Session Coordinators:** Prof. T V V L N Rao, MITS **Link:** https://meet.google.com/yxf-iyrr-nfv		
Paper ID	**Invited/Oral Session**	**Time**
Dr. Naresh Chandra Murmu, CSIR-CMERI Durgapur, India Title: TBA		11:40 AM-12:04 PM
ITRS113	Evaluation of the physico-chemical, tribological and oxidation stability of multistage chemically modified Calophyllum inophyllum oil Ananthan D Thampi, Pranav Prasannakumar, Sneha Edla, Adithyan K S, Akhil Kumar S, Baiju Sasidharan, Rani S College of Engineering Trivandrum, Kerala, India.	12:09 PM-12:21 PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

ITRS110	Influence of Nano and Extreme Pressure (EP) additives on the Lubricating Performance of Karanja oil Zahid Mushtaq *, M. Hanief National Institute of Technology, Srinagar, J&K, India	12:21 PM-12:33 PM
ITRS108	Halogen-free Ionic Liquids as Lubricant Additives: A Review Arun Kumar Bambam , Kishor Kumar Gajrani Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram,	12:33 PM-12:45 PM
ITRS112	A comparative study on the lubricant properties of epoxidized and transesterified vegetable oils Sneha Edla, Ananthan D Thampi, Pranav Prasannakumar, Rani S, College of Engineering Trivandrum, Kerala, India.	12:45 PM-12:57 PM
ITRS077	On the influence of axial distortions on lubricant film and friction force of top piston ring conjunction near to TDC Giorgos Antonakakis, Anastasios Zavos, Pantelis G. Nikolakopoulos* University of Patras, Patras 26504, Greece	12:57 PM- 01:09 PM (IST) 9:27 AM- 9:39AM (Greece Time)
ITRS120	Lubricity enhancing ionic liquids and nanoparticles for environmentally friendly lubricants Raimondas Kreivaitis, Milda Gumbytė, Jolanta Treinytė, Artūras Kupčinskas, Audrius Žunda Vytautas Magnus University. Agricultural Academy. K. Donelaičio str. 58, 44248, Kaunas, Lithuania	01:09 PM -01:21 PM (IST) 9:39 AM-9:51 AM (Lithuania Time)
ITRS072	Investigation and characterization of machinability on Ti-6Al-4V alloy using biodegradable esterified nano cutting fluid Cherian Paul*, Steffan M Cherian, Amith Aravind, Chacko Preno Koshy, Rittin Abraham Kurian Saintgits College of Engineering, Kerala-686532, India	01:21 PM- 01:33 PM
ITRS062	Synthesis and testing of groundnut oil based green cutting fluid for machining studies Shanmuka Srinivas M, Dheeraj Kumar, Suvin P S *, Satish V Kailas National Institute of Technology Karnataka, Surathkal	01:33 PM-01:45 PM
ITRS059	The correlation of Tool Wear and Surface Roughness under Sustainable Cryogenic CO2 Condition Nurul Hayati Abdul Halim, Che Hassan Che Haron*, Jaharah A. Ghani, Muammar Faiq Azhar Universiti Teknologi MARA, 40450 Shah Alam, MALAYSIA	01:45 PM-01:57 PM (IST) 4:15 PM-4:27 PM (MYT)
ITRS058	Modeling of Date Seed Oil blends with HNT additives and Application in Journal Bearings Mohammed Shabbir Ahmed, K.Prabhakaran Nair, TVVLN Rao, Ali Algahtani MITS and King Khalid University, Abha, Kingdom of Saudi Arabia	01:57 PM-02:09 PM (IST) 11:27AM-11;39AM (Saudi Arabia Time)
Lunch (2:09 PM – 2:30 PM)		
Session 16 (2:30 PM – 4:54 PM) **Session Chair:** Dr. Manjesh Singh, IIT Kanpur **Session Coordinators:** Dr. P S Suvin, NITK **Link:** https://meet.google.com/vjp-hsxv-bcb		
Prof. Salmiah Kasolang, Universiti of Technologi MARA, Malaysia **Title:** Porosity of Foam Materials and Potential Use as Oil Impregnated Materials		2:30 PM- 2:54 PM (IST) 5:00 PM-5:24 PM (MYT)
ITRS121	Effect of Fiber Orientation on Tribological Performace of Abaca Fiber Reinforced Epoxy Composite Under Dry	2:54 PM- 3:06 PM (IST)

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

	Contact Conditions M. Milosevic, A. Ruggiero, P. Valasek, D. Dzunic, S. Mitrovic Sestre Janjic 6, 34000 Kragujevac, Serbia	10:24 AM- 10:36 AM (Serbia Time)
ITRS031	Prediction of surface finish in extrusion honing process by regression analysis and artificial neural networks Jayasimha SLN*, K.N.Lingaraju, H.P.Raju *P.E.S College of Engineering, Mandya	3:06 PM- 3:18 PM
ITRS036	Tribological Performance of AZ91D/HfC p Magnesium Composite Prepared through Stir-Ultrasonic-Squeeze Casting Technique K.T. Sunu Surendran* and A. Gnanavelbabu *CEG Campus, Anna University, Chennai-600025	3:18 PM- 3:30 PM
ITRS075	Tribology in the age of digitalization and green deal – Tribology as a Service Franz PIRKER, et al. AC2T research GmbH, Viktor-Kaplan-Straße 2/C, 2700 Wiener Neustadt, Austria	3:30 PM- 3:42 PM (IST) 11:00 AM-11:12 AM (Austria Time)
ITRS034	Exploring Mechanical and Tribological Characteristics of Metal Additive Manufactured AlSi10Mg Alloy M. Kumar *, S. S. Satheesh Kumar, A. Megalingam , G. Rajamurugan KPR Institute of Engineering and Technology, Coimbatore, India	3:42 PM- 3:54 PM
ITRS035	Identification of Self-lubricating Mode for the Ultrasonic Treated AA6061-B 4 C-CNT Hybrid Composites A. Gnanavelbabu*, K.T. Sunu Surendran, K. Rajkumar and S. Ayyanar *CEG Campus, Anna University, Chennai-600025	3:54 PM- 4:06 PM
ITRS052	Tribodynamic performance improvement of aerodynamic journal bearings using synergistic micro-surface topographies Manas Ranjan Pattnayak, Raj Kumar Pandey, Jayanta Kumar Dutt I.I.T. Delhi, New Delhi-110016, India	4:06 PM- 4:18 PM
ITRS060	Study of Solid Particle Erosion Wear of Glass fibre Composite Filled with Filler: A Review Manoj Kumar, Hemalata Jena* KIIT Deemed to be University, Bhubaneswar	4:18 PM- 4:30 PM
ITRS200	Numerical Simulation of Erosive Wear Mauro Killary Hernández-Amador, Manuel Vite-Torres, Cesar Sedano de la Rosa, Ezequiel Alberto Gallardo-Hernandez* Unidad Zacatenco, Grupo de Tribología, Col. Lindavista, C.P. 07738 Ciudad de México, México.	4:30 PM-4:42 PM (IST) 5:00AM-5:12AM (Mexico Time)
ITRS041	The Lubrication of the Finite Journal Bearing with Variable Viscosity, Velocity-Slip, Ferrofluid Lubricant and Couple-Stress Fluid, in the Presence of the Finitely and Infinitely Long Magnetic Model. Tyrone Darryl Dass, Sreedhara Rao Gunakala *, Donna Comissiong University of the West Indies	4:42 PM-4:54 PM (IST) 7:12 AM-7:24 AM (Trinidad and Tobago Time)
Session 17 (2:30 PM – 4:54 PM) **Session Chair:** Prof. Alessandro Ruggiero**,** UNISA, Italy **Session Coordinators:** Prof. TVVLN Rao, MITS **Link:** https://meet.google.com/yxf-iyrr-nfv		
ITRS064	Tribological Hydrodynamic Behavior of Tilting Pad Thrust Bearings - The Effect of Incomplete Oil Film Konstantinos P. Katsaros *, Pantelis G. Nikolakopoulos University of Patras, Greece	2:30 PM- 2:42 PM (IST) 11:00AM-11:12 AM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

		(Greece Time)
ITRS067	Performance of hydrostatic thrust pad bearing operating with electro-rheological lubricant Divya Choudhary, Vivek Kumar, Naveen Sharma, Satish C Sharma Netaji Subhas University of Technology (NSUT), Dwarka, New Delhi.	2:42 PM - 2:54 PM
ITRS069	Performance of porous surface hydrostatic thrust bearing operating with non-Newtonian lubricant Pushpendra K Kushwaha , Vivek Kumar, Vinay Vakharia, Satish C Sharma Netaji Subhas University of Technology (NSUT), Dwarka, New Delhi	2:54 PM - 3:06 PM
ITRS070	Analysis of rough surface multi-lobe journal bearings operating in turbulent regime Kuldeep Narwat, Vivek Kumar, Simran Jeet Singh, Abhishek Kumar, Satish C Sharma Netaji Subhas University of Technology (NSUT), Dwarka, New Delhi	3:06 PM- 3:18 PM
ITRS068	Performance of textured surface hybrid thrust pad bearing operating with electro-rheological lubricant Atul Kumar Singh, Vivek Kumar, Simran Jeet Singh, Satish C Sharma Netaji Subhas University of Technology (NSUT), Dwarka, New Delhi.	3:18 PM- 3:30 PM
ITRS082	Modelling and Parametric Analysis of Abrasive Wear Behavior of Eulaliopsis Binata Fiber Reinforced Polymer Composites Using Response Surface Method Subhrajit Pradhan*, Ved Prakash, M Hemachandra, Samir Kumar Acharya National Institute of Technology, Rourkela, Odisha, India.	3:30 PM- 3:42 PM
ITRS081	Role of friction additives/sulphide mix and materials performing multi task towards brake performance and Environmental aspects – A Review A.Eakambaram*, M.A.Sai Balaji, S.Rasool Mohideen, P.Baskara Sethupathi B S Abdur Rahman Crescent Institute of Science & Technology, Chennai	3:42 PM- 3:54 PM
ITRS093	Ship Hull Corrosion And the Effect of Lack of Maintainence on the Impressed Current Cathodic Protection Shashank Department of Ship Technology, CUSAT - Kochi	3:54 PM- 4:06 PM
ITRS105	A Comprative Study of Mechanical and Tribologcial Properties of H-Ammc Reinforced With MWCNT Sintered by Conventional and Microwave Hybrid Heating Rajat Kumar, Sandeep Bansal, Dheeraj Gupta and Hiralal Bhowmick Thapar Institute of Engineering and Technology, Patiala, India	4:06 PM -4:18 PM
ITRS107	Performance Improvement of EN-8 Steel Alloy Cylindrical Mould Using Rotating Magnetorheological Honing Process Sunil Kumar Paswan, Kunal Arora, Anant Kumar Singh Thapar Institute of Engineering and Technology, Patiala, India	4:18 PM-4:30 PM
Dr. Andreas Rosenkranz, University of Chile, Santiago, Chile **Title:** 2D MXenes: Tunable mechanical and tribological properties		4:30 PM-4:55 PM (IST) 8:00 AM- 8:25 AM (Chile Time)

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

Session 18 (2:30 PM – 4:54 PM) **Session Chair:** Dr. A K Singh, VNIT Nagpur **Session Coordinators:** Dr. Jitendra Kumar Katiyar, SRMIST **Link:** https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09 **Meeting ID: 948 3346 0480** **Passcode: 398493**		
Prof. Denis Mazuyer, University of Lyon, LTDS, Ec École Centrale de Lyon, **Title:** Combining Experimental and Numerical Approaches to Understand Friction of Textured Lubricated Contacts		2:30 PM- 2:54 PM (IST) 10:00 AM -10:24 AM (France Time)
ITRS078	Importance of tribology in internal combustion engine – uses of boric acid in combustion engines. S. Ajay Central institute of petrochemical engineering and technology	2:54 PM- 3:06 PM
ITRS103	Tribology and Dentistry Mohammed Mujamil. A CIPET,Guindy,Chennai-636009.	3:06 PM- 3:18 PM
ITRS114	A preliminary study on the tribological properties and oxidation stability of rice bran oil with black pepper oil as a bio-additives Vivek V Kamal, Sneha Edla, Ananthan D Thampi, Nakul Pradeep, Muhammed Arif, Rani S College of Engineering Trivandrum, Kerala, India.	3:18 PM- 3:30 PM
ITRS118	Role of nano particles in aqueous lubrication Arun Rajput*, Deepak Kumar Indian Institute of Technology Kanpur, Kanpur, India	3:30 PM- 3:42 PM
ITRS132	New methods for Fe based coatings; Process parameter, influence on tribological properties and challenges Raied Mehtab, Sanjay Mohan SMVDU J&K, India	3:42 PM- 3:54 PM
ITRS133	Effect of Weight Percentage of WC Particles on Cavitation Erosion Behavior of NiCrSiC-WC Composites Clads Developed Through Microwave Cladding Sandeep Bansa*, Jonty Mago, Dheeraj Gupta, Vivek Jain Thapar Institute of Engineering and Technology, Patiala, Punjab, India.	3:54 PM- 4:06 PM
ITRS135	Economic modeling and energy assessment of machining tool steel under MQL environment using environmentally friendly cutting fluids Ashwani Verma, Kishor Kumar Gajrani IIITDM Kancheepuram, India	4:06 PM- 4:18 PM
ITRS136	Effect of Particle Size Variation on Structural and Tribological Behaviour of AA2014 Reinforced with Al2O3 Particles. Bharath V, V Auradi and Madeva Nagaral Sri Venkateshwara College of Engineering, Bangalore, India	4:18 PM- 4:30 PM
ITRS195	Duplex treatment, as an effective tool in improving the adhesion and wear behaviour of DLC and CrN hard ceramic coatings deposited on automotive tool steel. Shiraz Ahmed Siddiqui *, Maria Berkes Maros University of Miskolc, Hungary	4:30 PM-4:42 PM (IST) 12:00PM-12:12Pm (Hungary Time)
ITRS033 ITRS252	The Tribological and Rheological Properties of Vegetable Lubricating Grease modified of nanoparticles of TiO2 R. Kozdrach Institute for Sustainable Technologies, Radom, Poland.	4:42 PM-4:54 PM (IST) 12:12PM-12:24PM (Poland Time)
Session 19 (2:30 PM – 4:54 PM)		

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 2 (9-12-2021)

Session Chair: Dr. Avinsah Kumar, IIITDM Kancheepuram **Session Coordinators:** Dr. Mir Irfan Ul haq, SMVDU **Link:** meet.google.com/odf-irfs-zvm		
Prof. P. Ramkumar, IIT Madras, India **Title: TBA**		2:30 PM- 2:54 PM
ITRS142	Automobile engine tribology - approaching the surface J. SIVARAMAN Central Institute of Petrochemicals Engineering and Technology (CIPET), Chennai	2:54 PM- 3:06 PM
ITRS146	Investigations on the effect of tungsten carbide-cobalt particles on the hardness and wear properties of aluminium composite materials Gopal Krishna U B, Vasudeva B, Virupaxi Auradi and Madeva Nagaral SIT, Tumkur, Karnataka	3:06 PM- 3:18 PM
ITRS147	Analysis of Optimized parameters of HVOF spray coating by Taguchi Method and ANOVA analysis in coating Khushneet Singh, Sanjay Mohan Shri Mata Vaishno Devi University, Katra.	3:18 PM- 3:30 PM
ITRS313	Corrosion behaviour of engineering materials – a review of methodologies and environments Sheikh Aamir Farooq, Ankush Raina, Mir Irfan Ul Haq, Zulfiqar A Khan* *Bournemouth University, UK	3:30 PM- 3:42 PM (IST) 10:00AM-10:12AM (UKT)
ITRS316	Volume/shear work ratio dependency on contact pressure in abrasive wear modelling by DEM Egidijus Katinas, Rostislav Chotěborský Department of Electrical Engineering and Automation, Prague, Czech University of Life Sciences. Prague, Prague, Czech Republic	3:42 PM- 3:54 PM (IST) 11:12AM-11:24AM (Czechia Time)
ITRS150	Tribo-corrosion investigation on ultrafine grained laminates of Ti fabricated using LSEM Gursimranjot Singh, Pushpinder Kumar*, Ravinder Singh Joshi, Arshpreet Singh Thapar Institute of Engineering & Technology, Patiala, Punjab, India	3:54 PM- 4:06 PM
ITRS152	Effect of room and high temperature on dry sliding wear characteristics of stir casted LM13/B 4 C composites and LM13/ilmenite composites Rahul Gupta, Tarun Nanda, O. P. Pandey Thapar Institute of Engineering & Technology, Patiala, Punjab, India	4:06 PM- 4:18 PM
ITRS154	Nano-indentation of Highly Crosslinked Polymer Networks: A Molecular Dynamics Simulation Study Manoj K. Maurya, Manjesh K. Singh Indian Institute of Technology, Kanpur.	4:18 PM- 4:30 PM
ITRS155	Significance of biotribology in advanced biomedical applications: A Review Shivam Verma *, Nitin Sharma and Saurabh Kango National Institute of Technology-Jalandhar	4:30 PM-4:42 PM
ITRS140	On the Contact Pressures Predictions for Evaluation of Fretting Wear Mechanism Katerina A. Zampouni and Pantelis G. Nikolakopoulos University of Patras, Greece	4:42 PM-4:54 PM (IST) 1:12PM-1:24PM (Greece Time)

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

Session 19 **Session Coordinators: Dr. T V V L N Rao, MITS** **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**	**Time**
Plenary 3 Prof. Bharat Bhushan, Ohio University, Ohio, USA Title: TBA	9:00 AM – 9:35 AM (IST) 10:30 PM to 11:05 PM (UST) (9 Dec 2021)

Session 20 (9:35 AM – 12:24 PM)

Session Chair: Dr. Mruthyunjaya Swamy K B, NITK Surathkal, Karnataka

Session Coordinators: Prof. T VVLN Rao, MITS and Dr. Jitendra Kumar Katiyar, SRMIST

Link:
https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09
Meeting ID: 948 3346 0480
Passcode: 398493

Paper ID	Invited/Oral Session	Time
	Dr. Manjesh Singh, IIT Kanpur, India **Title:** TBA	9:35 AM-10:00 AM
ITRS141	Assessment of halogen free phosphonium based ionic liquid as lubricant additives for tribological and machining applications Arun Kumar Bambam, Kishor Kumar Gajrani IIITDM Kancheepuram, India	10:00 AM-10:12 AM
ITRS145	Development of Cera-metallic friction material for tractor applications – An interface study C.Venkatachalam, M A Sai Balaji, A Eakambaram, Baskara setupathy BS Abdur Rahman Crescent Institute of Science & Technology	10:12 AM-10:24 AM
ITRS156	Effect of ECAP on structural and wear properties of pure Cu G.Gunasree, Sheba Roman, K.Kusuma Sruthi Vignan's Institute of Engineering for Women, Visakhapatnam	10:24 AM -10:36 AM
ITRS158	Wire Electrical Discharge Machining of SiC Reinforced Magnesium matrix composite produced by powder metallurgy route S. Jayasathyakawin, M. Ravichandran, M.Meignanamoorthy, Jitendra Kumar Katiyar, V.Dhinakaran K. Ramakrishnan College of Engineering, Samayapuram, Trichy	10:36 AM-10:48 AM
ITRS159	Tribological performance comparison between biogrease and mineral grease lubricant with nanoparticle additives: A review Arif Izzuddin Muhammad, Nurul Farhana Mohd Yusof Universiti Sains Malaysia, Nibong Tebal, Malaysia	10:48 AM- 11:00 AM (IST) 1:18PM-1:30PM (MYT)
ITRS134	Investigation on tribological behaviour of Ti-6Al-4V laminates produced for Ti/GFRP stacked composite Pushpinder Kumar*, Ravinder Singh Joshi, Rohit Kumar Singla	11:00 AM- 11:12 AM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

	Thapar Institute of Engineering and Technology, Patiala, Punjab, 147004, India.	
ITRS051	Influence of h-BN on Tribological behaviour of AZ91D/h-BN composites: An Experimental study and analysis S. Ayyanar, A.Gnanavelbabu*, K. Rajkumar and P. Loganathan CEG Campus, Anna University, Chennai-600025, India.	11:12 AM-11:24 AM
ITRS055	Comparative Study on Microstructure, Mechanical and Wear Behaviour of Cu/hBN Composites Sintered Through Microwave and Muffle Furnace A. Gnanavelbabu*, M. Prahadeeswaran CEG Campus, Anna University, Chennai - 600 025, India.	11:24 AM-11:36 AM
ITRS162	Revealing the nanoscale wear behavior of interior and edge of CVD grown monolayer MoS2 flake Himanshu Rai*, Aditya Singh, Rajendra Singh, Nitya Nand Gosvami Indian Institute of Technology Delhi	11:36 AM-11:48AM
ITRS303	MICROSTRUCTURE AND MECHANICAL PROPERTIES OF IN-PROCESS COOLED ALUMINUM ALLOY THICK PLATE FRICTION STIR WELDS Ch. Ramakrishna, M. Venu, Ch. Naga Raju Sir CRR College of Engineering, Eluru, Andhra Pradesh	11:48 AM- 12:00 PM
ITRS048	Effect of Surface Mechanical Attrition Treatment (SMAT) through surface topography modification on Tribological properties of Inconel X-750 superalloy Vimal Edachery *, Moin Khan P , Aashish John, P S Suvin Indian Institute of Science, Bangalore 560012, India	12:00PM-12:12PM
ITRS330 ITRS333	Performance evaluation of machine learning algorithm in predicting surface roughness of AISI 304 steel in MQL turning. Vineet Dubey, Anuj Kumar Sharma, J. Ramkumar Centre for Advanced Studies, Lucknow, Uttar Pradesh	12:12PM-12:24PM

Session 21 (9:35 AM – 12:24 PM)

Session Chair: Dr Joy Prakash Misra, IIT BHU

Session Coordinators: Dr. Anuj Kumar Sharma, CAS-AKTU

Link: https://teams.microsoft.com/l/meetup-join/19%3ameeting_NWFjYWI3YmUtNmE3ZS00ZDU1LTgzY2EtZGU3NmY3ODBjYTI5%40thread.v2/0?context=%7b%22Tid%22%3a%22a0b6ea85-9e1b-4d0e-af80-e542011afc9a%22%2c%22Oid%22%3a%22497402c5-935d-4ccf-8225-05d48d4173f8%22%7d

Paper ID	Invited/Oral Session	Time
Dr. T V K Gupta, VNIT Nagpur, India **Title:** Issues in Metal Additive Manufacturing with Laser Cladding		9:35 AM-10:00 AM
ITRS161	Experimental Investigation on the performance of phosphonium phosphinate ionic liquid against scuffing Prasanth B Menon, P. Ramkumar Indian Institute of Technology Madras, India	10:00 AM-10:12 AM
ITRS164	Magnetorheological Fine Finishing of Spline Shaft Surfaces for Improved Performance Manpreet Singh, Kunal Arora, Anant Kumar Singh* Thapar Institute of Engineering and Technology, Patiala, India	10:12 AM-10:24 AM
ITRS168	Stability analysis of Finite Textured Journal Bearing with the Effect of Lubricant Slippage	10:24 AM -10:36 AM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

	Mohammad Arif , Saurabh Kango, Dinesh Kumar Shukla, Nitin Sharma National Institute of Technology Jalandhar	
ITRS169	Dry Sliding Tribological Behavior of Aluminium based Silicon Carbide Metal Matrix Composite (Al-SiCp) for high temperature applications Milind S.Mhaske, Dr. R.R.Navthar Pravara Rural Engineering College, Loni, SPPU, Pune, India	10:36 AM-10:48 AM
ITRS170	Thermal Analysis Of Textured Parallel Plate Bearings With Controlled Slip/No-Slip Boundary Condition Prashant G Nimbolkar, Saurabh Kango, Nitin Sharma, Mohammad Arif National Institute of Technology Jalandhar	10:48 AM- 11:00 AM
ITRS172	Review on Optimization Techniques of Brake Friction Composite Nikhil Pandita, Aditya Kumar Sharma and Dr. Vishal Ahlawat UIET, Kurukshetra University, Haryana	11:00 AM- 11:12 AM
ITRS176	Anti-friction lubricant for damping and sealing on solenoid armature M.Rajkumar, M A Sai Balaji, A Eakambaram, Baskara setupathy BS Abdur Rahman Crescent Institute of Science & Technology	11:12 AM-11:24 AM
ITRS177	A Model for Static Friction of a Soft and Hard Solid Interface Pawan Kumar Soni , Arun K. Singh , Jitendra K. Katiyar Visvesvaraya National Institute of Technology, Nagpur	11:24 AM-11:36 AM
ITRS181	Abrasive Tribo Behavior Assessment of Abaca Natural Fiber Composite *Ved Prakash, Samir Kumar Acharya NIT Rourkela, Rourkela, Odisha, India	11:36 AM-11:48AM
ITRS184	Influence of process variables on tensile behaviour of 316l stainless steel samples fabricated via selective laser melting process Meena Pant, Leeladhar Nagdeve, Girija Moona, Harish Kumar, Jitendra Kumar Katiyar National Institute of Technology Delhi, India	11:48 AM- 12:00 PM
ITRS300	Effects of different Process Parameters on the fabrication of Aluminium Matrix Composite by FSP. A review Varun Dutta, Suresh Jangotra Shri Mata Vaishno Devi University, Katra, J&K, India	12:00PM-12:12PM
ITRS305	Erosion Wear Behaviour of Nano-Zirconia Filled Wild-Cane Fiber Reinforced Epoxy Composite: Experimental and Optimisation Approach Pruthwiraj Sahu, Mantra Prasad Satpathy*, Pravat Ranjan Pati KIIT Deemed to be University, Bhubaneswar, India	12:12PM-12:24PM
Session 22 (9:35 AM – 12:24 PM) **Session Chair:** Dr. Anoop Kumar Sood, NIFFT Ranchi **Session Coordinators:** Dr. Ranjeet Kumar Sahu, NITK **Link:** https://meet.google.com/yxf-iyrr-nfv		
Paper ID	**Invited/Oral Session**	**Time**
Dr. Chacko Preno Koshy, Saintgits College of Engineering, Kerala, India **Title:** Formulation and Testing of Nano-lubricants for Internal Combustion Engine Applications		9:35 AM-10:00 AM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

ITRS199	Dry Sliding Wear Behaviour of Aa6082 Reinforced with SiC Particles Through Ex-Situ Casting Techniques S. Surendarnath*, G. Ramesh, T. Ramachandran , R. Dharmalingam, S. Muruga Poopathi Sri Venkateswara College of Engineering & Technology (A), Chittoor	10:00 AM-10:12 AM
ITRS198	Surface Engineering of Ti6Al4V Alloy for Tribological Applications: A Review Jibin T Philip*, Ananthakrishnan R, Rubin Binu Roy, Atul Sundaresan, and Robin Santhan Amal Jyothi College of Engineering, Kanjirappally-	10:12 AM-10:24 AM
ITRS137	Prediction of Dry Sliding Wear Behavior of AA7075-B4C Composites S.V. Alagarsamy* and H. Saravanan Mahath Amma Institute of Engineering and Technology, Pudukkottai, Tamil Nadu, India.	10:24 AM -10:36 AM
ITRS063	Wear Analysis and Prediction of Tribological Behaviour of Alkaline Treated Hemp Filler Reinforced Epoxy Composite Geetakshi Teli *, Vijay Kumar Mahakur, Rajdeep Paul, Sumit Bhowmik NIT Silchar, Assam 788010, India	10:36 AM-10:48 AM
ITRS045	Cyclic oxidation and hot corrosion behaviour of HVOF sprayed NiCrAl coating on industrial boiler tube steels Ramesh M R, Subba Rao Medabalimi National Institute of Technology Karnataka, Surathkal	10:48 AM- 11:00 AM
ITRS185	Tribological assessment of 316l stainless steel fabricated by selective laser melting process Meena Pant, Leeladhar Nagdeve, Girija Moona, Harish Kumar, Anuj Sharma National Institute of Technology Delhi, India	11:00 AM- 11:12 AM
ITRS180	Effect of Titanium Nitride particles on wear behaviour of Mg ZK60A alloy composites processed by P/M route H. Saravanan *, V.Dhinakaran and S.V. Alagarsamy Mahath Amma Institute of Engineering and Technology, Pudukkottai	11:12 AM-11:24 AM
ITRS225	AN EMPIRICAL ASSESSMENT AND PERFORMANCE ANALYSIS OF WIRE ELECTRICAL DISCHARGE MACHINING CHARACTERISTICS OF HARD TI–6AL–2SN–4ZR–2MO A. Perumal, S. Baskaran, R. Prithivirajan, S. Suresh Kumar, P.R.Rajkumar, T.Gangadharan * Sethu Institute of Technology, Kariapatti, India.	11:24 AM-11:36 AM
ITRS229	Dry Sliding Wear behavior of Al/Kyanite Metal Matrix Composites M. S. Prabhudev*, H.B.Nirajan, M.P. Chowdiah & V.K.Basalalli *Government Polytechnic, Kalgi, Karnataka	11:36 AM-11:48AM
ITRS248	Repeatability of Friction and Wear of Different Material Pairs at 1000 °C under Unidirectional Sliding Motion Sravan Josyula, Harish Prasanna, Debdutt Patro, Fabio Alemano, Deepak Veeregowda Global Applications Lab, Ducom Instruments, India	11:48 AM- 12:00 PM
ITRS298	Reinforcement of different Fine Grains particles in Aluminum Alloy by FSP Technique – A Review Suresh Jangotra*, Er. Varun Dutta *Shri Mata Vaishno Devi University, Katra, J& K, India	12:00PM-12:12PM
ITRS297	Tribological and Mechanical Properties of Zinc aluminium (ZA-27)/aluminium Zinc alloy (Al-25Zn): a	12:12PM-12:24PM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

	Comparative Review and Research Dr. Parmeshwar P. Ritapure*, Rashmi G. Yadav, Bharat D. Aldar, Dr. Yashwant R. Kharde *Zeal College of Engineering and Research, Pune, India.	
Session 23 (9:35 AM – 12:24 PM) **Session Chair:** Dr. Ankush Anand, SMVDU **Session Coordinators:** Dr. Mir Irfan Ul Haq, SMVDU **Link:** meet.google.com/odf-irfs-zvm		
Paper ID	**Invited/Oral Session**	**Time**
Dr. Prabakaran Saravanan, BITS Pilani Hyderabad Campus, India Title: TBA		9:35 AM-10:00 AM
ITRS266	Influence of Normalized enthalpy on the Morphology of Direct Metal Deposited Inconel 718 Chaitanya Gullipalli, Nikhil Thawari, Prayag Burad, T. V. K. Gupta Visvesvaraya National Institute of Technology, Nagpur India.	10:00 AM-10:12 AM
ITRS268	An Investigation on Tribological Properties of Rail and Wheel under Different Environmental Conditions using Pin-on-Disc Tribometer Sachin, Ajeet Yadav, Rabesh Kumar Singh*, Anuj Kumar Sharma, Jitendra Kumar Katiyar * Centre for Advanced Studies, Dr. A.P.J. Abdul Kalam Technical University, Lucknow, India	10:12 AM-10:24 AM
ITRS270	Corrosion and Wear Behavior of Stir Cast, Brick Powder Reinforced, Aluminum based Metal Matrix Composites Vineet Jha, Shubham Kumar Singh, Sarvagya Shukla, Gopal Ji* *Centre for advanced studies, Dr APJAKTU Lucknow, U.P., India.	10:24 AM -10:36 AM
ITRS239	A comparative assessment of performance behavior of Mineral and ester base engine oils with or without containing metal oxide nano-particles. Ajay Kumar, TCSM Gupta* *Apar Industries Ltd, Navi Mumbai 400701, India.	10:36 AM-10:48 AM
ITRS275	Influence of boron carbide content on dry sliding wear performances of AZ91D magnesium alloy. Aatthisugan I, Murugesan R*, T.V.V.L.N. Rao *SRM Institute of Science and Technology, Kattankulathur-India	10:48 AM- 11:00 AM
ITRS292	Influence of unidirectional laser texture with different laser frequency and scanning speed on wettability and surface energy of Hastelloy C22, C245 and X Ambesh Singh*, Abel Tomy, Vimal Edachery, Suvin P.S, Arun Augustin *National Institute of Technology Karnataka, Surathkal, India.	11:00 AM-11:12AM
ITRS295	Effect of full and partial texturing on tribological performance of meso scale air journal bearing: an experimental study. Nilesh D. Hingawe*, Skylab P. Bhore *Motilal Nehru National Institute of Technology Allahabad, Prayagraj India	11:12 AM- 11:24 AM
ITRS296	Comparison between tribological performance of nano additive lubricants containing SiO2 and Cu particles Syed Junaid*, Nitya Nand Gosvami *Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India	11:24 AM-11:36 AM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

ITRS301	Surface Topography Evolution and Pitting under Rolling/ Sliding Motion to Pearlitic Steel Sudhanshu Kumar*, Mayank Tiwari and Surajit Kumar Paul *Indian Institute of Technology Patna	11:36 AM-11:48 AM
ITRS307	Design of LQG controller for an active magnetic thrust bearing Pranshu Shukla, Balaji Sankar NIT Suratkal	11:48 AM-12:00 PM
ITRS308	Dry Sliding Tribological Behavior of AZ31-B 4 C Nano Composites Vikram P.Titarmare*, Sudip Banerjee, Prasanta Sahoo *Jadavpur University, Kolkata	12:00 PM- 12:12 PM
ITRS309	Study of Sinter Return Fines Generation and Their Effective Utilization: A Comprehensive View for Sinter Making in Rourkela Steel Plant Anup Kumar Dutta, Prasanta Kumar Padhi, M. Sreenivas Rao *Rourkela Steel Plant, Steel Authority of India Limited	12:12 PM-12:24 PM
Session 24 (9:35 AM – 12:24 PM) **Session Chair:** Dr. Matruprasad Rout, NIT Trichy **Session Coordinators:** Dr. P S Suvin, NITK **Link: https://meet.google.com/vjp-hsxv-bcb**		
Paper ID	**Invited/Oral Session**	**Time**
Dr. T C S M Gupta, Apar Industries Mumabi, India **Title:** Environmentally Acceptable Lubricants: A Paradigm shift to improve product performance and sustainability		9:35AM-10:00AM
ITRS149	Lubricant performance against white etching area formation in bearing steel under impact sliding loading Davis Linto, P. Ramkumar Indian Institute of Technology Madras, Chennai, India	10:00 AM-10:12 AM
ITRS321	Experimental investigation and modelling on the end milling of wire arc additive manufactured feature. Sai Teja B, Shanmuka Srinivas M, Surya Ganesh V, Venkata Kedara Krishna P, Ravi Sankar M* *Indian Institute of Technology Tirupati, India - 517506	10:12 AM-10:24 AM
ITRS317	Tribological properties of Hybrid Natural Fiber Reinforced polymer composites under different environmental conditions: A Review Asrar Rafiq Bhat, Rajiv Kumar School of Mechanical Engineering, Shri Mata Vaishno Devi University, Katra, J&K	10:24 AM -10:36 AM
ITRS318	3D Printing of polymers using FDM: A study on their properties. Abrar Malik, Mir Irfan Ul Haq, Ankush Raina School of Mechanical Engineering, Shri Mata Vaishno Devi University, Katra J&K	10:36 AM-10:48 AM
ITRS322	3D Printed Polymeric Parts: Mechanical and Tribological Behaviour Jaspreet Singh, Ankush Raina, Mir Irfan Ul Haq* *School of Mechanical Engineering, SMVD University, Katra, J&K, India	10:48 AM- 11:00 AM
ITRS311	Mechanical, Corrosion and Tribological Behaviour of AA 5052/TiB_2 Composites for Marine Applications. Aamir Farooq, Ankush Raina, Mir Irfan Ul Haq *School of Mechanical Engineering, SMVD University, Katra, Jammu and Kashmir, India	11:00 AM-11:12AM

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

ITRS312	Friction Behaviour of 3D Printed PLA Parts- Effect of Surface Texturing Brajesh Kumar, Ankush Raina, Mir Irfan Ul Haq* *School of Mechanical Engineering, SMVD University, Katra, Jammu and Kashmir, India	11:12 AM- 11:24 AM
ITRS299	Nanosecond Laser Surface Texturing for High friction applications D. Nazeer Basha, G. L. Samuel, Ravi Bathe International Advanced Research Centre for Powder Metallurgy and New Materials, (ARCI), Hyderabad, India	11:24 AM-11:36 AM
ITRS148	Surface characterization and corrosion study of ZrSi(N,O) Nano Composite Coating on Ti6Al4V P. Jeyalakshmi, Vivek Kashyap, and P. Ramkumar* Indian Institute of Technology Madras, Chennai, India	11:36 AM-11:48 AM
ITRS294	A study on the friction and wear behavior of PTFE filled with boron carbide nanoparticles Aldar B.D., Dr. Prabhune C.L, Sujata S. B. Department Of Mechanical Engineering Zeal Collage of Engineering and Research Pune.	12:00 PM-12:12 PM
ITRS319	Effect of Electrochemical Potential on Tribocorrosion Behaviour of AISI 304 Stainless Steel in Sea Water. Sabri Alkan Bandırma Onyedi Eylül University, Maritime Vocational School of Higher Education, Department of Motor Vehicles and Transportation Technologies, Turkey	12:12 PM- 12:24 PM (IST) 9:42AM-9:54 AM (Turkey Time)
ITRS310	Surface Metallization of Laser Powder Bed Fusion Manufactured Polyamide Parts Binnur Sagbas, Hüseyin Yüce Mechanical Engineering Department, Yildiz Technical University, Turkey	12:24 AM-12:36 PM (IST) 9:54 AM-10:06 AM (Turkey Time)
Session 25 (12:30 PM – 1:30 PM) **Business Meet** **Session Coordinator: Dr. Jitendra Kumar Katiyar, SRMIST** **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**		
Ducom Instruments Bangalore		12:30 PM-12:45 PM
Apar Industries Navi Mumbai		12:45PM-1:00 PM
Mr. V. K. Chadda (Ex. BARC Scientist), Advisor, Expert Vision Lab and Biogreen Lifesciences		1:00PM-1:30 PM
Lunch (1:00 PM – 2:00 PM)		
Session 26 **Session Chair: Prof.** Alessandro Ruggiero, UNISA, Italy **Session Coordinator:** Dr. Jitendra Kumar Katiyar, SRMIST **Link:** **https://zoom.us/j/94833460480?pwd=MWNYNVI5R1IwNTh0d0NLSzQvZXNRZz09** **Meeting ID: 948 3346 0480** **Passcode: 398493**		**Time** 2:00PM-5:00PM (IST) 9:30AM-12:30 PM (Italy Time)
Keynote 5 Prof. Zulfiqar A Khan, Bournemouth University, UK		2:00 PM -2:35 PM (IST)

2nd VIRTUAL INTERNATIONAL TRIBOLOGY RESEARCH SYMPOSIUM 2021
8th – 10th December 2021
Schedule of Day 3 (10-12-2021)

Title: A synergistic approach to wear-corrosion modelling applied to nanocomposite coatings	8:30 AM-9:10 AM (UK Time)
Keynote 6 Dr. Ben Beake, Manchester Metropolitan University, UK **Title:** New multi-sensing nanotribology test with electrical contact resistance and friction measurement	2:35 PM – 3:10 PM (IST) 9:10 AM-9:45 AM (UK Time)
Keynote 7 Prof. Carsten Gachot, Vienna University of Technology, Austria **Title:** Easy Glide – How Ionic Liquids could save Helicopter Gears from Failure	3:10 PM-3:45 PM (IST) 10:40 AM-11:25 AM (CET)
Keynote 8 Prof Andreas Almqvist, Luleå University of Technology, Sweden **Title:** Computational Tribology	3:45 PM-4:20 PM (IST) 11:15 AM-11:50 AM (Sweden Time)
Valedictory & Vote of Thanks	4:25 PM-5:00 PM

ITRS029
Optimization of surface roughness and wear rate during sliding of tribopair using GA

Mohammad Hanief
Mechanical Engineering Department,
National Institute of Technology-Srinagar

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Abstract. Wear of a surface results in two important changes during the relative motion: material loss and surface roughness change. The minimum surface roughness with maximum wear rate is desirable in most of the machining processes. The present study aims to optimize the operating parameters and material hardness to attain minimum surface roughness with a maximum wear rate. The operating parameters considered in this study are time; sliding distance and hardness. The optimization of surface roughness and wear rate was carried out by developing power-law models as objective functions. The objective functions were optimized using a genetic algorithm. The experiments were conducted on a reciprocating tribometer with a ball-on-disc configuration. Three different tribo-pairs were used for experimentation. A 52100-chromium steel ball was allowed to slide with bronze (gunmetal), mild-steel, and EN-31 steel discs under different operating conditions. The surface roughness and wear rate of the samples for each test were determined by weight loss method and roughness meter respectively. The model responses and experimental results were compared to check the accuracy and competence of the models. The accuracy of the models was assessed using statistical parameters viz, (MAPE) mean absolute percentage error, (R^2) coefficient of determination, and mean square error (MSE). Followed by the sliding time and material hardness, sliding distance was found to be the predominant factor that influences the wear and surface roughness. Finally, genetic algorithm was used for optimization of the process parameters. It was found that the optimum values of the hardness, sliding distance, and sliding time were 122.47 BHN, 4.8 m, and 2.63 min respectively.

Keywords: optimization, surface roughness, wear rate, genetic algorithm, regression

ITRS030
Effect of Low Weight Fraction of TaC Ultra High Temperature Ceramic on Wear properties of Mg-AZ91D Lightweight Alloy

Gnanavelbabu[1], K.T. Sunu Surendran[1], K. Rajkumar2*
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Abstract: In this research work, the effect of low weight fractions of Tantalum carbide (TaC) Ultra-high Temperature Ceramic (UHTC) particles on the wear behaviour of Mg-AZ91D alloy was investigated. Composites containing 2.5, 5 and 7.5 wt.% of TaC particles were fabricated using novel ultrasound assisted stir-squeeze casting method. The evaluation of microstructure, porosity and hardness of the composites was carried out prior to the wear test. A pin-on-disc tribometer configured with an EN31 steel disc was used to investigate the wear behavior of the materials at room and elevated temperatures. At room temperature wear tests, normal loads

ranging 12.5-50 N and sliding speeds ranging 0.25-1 m/s were applied for finding the Specific Wear Rate (SWR) and Coefficient of Friction (COF). The high temperature wear behavior was examined at different temperatures between 50 and 200 ^{o}C. The addition of 2.5, 5, and 7.5 wt.% TaC particles increased the base matrix hardness by 7.04%, 14.08% and 29.58% respectively. In all sliding conditions, the experimental results showed an improvement in the tribological performance of the composites compared to an unreinforced alloy. The results showed a declining trend for SWR and COF, with an increase in normal load and sliding speed. The examination of worn surface features and wear debris characteristics indicated abrasion, oxidation and delamination wear mechanisms. SWR of materials increased with the increase in the wear test temperature. However, due to the difference in reinforcing conditions, the critical temperature for drastic increases in SWR was different for composites. Abrasion, adhesion, oxidation and delamination were the wear mechanisms operated at elevated temperature conditions.

Keywords: Magnesium composites; AZ91D; Tantalum carbide; Ultrasonication; Wear behavior.

ITRS031

Prediction of surface finish in extrusion honing process by regression analysis and artificial neural networks

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Abstract: The current work explores the influence of process parameters such as mesh size and volume fraction of abrasives with number of passes, on the interior surface quality of a pre machined component by extrusion honing process. The finishing process is highly flexible and unconventional while modifying the surfaces in case of miniature components involving complex profiles. The method is extensively used to deburr, polish, edge contour and removing recast layers by producing compressive stresses. By, the pressurized flow of semi viscous abrasive laden across the surface to be processed. The experimental study has been carried out on Inconel-625 alloy by one way EH process, with the carrier medium silicone polymer blended with SiC as abrasives. Experiments are planned by constructing L27 orthogonal array for the factors such as mesh number 36, 54, 60 and volume fraction 35, 40, 45 % of abrasives followed by number of passes 5, 10 and 15. Also, the study focuses in developing a regression model, training neural network and comparison of experimental R_a with both regression and ANN model. The prediction of R_a is accomplished by developing a linear regression model and a feed forward back propagation neural network model.

Key words: Extrusion honing (EH), Surface finish (SF), Material removal (MR), Artificial neural network (ANN), Abrasives.

ITRS032
Insitu imaging to identify scratch damage of BCR 692 reference DLC coating

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Abstract: Coatings is one of the widely used surface modification method which enhances the tribological performance of a system. Though distinct changes in acoustic emission (AE) and frictional force (FF) indicate damage events during scratch, visual inspection using microscopy is the most reliable way to determine the failure mechanisms of the coating. In this study we report the scratch damage mechanisms of a certified reference material, DLC coating (BCR 692), developed by the Institute of Reference Materials (IRMM) and Measurements, European Commission Joint Research Center, Belgium. Friction force and acoustic emission were acquired in real time during the scratch test combined with integrated imaging of the entire scratch track. Data from al the sensors as a function of scratch length were superimposed on the stitched scratch image to identify and measure the cohesive and adhesive failure modes and critical loads. Initiation of edge cracks marked the first critical failure for BCR 692 sample, and this correlated well with the acoustic emission signal thereby unambiguously establishing formation of edge cracks. Further progressive damage with increasing loads lead to edge spallation and central cracking which could be simultaneously identified from the image, acoustic emission intensity as well as change in traction force. The critical failure loads for the cohesive (Lc1) and multiple adhesive failures (Lc2 and Lc3) were determined by measurement of the location from the origin of the scratch. In-situ images correlated well with the Lc1, Lc2 and Lc3 failure atlas for BCR 692. The reported failure loads for all three scratches on BCR 692 were within the precision limits reported by the standard.

Keywords - Scratch, Adhesion Strength, InSitu Imaging, Acoustic Emission,

ITRS033
The Tribological and Rheological Properties of Vegetable Lubricating Grease modified of nanoparticles of TiO2

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Abstract: The article presents the influence of TiO2 as a modified additive on tribological and rheological properties of vegetable lubricating composition. The tribological properties of greases modified of TiO2 nanoparticles were evaluated using rotational rheometer MCR 102 with tribological cell T-PTD 200. In addition, the worn surface of the steel ball was investigated via Raman spectroscopy and X-ray photoelectron spectroscopy (XPS). The rheological properties of tested greases were carried out the optical rheometer of DWS RheoLab Swiss company LS Instruments AG. The analysis of friction factor during the test for the tested lubricating composition indicates a significant change in this parameters for tested lubricants. A change of the value of evaluated tribological parameter leads to a change in the structure of the

composition carried out tests and a change in the effectiveness of the tribological protection of the tribosystem. The content of the used additive in the lubricant structure affects the level of the anti-wear properties, as evidenced by the results obtained during the tribological tests presented in this article. The DWS technique provides the ability to obtain information about the viscoelastic state of non-Newtonian liquids and provide the monitoring of structural changes after tribological tests. The observation of the movement of the dispersed phase particles and the evaluation of the microstructure changes in the solutions based on the results of the correlation function MSD in time, complex viscosity, complex modulus and the research of the G 'and G" modulus in wide frequency range provides a comprehensive microstructure characteristic of the tested greases at the microscopic level.

Key words: lubricating grease, vegetable oil, **t**itanium dioxide (TiO2), tribological properties, friction factor, rheological properties, Mean Square Displacement, storage modulus G', loss modulus G''

ITRS034

Exploring Mechanical and Tribological Characteristics of Metal Additive Manufactured AlSi10Mg Alloy

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Abstract: Metal Additive Manufacturing (MAM) is a recent versatile manufacturing technique that plays a significant role in producing automotive, aerospace components and medical implants. It has become inevitable nowadays due to its easiness in production process and it is economically viable. Direct Metal Laser Sintering (DMLS) is one among the best techniques of MAM and getting commercially popularized in recent years as it can be used to produce almost all metal 3D products. DMLS uses a precise, high-intensity laser to micro-weld the powdered metals and alloys to form fully functional metal components. The present work emphasizes on investigating the mechanical and tribological properties of Direct Metal Laser Sintered AlSi10Mg alloy. As a part of mechanical characterization, the Vickers hardness and tensile strength are investigated and the same are being compared with as-cast and Selective Laser Melted (SLM) AlSi10Mg alloy. The experimental results reveal that the DMLSed AlSi10Mg alloy has shown 9.25%, 8.25% improved hardness and 14.23%, 83.85% enhanced tensile strengths than that of as-cast and SLMed alloy respectively. In tribological characterization, the Specific wear rate and Coefficient of Friction (CoF) of DMLSed AlSi10Mg alloy are investigated. The tests results exhibited that at 20 N applied load, 4.18 m/s sliding velocity and 1600 m sliding distance the DMLSed alloy offers minimum specific wear rate and at 40 N applied load, 2.06 m/s sliding velocity and 2400 m sliding distance, the specimen offers minimum coefficient of friction. Fractography is carried out on fractured surfaces to determine the cause of failure during tensile test. Metallographic analysis of worn-out samples is also reported. Grey Relational Analysis (GRA) the multi response optimization technique is

employed to get the improved wear resistance and preferable CoF.
Keywords: AlSi10Mg alloy, DMLS Process, Mechanical properties, Tribological properties, GRA.

ITRS035
Identification of Self-lubricating Mode for the Ultrasonic Treated AA6061-B4C-CNT Hybrid Composites

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Abstract: In this research work, the self-lubricating behaviour of boron carbide (B4C) and carbon nanotube (CNT) reinforced 6061 aluminium alloy matrix hybrid composites was investigated. Hybrid composites were prepared by varying the volume percentages (5-15%) of B4C (10-45 μm) and CNT (30-50 nm). Novel ultrasonic vibration (frequency - 20 kHz and power - 2.5 kW) assisted stir casting process was used for fabricating hybrid composites. Friction and wear behaviour of hybrid composites at dry sliding conditions were evaluated using a pin-on-disc type tribometer equipped with EN-8 as counterface material. Normal load ranging 15-45 N and sliding speed ranging 1-2 m/s were applied during the experiments. The self-lubricating properties of different hybrid composites were assessed through the examination of the worn surface of pins using surface characterization techniques such as Scanning electron microscopy, Electron dispersive spectroscopy and Raman spectroscopy. The experimental results indicated that the addition of CNT particles increases the hardness of hybrid composites. The matrix strengthening efficiency of CNT was found to be better at 10 vol.% of B4C, indicating a maximum hardness ranging from 102 to 109 VHN. In comparison, hybrid composites of 10 vol.% of CNT showed a superior tribological performance at all wear testing conditions. The mode of wear of hybrid composites suggested by the analysis on the worn pin surface was as follows: Scarce (5 vol.% CNT), Tribolayer (10 vol.% CNT) and Fracture (15 vol.% CNT).

Keywords: Aluminium hybrid composites; Boron carbide, Carbon nanotube; Ultrasonication; Friction and wear; Self-lubrication.

ITRS036
Tribological Performance of AZ91D/HfCp Magnesium Composite Prepared through Stir-Ultrasonic-Squeeze Casting Technique

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Abstract: The present work investigates about the influence of Hafnium carbide (HfC), an ultra-

high temperature ceramic reinforcement on the dry sliding wear behavior of AZ91D magnesium composite. AZ91D/5 wt.% HfC composite and AZ91D alloy were fabricated using stir-Ultrasonic Treatment (UST)-squeeze casting method followed by heat treatment (T6). Microstructure and intermetallic phase studies were performed using scanning electron microscopy and X-ray diffraction techniques. Density, porosity and hardness of the materials were determined. Wear tests at room temperature were conducted at various sliding speeds (0.25-1 m/sec) and normal loads (12.5-50 N), using a pin-on disc tribometer. The temperature of wear varied from 50-200 ^{o}C for high-temperature wear tests. SEM image of the composite confirmed the homogeneous dispersion of HfC particulate reinforcements in AZ91D matrix. The β-$Mg_{17}Al_{12}$ precipitates were in a discontinuous form in the matrix due to T6 heat treatment. The combined effects of UST and squeeze pressure reduced the porosity (0.53%) and enhanced hardness (88±1 VHN) of the composite. Compared to alloy, the composite showed better wear performance under all test conditions. Increasing the normal load increased the wear rate of both materials, but wear rate decreased with an increase in sliding speed. The friction at the sliding interface decreased with an increase in normal load and sliding speed. The mechanisms of wear for both materials were abrasion, delamination and oxidation at room temperature. At high temperatures, there was a dramatic increase in the wear rate of the alloy at 150 ^{o}C, whereas the wear resistance of composites improved up to 150 ^{o}C due to the presence of small amounts of HfC reinforcement. Abrasion, oxidation, delamination and plastic yield were the primary wear mechanisms at high temperatures.

Keywords: AZ91D; Hafnium carbide; Ultrasonication, Dry sliding wear, Wear and friction.

ITRS037

Finite Element Method Based Transient Wear Modelling Using Constant Extrapolation Technique for Steel-On-Steel Dry Sliding Contact

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Abstract: Transient wear regime usually has higher wear rate compared to steady state. Metals and metal matrix composites have longer transient wear regime. Hence, to determine accurate and precise wear of these materials, computation of transient regime is essential. Total wear in transient wear regime consists of transient wear and linear wear components. This paper focuses on numerically predicting total wear in transient regime of 316 stainless steel pin against AISI 52100 bearing steel disc and compare with experiment wear results from Pin-on-Disc (PoD) tribometer in dry sliding condition for 20 N and 30 N. Novel methodology is proposed for modelling total wear by calculation of linear wear component using finite element analysis and transient wear component using nonlinear regression. Linear component is simulated using Abaqus FEA UMESHMOTION with constant extrapolation technique to reduce computational time without affecting accuracy, whereas transient component is deduced from experimental data with the help of Gauss-Newton iterative method. Further, total wear is modelled by addition of linear and transient wear components. The simulated results have good agreement with experimental results within error of 11% for both loads. Corresponding transient wear rate was found to be approximately 2.5 times higher than steady state wear. This establishes the

robustness of proposed methodology.

Keywords: Finite element analysis, pin-on-disc, steel, transient wear, UMESHMOTION, wear

ITRS038

THE EFFECT OF SCANDIUM (Sc) ONTO MECHANICAL PROPERTIES AND WEAR PROPERTIES OF Al- 7 wt.% Si ALLOY

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Abstract: Aluminium-silicon (Al-Si) alloys is the one of most metal matrix composites (MMCs) have important high-strength Al alloys. Besides, Al-Si alloys are quite attractive due to their low density, their capability to be strengthened by precipitation, their good corrosion resistance, high thermal and electrical conductivity.Al-Si system are widely used in light-weight constructions and transport applications requiring a combination of high strength and ductility. In this research, Al- 7wt.%Si master alloy was reinforced with 0.2 to 0.8 wt.% scandium (Sc). Al-Si and Sc were melted in high furnace at 720 °C. The Al-Si-Sc composite then were poured to stainless steel mould and let it solidified at room temperature. Ultimate tensile strength (Instron) machine, hardness vickers tester and pin-on disc machine were used to characterize the tensile, hardness and wear properties of Al-Si-Sc composite alloys. From results obtained, the increasement of Sc contents increased the value of tensile and hardness properties to Al-Si alloy. The mechanical studies showed that the ductility of Al-Si alloy was much lower in the absence of Sc. The tensile strength of unrefined Al-Si and Al-Si with 0.6 wt.%Sc were recorded 325 and 377.3 MPa respectively. The hardness value for the unrefined Al-Si alloy also shows less compared with Al-Si with grain refiner, 0.8 wt.%Sc, which were 70 and 85 MPa. This showed the results were significant improvements in mechanical properties have been obtained with the use of Sc as grain refiner to Al-Si alloy. For the wear characterization, it shows that the 0.6 wt.% Sc that were added to Al-Si alloy gave the lowest wear rate which was 0.7×10^{-4} at 100 N, while for 150 N the wear rate of that composite was 1.25×10^{-4} g/min respectively. Microstructure of Al-Si with Sc has much finer microstructure compared to unfine Al-Si alloy. Increased Sc in Al-Si alloy has influenced on the grain refinement and improves the mechanical strength of this composite.

Keywords: Al-Si alloy, scandium, mechanical properties, wear rate

ITRS039

A comprehensive review on abaca fiber reinforced polymer composites

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Abstract: Abaca is a strong competitor among natural fibers for the purpose of fiber composite development. Due to its high durability, long fiber length, flexibility and mechanical strength, abaca fiber has good potential for becoming a renewable source of fiber for applications in technological and industrial fields. Discussed the influence of various treatment strategies for the preparation of abaca-based composites results in the improvement of its properties than that of bare polymer materials and that of other synthetic fibers. Being sustainable and eco-friendly, abaca fiber-reinforced composites show better strength with no substantial weight gain properties that could be exploited in varied technological and commercial applications. The enhanced characteristics of the composites are widely explored for a wide variety of applications in automotive and other industries. Presently, reinforcing is completed with natural fiber over man-made fiber. Natural fibers are economical and ample. Due to nontoxic character, mechanical properties of fibers can be enriched by treating it with chemicals. Many researchers concentrate on natural fiber-based composites to support the 'Go by Green' campaign. The effective use of abaca fiber reinforced polymer composite in manufacturing of external parts of cars has become extremely popular and hence the usage of abaca as reinforcement material in polymer matrices has increased significantly. The extraction, treatments and properties of abaca fiber are highlighted in this review. An overview about the related research works on properties such as structural, thermal and mechanical. Various preparation techniques of abaca fiber reinforced composites are also provided. The gaps in research from the literature that show the scarcity of studies on topics such as simulation and designing of mechanical characteristics of abaca fiber composites constructed on polymer matrices such as epoxy, polylactide, high density polyethylene, phenol formaldehyde and polyester are also highlighted.

Keywords: Natural fiber, Durability, Sustainable, Eco-friendly, Fiber-reinforced composites, Polymer

ITRS040

Effect of Rare Earth Oxides (REOs) on Tribological Behaviour of Aluminium Hybrid Composites: Experimental Investigations and Predictive Modelling

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Abstract: Aim of current research is to explore the effect of cerium oxide as REOs on tribological properties of aluminium hybrid composites with different composition of SiC and Al_2O_3 as reinforcements. For this purpose composites were synthesized by varying SiC/ Al_2O_3 from 2.5 wt.% to 7.5 wt.% in equal proportion and CeO_2 from 0.5 wt.% to 2.5 wt.% in Al-6061 matrix. The addition of cerium oxide as 2.5 wt.% in addition to 7.5 wt.% each of SiC and Al_2O_3 in composites leads to the formation of intermetallic phase (Al_4Ce_3) in sample. These intermetallic formations resulted in improved wear rate up to 87.28%. For prediction of the effect of incorporating REOs reinforcements on the tribological behaviour of hybrid composites, experimental data of wear tests are used to create 3D models based on Levenberg-Marquardt Algorithm (LMA) neural networks. The experiment data consists of different wt.% of CeO_2(0.5, 1.5 and 2.5 wt.%), sliding distance as 1000, 1500 and 2000 m and normal loads of 10 N, 20 N and 30 N. The results of this predictive modeling show that the LMA- neural networks models have a high level of accuracy in the prediction of tribological properties for REOs reinforced-aluminium hybrid composites. The network structure 3-2-1-1 predict better specific wear rate with minimum mean square error using back-propagation approach of Levenberg-Marquardt training algorithm. The statistical parameters i.e., correlation value was observed as 0.98733, which is also an indication better wear rate. Finally, microstructural evolution and understanding of the possible mechanism for improved wear rate in hybrid composites were investigated through EBSD analysis. The EBSD data allows a distinction between grain and subgrain structures with flexible misorientation threshold values. The development of GNBs (geometry necessary boundaries) and LAGBs due to DRV (dynamic recovery) is observed at measurement points with low or moderate plastic deformation throughout all investigated composites. Finally, worn out surfaces and wear debris of composites have been analyzed using SEM for different wear mechanisms.

Keywords: Rare Earth Oxides; Levenberg-Marquardt Algorithm; Specific wear rate; Microstructure; grain boundary

ITRS041

The Lubrication of the Finite Journal Bearing with Variable Viscosity, Velocity-Slip, Ferrofluid Lubricant and Couple-Stress Fluid, in the Presence of the Finitely and Infinitely Long Magnetic Model.

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Abstract: In this paper, we study the effect on the finite journal bearing, with variable viscosity, velocity-slip, a ferrofluid lubricant, and couple stress in the presence of the finitely long magnetic model (FLMM) and infinitely long magnetic model (ILMM). The lubricant is non-Newtonian due to the constituent parts of the couple stress fluid and the ferrofluid. The modified Reynolds equation was solved numerically using the Finite Difference Method to obtain the pressure distribution, and the variable viscosity was modeled using the Barus formula. The slip-velocity is engineered on the bearing surface, and an infinitely long wire is placed at a distance *R* (greater than the bearing radius) from the bearing center. In contrast, for the FLMM,

the current passes through a finite wire at a distance similar to the ILMM. This current-carrying wire produces a magnetic force that affects the ferrofluid lubricant as an external body force. We investigated the effect of the FLMM and ILMM on the bearing characteristics. The result indicates that the FLMM displayed better load-carrying ability than the ILMM. The hydrodynamic pressure in the FLMM is higher than its counterpart, and the friction was also significantly reduced. Furthermore, the magnetic parameter enhances the pressure distribution and the load-carrying capacity of the bearing. The combined effect of the high couple-stress and low piezo-viscosity parameters yields the lowest friction, especially for the finitely long magnetic model.

Keywords: Finitely/infinitely long magnetic model, variable viscosity, couple-stress fluid, ferrofluid, finite journal bearing.

ITRS043

Friction and wear response of tri-ceramic reinforced copper-based hybrid composites under dry sliding condition

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Abstract: The current investigation sought to discuss the dry sliding friction and wear behaviours of copper based hybrid composites, designed by stir-casting technique. Tungsten carbide (WC), boron nitride (BN) in certain content and variable amount of boron carbide (B4C) were added in copper matrix astri-ceramic reinforcements. Four different copper based hybrid composites were developed and designated as hybrid composite-1, 2, 3 and 4 (HC-1, HC-2, HC-3 and HC-4) according to the variable contents of B4C from 0, 0.5, 1.0 and 1.5 wt% respectively. Hardness and density were measured by Brinell hardness test and Archimedes' principle; it was observed that the hardness of hybrid composites is higher compare to its matrix however the experimental density was lower. Wear and friction investigation was done using the pin-on-disk machine, where the wear pin was slid against the rotating disc of EN 31 material under dry sliding condition at different normal load of 9.81, 19.62, 29.43 and 39.24 N for sliding distance 8,748 m. It was revealed that the cumulative volume loss with sliding distance in hybrid composites was lower than the copper matrix and similar trend was also observed for average coefficient of friction with normal load for hybrid composite materials although the nature of curves was fluctuating. To disclose the wear mechanism, worn surfaces were analyzed by scanning electron microscopy (SEM), energy dispersive analysis of x-rays (EDAX) and atomic force microscopy (AFM), basically two type of wear mechanism i.e., adhesive and abrasive were involved during dry sliding of the investigated materials along with some transfer layers of wear debris. Adhesive wear is dominating over abrasive in matrix, however; abrasive and transfer layer of wear debris are mostly observe in the hybrid composites.

Keywords: Hybrid composites, Friction, Wear, Worn Surface, Debris, Wear Track, Dry Sliding

ITRS045
Cyclic oxidation and hot corrosion behaviour of HVOF sprayed NiCrAl coating on industrial boiler tube steels

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Abstract: Components of energy-production systems are subjected to several degradation processes resulting from the complex multi-component gas environment, including oxidation and molten-salt-induced attacks. At high temperatures, the coatings provide a protective scale development on the surface to maintain long-term stability. In the present investigation, a high-velocity oxyfuel thermal spray process was used to deposit NiCrAl alloy coatings on boiler tube steels designated as ASTM-SA210-GrA1, ASTM-SA213-T11. Thermo cyclic oxidation behaviour of coated steels was investigated in static air and molten salt (Na_2SO_4-60%V_2O_5) environment for 50 cycles at 900ºC. The Thermogravimetric approach was used to estimate the kinetics of oxidation. X-ray diffraction, SEM/EDAX, and EPMA techniques were used to characterize the formed oxide scale. Lower parabolic rate constant (K_p) of NiCrAl coatings compared to the uncoated steels proves lower oxide rates of coated steels. Uncoated steels experience intense spalling and peeling of oxide scale from the surface. The coated steels subjected to oxidation in air exhibit slow scale growth kinetics and oxides of α-Al_2O_3 and Cr_2O_3 on the outermost surface, while accelerated oxidation caused by the molten salt exhibits metastable Al_2O_3. Preferential oxidation of Al and Cr along the nickel-rich splat boundary prevents oxygen from entering the coating through pores and voids, causing the oxidation rate to reach a steady state.

Keywords: HVOF thermal spray process; Cyclic oxidation; Hot corrosion; NiCrAl coating; Boiler tube steel; Characterization.

ITRS047
High-Temperature Calcium Fluoride (CaF_2) Solid Lubricant Material: A Review

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Abstract: This paper provides a review of the latest developments in high-temperature Calcium Fluoride (CaF_2) solid lubricant material. Solid lubricants like Molybdenum disulphide, Graphite, Hexagonal boron nitride, Barium Fluoride, and Calcium Fluoride can be suitably used for high temperature and harsh environmental application. Among the solid lubricants, calcium fluoride is widely used due to its excellent lubricity at elevated temperatures. The liquid and gas lubricants deteriorate its properties at elevated temperatures. The combined application of low temperature and high temperature solid lubricants provides synergic effect and reduce friction, wear from room temperature to elevated temperature. This paper first discusses the basic design criteria of high-temperature solid lubricants like its low co-efficient of friction, high wear resistance, a wide range of applications, and also discusses the construction methods of CaF_2 solid lubricant material. Then review the developments in composite coating especially thermal spray coating and composites using CaF_2 as solid lubricant material. Finally, shortly explain the practical applications of CaF_2 solid lubricant reinforced, coated composite materials and also suggest methods to develop CaF_2 solid lubricant from low-cost discarded materials. These studies help to identify and understand the area of high-temperature tribology and methods of developing low-cost solid lubricant from discarded materials as an alternative to reduce pollution and manufacturing costs.

Keywords*:* Solid Lubricant Materials, High-Temperature Lubrication, CaF_2, Co-efficient of friction, Thermal Spray Coating

ITRS048

Effect of Surface Mechanical Attrition Treatment (SMAT) through surface topography modification on Tribological properties of Inconel X-750 superalloy

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Abstract: The majority of the problems responsible for the complete failure of the engineering metals initiates from the surface. Thereby mechanical properties of the material get affected and result in life span reduction. Nonetheless, these difficulties have been addressed with the help of surface mechanical attrition treatment (SMAT) treatment. In this work, SMAT was performed on Inconel X-750, Nickel-chromium superalloy to enhance its wear resistance. For this purpose, Al_2O_3 particles with 80 mesh size were shot onto the surface of Inconel X-750. The 3D surface topography of Inconel X-750 alloy affirms considerable surface deformation and increased surface roughness after SMAT. Besides, the surface attributes of the SMAT superalloy were carefully inspected utilizing an optical profilometer. The variation of increase in load with width and depth of wear scar prior and soon after SMAT was addressed. The tribological properties of Inconel X-750 prior and soon after SMAT were carefully inspected utilizing a ball-on-flat tribometer, reciprocating type. Results showed the decrease of (27-47) % wear rates after SMAT,

which could be credited to this roughness increase, decrease in friction. The shear stress distribution using Hertz Contact Stress Analysis and Contact temperature analysis by Tian and Kennedy approach for Inconel X-750 were addressed. The wear mechanism of SMATed Inconel X-750 was discussed utilizing the SEM micrographs. Electron Backscatter Diffraction (EBSD) analysis was performed to analyze the microstructures before and after SMAT. EBSD proved that grain refinement, dynamic recrystallization occurs in the SMAT sample.

Keywords: SMAT, Inconel X-750, surface modification, friction wear, EBSD.

ITRS050

Mechanical and Tribological Characterization on Light weight AZ91D/WS_2 composites processed via Stir-Squeeze casting

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Abstract: The purpose of this study is to assess the wear behaviour of self-lubricating composite under different weight percentages (2.5, 5.0, 7.5) of WS2 reinforced particles by squeeze casting. The effect of squeeze pressure on the distribution of WS2 particles reveals a uniform distribution without any casting defects. The mechanical and physical properties, including hardness and ultimate tensile strength, are studied in this study. Comparing the fabricated composites and AZ91D matrix alloy demonstrates a 41.75 % improvement in micro Vickers hardness and a 55.25 % improvement in tensile strength. The wear test evaluates their tribological properties under varying testing conditions applied load (10, 20, 30, 50 N), sliding velocity (1m/s and 2m/s) with constant sliding distance. The results indicated an improvement in wear resistance for the composites was attributed to significant grain refinement upon stir-squeeze process. As a result of a mixed lubrication layer at a higher weight percent of WS2 particles reinforced composite, severe wear is absent in AZ91D/7.5wt.% WS2 composite. The 3D surface topography and SEM imaging are used to analyze worn surface morphology and surface characteristics. The morphology of worn out surface and wear debris revealed at higher load and sliding velocity oxidation and adhesion as major wear mechanism in higher wt.% of reinforced composite whereas un reinforced alloy plastic deformation and sub-surface delamination wear mechanism was observed.

Key words: AZ91D, Squeeze casting, Wear and Friction behaviour; Solid Lubrication, 3D surface topography, SEM

ITRS051

Influence of h-BN on Tribological behaviour of AZ91D/h-BN composites: An Experimental study and analysis

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Abstract: Self-lubricating composite materials have become inevitable in many current-day engineering applications. As a result, developing sustainable self-lubricating magnesium composite has become the order of the day to mitigate the removal of material. This research investigated the impact of hexagonal Boron Nitride (h-BN) on AZ91D composites wear and friction performance. The analysis demonstrates the effectiveness of h-BN particles present in the matrix to minimize wear. In addition, a liquid metallurgy-squeeze casting technique is used to process the composites by the varying level of h-BN in terms of weight percentage (0, 2.5 and 5.0 wt.%). The physical and mechanical properties, microstructural analysis, and wear and friction performance of fabricated composites have been analyzed and investigated. The experimental investigation observed that h-BN particles are uniformly dispersed throughout the matrix alloy as perfect grain boundaries in solid magnesium solutions. By incorporating reinforcement particles, density, hardness, and tensile strength are increased. In addition, the wear test results indicate that a significant improvement in the wear performance of composites was achieved with the addition of h-BN reinforcing particles in the matrix alloy. Surface morphology was examined through the Scanning Electron Microscopic (SEM), and a 3D surface profilometer is used to understand the wear mechanism that has occurred.

Key words: Hardness; Fracture analysis; SEM Microscope; wear and friction behaviour; surface roughness.

ITRS052

Tribodynamic performance improvement of aerodynamic journal bearings using synergistic micro-surface topographies

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Abstract: Aerodynamic rigid bore journal bearings have been employed to support and guide lightly-loaded high-speed rotors in micro-turbomachines, MEMs devices, PCB manufacturing instruments, dental hand-piece due to their simple geometry, low power loss and oil/grease free environment. However, these bearings possess very low load-carrying capacity, and rotors supported on them are vulnerable to dynamic instabilities such as air-whip and subsynchronous vibrations. Moreover, aerodynamic bearings also exhibit high friction and wear during rotors start-ups and shut-downs due to the physical contacts between the journal and bearing surfaces. Thus, developing new aerodynamic journal bearings with higher load-carrying capacity and improved rotordynamics is a vital task from engineering perspective. Literature survey has

revealed that pocketed or textured bore journal bearings have yielded better tribodynamics. Motivated by this, authors conceived a new aerodynamic journal bearing (AJB) bore having the synergistic presence of pockets and textures to further improve the tribodynamic performances. The proposed unique geometry of bore comprises a primary rectangular pocket in the pressure-building zone followed by the placement of tiny rectangular/trapezoidal textures towards the trailing side of the previous one. Static (minimum film thickness and friction force) and dynamic (bearing coefficients and critical mass) performance parameters with the newly conceived aerodynamic journal bearing bore have numerically been explored by solving the compressible lubrication equation. The newly conceived bore has produced a substantial 21% increase in minimum film thickness, significant 12% reduction in coefficient of friction, and excellent 170% improvement in the system critical mass compared to the conventional plain bore AJB.

Keywords: Aerodynamic journal bearing; micro-pocketed bore; surface textures; compressible flow dynamics; performance behaviors

ITRS053
Numerical Studies on Roller Bearings Using Empirical Model and Response Surface Method

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Abstract: This article deals with experimental mathematical model and experimental results relationship of deep groove ball bearings with radial load. The expression for the experimental mathematical model (EMM) has been presented to estimate rolling bearing vibration response due to dispersed flaws under radial load. Using dimensional analysis, a large number of variables can be simplified into a small number of dimensionless pi terms. The EMM establishes dimensionless equation to exhibit relationship between dependent terms and independent terms. The work presents characteristics of defective bearing parameters under different load and speed condition. The effect of size and location of defects in bearing on vibration response are studied using EMM. The proposed research utilises RSM to examine the relationship between bearing vibrations and defect size, load, and speed. Comparison between EMM and RSM show good agreement with experimental results. The methodologies may be used to rotor-bearing systems with a high number of variables to generate approximate mathematical models that accurately anticipate vibration responses and fault frequencies.

Keywords: EMM; dimensional analysis; response surface method; rotor-bearing; deep groove ball bearing.

ITRS054
Investigation of Tribological Characteristics of Copper-Titanium Alloys Processed by Multi-Axial Cryo-Forging

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Abstract: Cu-XTi alloys (X = 1.5% and 4.5%) were subjected to multi-axial forging (MAF) under cryogenic condition up to 3 passes successfully. Characteristics of the MAF processed alloys were analyzed using microstructural analysis, hardness and wear tests. Worn surface morphology and elemental analysis was done by scanning electron microscope (SEM). The hardness of samples increases with higher MAF passes due to strain hardening and grain refinement. Wear test was done for six different sliding distances (500 m, 1000 m, 1500 m, 2000 m, 2500 m and 3000 m), two different load (10 N and 20 N), and two different velocities (1 m/s, and 2 m/s) using the pin on disc wear test rig. Wear loss of as-received samples is higher than MAF processed samples due to an increase in hardness, but wear loss increases as the load increased. Coefficient of friction is reduced with the increase of MAF pass is due to strain hardening effect. The worn surface exhibits the plastic deformation regions, delamination, ploughing and formation of oxide layers which was revealed in X-Ray diffraction (XRD) analysis.

Keywords: Cu-Ti alloy, Multi-Axial Cryo Forging, Coefficient of Friction and Wear.

ITRS055

Comparative Study on Microstructure, Mechanical and Wear Behaviour of Cu/hBN Composites Sintered Through Microwave and Muffle Furnace

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Abstract: In the present study, Copper (Cu)/hexagonal boron nitride (hBN) composites with weight percentages of 1.5, 3 and 4.5 were fabricated through powder compaction technique followed by sintering process. Microwave and muffle sintering techniques were used, to analyse the microstructure, mechanical and wear behaviour of Cu-hBN composites. The mechanically alloyed powders were compacted by cold press and samples were sintered for 60 minutes at 800 °C. The XRD patterns revealed that solid solution alloy was formed during the mechanical alloying process. The microstructural, physical, mechanical, and tribological properties of Cu-hBN composites were investigated. Microstructure study revealed that microwave sintering achieved better particle dispersion than the muffle sintering process. Density, porosity, hardness, and compression strength were better in microwave sintered composite than muffle sintered composites. Wear properties of the composites were evaluated using the pin-on-disc setup at ambient and elevated temperatures (300 - 500 °C), with the varying loads (10 - 40 N). Thus, the microwave sintered composites tribological properties improved due to the homogeneous distribution of hBN particles in both dry and elevated conditions. The addition of hBN further improves the coefficient of friction and minimize the wear rate due to the formation of the hBN

tribolayer. Morphology of worn-out surfaces and wear debris were analysed to understand the wear mechanisms.

Keywords: Copper, Hexagonal boron nitride, microwave sintering, muffle sintering, wear behaviour.

ITRS056

Dry sliding wear behavior of surface-modified Al 6061-T6 alloy with WS_2 solid lubricant through electric spark deposition technique

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Abstract: Automotive and aerospace industries use a material having high strength to weight ratio and low density; Al 6061-T6 is one of them. The complexity of poor surface and tribological characteristics are unable to use in reliable parts like cylinder liner, engine cradle, bearing surface and brake components. This paper aims to investigate the wear behavior of WS_2 deposited Al 6061-T6 alloy under dry sliding conditions. The morphology of used WS_2 powder was evaluated using a scanning electron microscope (SEM) with line spectra of energy dispersive spectroscopy (EDS). The WS_2 deposition was achieved through a novel electric spark deposition technique. The surface morphology of WS_2 deposition was analyzed using SEM. The WS_2 deposited surface exhibits superhydrophobicity with a contact angle (CA) of 121.3°. The dry sliding wear behavior of WS_2 deposited Al 6061-T6 substrate was investigated using standard pin-on-disc experimentation. Among the varied input parameters, the applied load was identified as the most influencing parameter on the wear rate. The WS_2 worn surface has been examined using SEM to identify the mode of wear. Furthermore, the EDS line spectra have confirmed the presence of elements after the tribological test. Worn surface examined by 3D scanning using weight light interferometry (WLI) to ensure material removal. However, the wear track formed on the counter body surface has also been analyzed by SEM. Almost all the manufacturing industries are now focused on new surface modification techniques to improve surface and tribological properties. The present investigation reveals the wear behavior of electric sparked deposition of WS_2 on Al 6061-T6 alloy and its associated wear mechanisms for tribological applications.

Keywords: Al 6061-T6 alloy, Electric spark deposition, Surface modification, WS_2 deposition, Wear behavior

ITRS057

Effect of Equal Channel Angular Extrusion on Wear and Corrosion resistance of Mg-9%Al-0.5%Zn light weight alloy

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Abstract: Equal channel angular extrusion (ECAE) of AZ91 Mg alloy, at 598K, with four numbers of passes, has been successfully pressed. Microstructure observations, microhardness, wear test and corrosion study were accomplished to investigate the effect of grain refinement on wear and corrosion behaviours. The wear behaviour of the coarse and fine-grained Mg alloys was examined through L9 orthogonal array experiments in order to understand the wear behaviour under varies control parameters. It was shown that Equal channel angular extruded AZ91 Mg alloy increased the wear and corrosion resistance of the Mg alloy through the formation of fine grain and uniform distribution of secondary β- phase respectively. Also, the wear and corrosion performance of AZ91 Mg alloy were discussed evidently through SEM morphologies.

Keyword: AZ91; ECAP; Grain Refinement; Wear; Corrosion.

ITRS058

Modeling of Date Seed Oil blends with HNT additives and Application in Journal Bearings

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Abstract: There has been a growing concern for the use of mineral oils as lubricants because of the worldwide interest in environmental issues.This has promoted the research and development of using vegetable oil as alternative base oilfor fossil fuellubricants.According to World Energy Outlook 2016 there is a pressing need for renewable energy, since the pollution rate is tremendously increasing.Vegetable oils in general have excellent properties such as high viscosity index,high lubricity,high flash and fire point,low evaporative loss,high biodegradability and low toxicity with regard to their use as base oil for lubricants.On negative side they are known to possess low thermal, oxidative, hydrolytic stabilizers,poor low temperature characteristics and poor corrosion protection. Bio-oils due to their polar triglycerides structure can provide strong lubricity than conventional mineral oil.Vegetable oils are particularly effective as boundary lubricants.

The disposing of used industrial oil is of the greatest threat to aquatic life and even for earth.It is estimated that nearly 12 million tons of lubricant wastes are thrown to the environment every year. Therefore biodegradability has become an inescapable factor in design of fuels and lubricants.Since mineral oil reserves are diminishing fast and is not biodegradable, the demand on eco-labeled products became high. Vegetable oils are environmentally safe and a renewable

energy source.
Most renewable energy works have been reported for vegetable oils like coconut oil, soybean oil, castor oil, jojobaoil, rice bran oil, rapeseed oil and rubber seed oil.However in the existing literature the investigation on development of bio lubricantfrom date seed and study of its physicochemical and tribological properties are scarce. Therefor it is felt that there is a need to evaluate the properties of oil from date seed and seek the possibility of development of a bio lubricant for this.If such study is carried out it will be beneficial to the countries especially in the middle-east where plenty of date palm trees are available.From the preliminary studies carriedout on dateseed oils the viscosity,flash fire point are comparable to the commercially available lubricants SAE 20W40 and this is a good indicator for the development of date seed lubricant.The objectives of present work are the following

1) Select the proper additives to enhance the properties of seed oil which to those of commercially available lubricant SAE 20W40.
2) Blending of date seed oil with other base oils and study of its properties, if the properties of date seed alone are not satisfied to the desired level.
3) To study the effect of addition of nano materials on the properties of formulated oil.
4) Obtain an empirical relation between viscosity and concentration of nano materials in the formulated date seed oil.
5) To compute the static performance characteristics of plain journal bearing when it is operated with date seed oil.

Keywords: Halloysite nanotubes, Biolubricants, Journal Bearings, Lubricant viscosity

ITRS059

The correlation of Tool Wear and Surface Roughness under Sustainable Cryogenic CO_2 Condition

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Abstract: This paper investigates the correlation between the progress of surface roughness and the tool wear patterns of carbide multi-coated ball nose insert when high-speed milling Inconel 718 under cryogenic conditions. The coolant for the cryogenic system was a combination of gaseous and liquid CO2 and compressed air where its temperature was controlled at 60 ± 5℃. The cutting parameters were varied as follows; cutting speed: 120–140 m/min, feed rate: 0.15–0.25 mm/tooth, and axial depth of cut: 0.3–0.7 mm. Experimental results revealed that the surface roughness (Ra) was highly influenced by the cutting tool edge conditions with a significant correlation between them. The progress of Ra could be classified into 3 main stages: rapid increase, inconsistent and stable conditions along the cutting process. After the first cutting interval, the Ra rose sharply with respect to the steady increase of the tool wear rate. FESEM analysis found that the formation of abrasive wear along the cutting edge and chipping near to

the depth of cut (DOC) which believed happened due to continuous rubbing and sliding friction between the tool and the abrasive carbide particles in the alloys of Inconel 718 caused the rapid increase of tool wear as well as surface roughness. While the intermittent build-up-edge (BUE) formation on the tool edge which generates friction and heat at chip-tool and workpiece-tool interfaces caused inconsistent readings of Ra. The unstable BUE dragged along the coating material resulting in the delamination of the coating materials which exposed the base material of the tools. Sliding of the uncoated tool over the workpiece resulted in notching at the flank face. The notching on the flank face caused the trailing edge tended to be close to the machined surface. During cutting, it acted as a wiper where its polishing action removed the peaks of the feed marks due to the kinematic effect of the ball nose-shaped insert. This situation continued with the better and stable value of Ra and the increase of tool wear. This correlation can be applied to predict the surface roughness and tools' wear condition when milling Inconel 718 at high cutting speeds.

Keywords: Inconel 718; Carbide Coated Tool; Cryogenic Machining; Tool Wear; Surface Roughness

ITRS060

Study of Solid Particle Erosion Wear of Glass fibre Composite Filled with Filler: A Review

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Abstract: Nowadays glass fibre has got lot of attention due to its several benefits over metal. The application of GFRP from household application to spacecraft is unimaginable. Its utilisation can be increased further by improving its property through addition of the third phase i.e., filler in the polymer matrix composite. In the present paper review the solid particle erosion wear of glass fibre composite with and without filler addition. A general idea of the problem of solid particle erosion is established with respect to the processes and modes during erosion wear. A detail experimental study of solid particle erosion of the composite and its finding are shown here. The influence of filler as an important process parameter in solid particle erosion wear is also studied. Both conventional and nonconventional filler are added in the GFRP and they capable to improve the wear property. Recent findings on non-conventional filler like red mud, fly ash, cupper slag have been widely popular as filler to improve the wear, mechanical and other property of the composite. Study is also proposed on how wear resistance of GFRP composites can be improved with respect to structure, size and content of filler.
Keywords: Erosion wear, GFRP, Hybrid composite, Filler, Polymer composite

ITRS061

Effect of Surface Mechanical Attrition Treatment (SMAT) through surface topography modification on Tribological properties of Inconel X-750 superalloy

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Abstract: The majority of the problems responsible for the complete failure of the engineering metals initiates from the surface. Thereby mechanical properties of the material get affected and result in life span reduction. Nonetheless, these difficulties have been addressed with the help of surface mechanical attrition treatment (SMAT) treatment. In this work, SMAT was performed on Inconel X-750, Nickel-chromium superalloy to enhance its wear resistance. For this purpose, Al_2O_3 particles with 80 mesh size were shot onto the surface of Inconel X-750. The 3D surface topography of Inconel X-750 alloy affirms considerable surface deformation and increased surface roughness after SMAT. Besides, the surface attributes of the SMAT superalloy were carefully inspected utilizing an optical profilometer. The variation of increase in load with width and depth of wear scar prior and soon after SMAT was addressed. The tribological properties of Inconel X-750 prior and soon after SMAT were carefully inspected utilizing a ball-on-flat tribometer, reciprocating type. Results showed the decrease of (27-47) % wear rates after SMAT, which could be credited to this roughness increase, decrease in friction. The shear stress distribution using Hertz Contact Stress Analysis and Contact temperature analysis by Tian and Kennedy approach for Inconel X-750 were addressed. The wear mechanism of SMATed Inconel X-750 was discussed utilizing the SEM micrographs. Electron Backscatter Diffraction (EBSD) analysis was performed to analyze the microstructures before and after SMAT. EBSD proved that grain refinement, dynamic recrystallization occurs in the SMAT sample.

Keywords: SMAT, Inconel X-750, surface modification, friction wear, EBSD.

ITRS062

Synthesis and testing of groundnut oil based green cutting fluid for machining studies

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Abstract: Cutting fluids are applied at the machining zone for the reduction of heat generated and to reduce the friction at the machining interfaces. The commercially available cutting fluids used in industries for improving the machining performance are petroleum based. However, application of fluids these is creating many issues due to their poor biodegradability, toxic nature. Hence it is the need of the hour for finding a best alternative to these fluids. The oils derived from natural sources such as plants, trees are searched as alternatives to replace this petroleum based fluids. In the present study, ground nut oil based cutting fluid is prepared, characterization studies such as particle size analysis is carried out, friction testing and machining performance are evaluated. Results showed that the green cutting fluid (GCF) with hydrophilic lipophilic balance of 9 has shown least separation. The synthesized GCF has shown equal performance in terms of friction reduction and drilling forces reduction with respect to commercially available petroleum based fluid. Hence, it can be concluded that the cutting fluid formulated from natural sources are one of the best alternatives and are better basis for development of alternatives to petroleum based commercial fluids.
Keywords: Drilling, machining, green cutting fluid, friction, cutting forces, HLB

ITRS063

Wear Analysis and Prediction of Tribological Behaviour of Alkaline Treated Hemp Filler Reinforced Epoxy Composite

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Abstract: This paper aims to perform a detailed study on the tribological properties of alkali-treated hemp filler reinforced epoxy composite for different filler percentages in the prepared composites. Amongst the various natural fibres, hemp reinforced polymer composites are considered to rival glass fibre composites based on mechanical properties. Hemp fibres have been extensively used in various manufacturing industries and this study works towards investigating the usage of hemp filler reinforced composites as a potential addition. Also, the inability of thermoplastic composites to withstand high temperatures and lack of strength led us to consider the fabrication of thermosetting polymer composites. Initially, hemp filler is prepared and mercerized with a 5% NaOH solution. After pre-treatment, the samples are prepared to contain (0%, 2.5%, 5% and 7.5%) hemp filler using the hand layup technique. Wear tests are performed on the samples using a pin-on-disc tribometer in a dry environment for three different normal loads (5, 10 and 15 N), sliding velocity 550 RPM, and three sliding distances (1,000, 2,000, and 3,000 m) for friction against a stainless-steel disc. The results indicated the effects of operating parameters and filler percentage in the test samples. Among all composites, 2.5 wt% hemp filler composite has generated the minimum wear. The worn surfaces of the composites are also studied and analyzed using a scanning electron microscope. The images showed various types of cracks, debonding and deformation on the surfaces of the tested samples. Apart from the tests, the wear properties of the composites with varying filler percentages are also predicted using regression and artificial neural network (ANN) models. Comparing the two models, the ANN model showed a more accurate performance.

Keywords: Hemp particulates, surface treatment, tribology, coefficient of friction, surface morphology analysis, regression analysis, artificial neural network.

ITRS064
Tribological Hydrodynamic Behavior of Tilting Pad Thrust Bearings - The Effect of Incomplete Oil Film

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Abstract: Since their invention from Albert Kingsbury and George Michell, fluid film thrust bearings have been used as crucial machine elements in many industrial, marine and automotive applications. The relative motion of two friction surfaces along with the wedge created by the

tilting pad and the rotor allow such bearings to carry heavy axial loads in rotating machinery. Regardless of the lubricant's type, the integrity of the oil flow has a significant influence in the bearing's tribological behavior. In this paper a finite difference approach is developed in order to investigate the influence of incomplete oil films on tilting pad thrust bearings' operation, using three different types of lubricants, a mono-grade SAE30, a multi-grade SAE10W40 and a bio-lubricant AWS100 at a range of rotational velocities. In order to model the various cases of incomplete oil film, relevant boundary conditions have been applied. Three different cases of incomplete oil film profiles have been studied: oil film loss on the inner radius, oil film loss on the outer radius and oil film loss on both inner and outer radius of the bearing symmetrically applied from the middle of the fluid film. The results show that an incomplete film can have a significant effect on the pressure distribution, the friction force and the load carrying capacity of a tilting pad thrust bearing. In the current investigation, oil film loss in the outer radius had the most negative influence on the tribological characteristics of the bearing with the case of 60% inlet oil coverage showing up to 67% of load carrying capacity reduction in all examined lubricants.

Keywords: hydrodynamic lubrication, thrust bearings, incomplete film, tribological behaviour, finite difference.

ITRS065

Investigation on tribological properties of aluminum alloy A356 coated with Alumina

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Abstract: The degradation of materials by wear is reduced by incorporating the methodology of wet chemical technique, which is used to produce thin films over the solid surface. Sol-Gel coating method is one of the wet chemical techniques, play a vital role in the industry among the conventional coating method as it provides better tribological and corrosive properties. This paper deals with evaluating tribological properties such as coefficient of friction and volumetric wear loss as well as corrosive stability of alumina coated aluminum alloy A356. Coating parameters affecting the tribological properties are identified, designed the experiments using Taguchi orthogonal array and optimized by grey relation analysis (GRA). The tribological characteristics at room temperature considering the experiments from Taguchi orthogonal arrays have been evaluated using a Pin on Disc (POD) tribometer. Among the Sol-gel coating parameters chosen for minimizing the effect of wear and coefficient of friction between surfaces, the temperature for heat treatment and pH of the sol-gel are identified as potential one that affect the tribological properties. The corrosive stability of the samples has been evaluated by corrosion current, corrosion potential, and corrosive stability methods. It is found that tribological properties and corrosive stability are improved for the coated sample compared with the uncoated sample.

Keywords: Surface Engineering, Sol-gel coating, Tribological properties, Corrosive stability, Optimization, Taguchi analysis, grey relation analysis

ITRS066

Investigation of wear performance for corn hub husk particle-nano graphene filler reinforced epoxy composite at different load conditions

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Abstract: Today, natural fiber reinforced polymer composites are gaining serious attention from researchers because of environmental concerns. Among the properties of bio fiber / filler that influenced material designers were their low cost, lighter weight, ease of availability, better mechanical properties, eco-friendliness, and recyclable nature. The present study is focused on the development of waste-based corn hub husk filler and graphene nanoparticle-based hybrid reinforced polymer composite and investigate the wear performance of developed polymer composite at different loading conditions. The composites were developed with different weight fraction of corn hub husk particles (0, 2.5%. 5%, 7.5% and 10%) with constant 0.5% (by weight) graphene nanoparticle. The tribological behaviour of developed composites was performed by using a pin on disk multi-tribometer with a smooth surface of stainless steel under dry sliding contact conditions. The results suggest that as the corn hub husk particle-graphene nanoparticle loading increases up to 5%, the developed composites showed superior wear performance, while after increments in weight fractions; decrements in wear performance were analyzed. The microstructure and morphology behaviour on the worn surface of developed composites were analyzed with the help of scanning electron microscopy.

Keyword- Nanoparticle composite, Graphene particle, Tribological behaviour, hybrid composite, bio filler.

ITRS067

Performance of hydrostatic thrust pad bearing operating with electro-rheological lubricant

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Abstract: An ER fluid basically consists of dielectric particles suspended in an insulating viscous medium. Electro-Rheological (ER) lubricant is a kind of smart lubricant which is founding application in hydraulic valves, power transmission devices, damping system, etc. In this article, use of ER lubricant has been theoretically investigated in hydrostatic thrust bearing.

The Reynolds equation has been used to model the flow of ER lubricant in the bearing clearance space. Continuous Bingham model has been used to express the viscosity of ER lubricant as function of yielding stress, applied electric field, and shear strain rate. The Reynolds equation has been solved using finite element method (weighted residual approach) to computed film pressure as primary variable and lubricant flow rate, load supporting capacity, stiffness and damping parameters as associated performance indices. Effect of recess shape/configuration and ER lubricant is investigated on bearing performance indices. It has been observed that application of ER lubricant significantly enhances the load supporting capacity (48.2%) and stiffness parameter (48.8%) and damping parameters (4.95%) of bearing. The enhancement in performance indices is noticed to be depending on geometric shape of recess. For instance, the maximum enhancement in load carrying capacity is provided by circular and rectangular recess shapes, and maximum enhancement in stiffness parameter is provided by elliptical recess shape.

Keywords: Hydrostatic thrust bearing, Electro-rheological Lubricant, Recess shape, Finite element method.

ITRS068

Performance of textured surface hybrid thrust pad bearing operating with electro-rheological lubricant

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Abstract: This article deals with numerical simulation of textured surface hybrid thrust bearing operating with Electro-rheological (ER) lubricant. An ER fluid is made up by dispersing dielectric particles in an electrically insulating oil. The ER lubricant is numerically modelled using continuous Bingham fluid model. The texture has been provided in the form cylindrical and square shape micro-depression oriented along circumferential and radial direction. The numerical simulation of bearing system is performed using finite element weighted residual method. The system of equations is solved for film pressure using Newton-Raphson's method. The bearing performance is presented in terms of film pressure, flow rate, frictional power loss, stiffness and damping coefficients. The texture has been optimizing for area density, depth and size for getting maximum load supporting capacity and stiffness coefficient and minimum frictional power loss. The numerical simulation results suggested a substantial enhancement in load supporting capacity and film stiffness coefficient owing to synergistic use ER lubricant and optimize geometric parameters of micro-texture.

Keywords: Hybrid thrust pad bearing, textured surface, Electro-rheological Lubricant, FEM.

ITRS069

Performance of porous surface hydrostatic thrust bearing operating with non-Newtonian lubricant

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Abstract: This paper presents theoretical investigation on performance of porous surface hydro-static thrust bearing operating with non-Newtonian lubricant. Cubic shear stress fluid law has is used to describe the shear-thinning lubricant in the bearing. Pressure flow factor based on Patir and Cheng average flow model has been used to describe flow of lubricant in longitudinal, isotropic and transverse rough bearing surfaces. Finite element method (weighted residual approach is used to convert non-Newtonian Reynolds equation into a set of algebraic equations. The global set of algebraic equations obtained after weak formulation, is solved using Newton-Raphson method to compute fluid pressure. Gauss Legendre quadrature is used to compute load supporting capacity, lubricant flow rate, stiffness and damping parameters of the bearing. The influence of porosity of porous layer, flow index of non-Newtonian lubricant, and recess shape are investigated on bearing performance parameters. It is noticed that the porosity and shear-thinning of lubricant have adverse effect on the bearing steady-state and dynamic performance. However, these adverse effects can be partially mitigated by judiciously selecting recess shape and roughness orientation on bearing surfaces.

Keywords: Hydrostatic thrust bearing, shear-thinning lubricant, Porous layer, Recess shape, FEM.

ITRS070

Analysis of rough surface multi-lobe journal bearings operating in turbulent regime

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Abstract: This paper deals with theoretical investigation of rough surface circular and multi-lobe journal bearings operating in turbulent regime. The lubricant is assumed to shear thinning in nature and is described using cubic shear stress fluid law. A generalized Reynolds equation incorporating the parameters for turbulent flow, micro-roughness and non-Newtonian flow index is used to numerically simulate bearing. Pressure flow factors as proposed by Patir and Chang

has been used to describe fluid transport phenomenon in rough bearing surfaces. Effect of turbulent flow is considered by using linearized turbulent theory as proposed by Ng and Pan. Reynolds equation has been converted to set of algebraic equations by finite element formulation (weighted residual method). Newton-Raphson's method is employed to computed film pressure over bearing domain. The values of film pressure are used to compute minimum film thickness, frictional power loss, stiffness and damping coefficients of bearings. It has been noticed that shear-thinning lubricant has adverse effect on the minimum film thickness and frictional power loss. However, turbulent condition is noticed to enhance the minimum film thickness, stiffness and damping coefficients of bearings. The presence of transverse roughness vis-à-vis longitudinal roughness (and smooth surfaces) significantly enhance steady-state and rotor-dynamic performance of bearings. Lastly, two lobe bearing configuration offer higher value of minimum film thickness and better rotor-dynamic performance as compared to other configurations of bearing investigated in the study.

Keywords: Journal Bearing, Multi-lobe bearings, Turbulent regime, Surface roughness, Shear thinning lubricant.

ITRS071

On Wear Behaviour of Different Grades of Spheroidal Graphite (SG) Cast Iron

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Abstract: Spheroidal Graphite (SG) Cast Iron is a material of choice in automobile industry owing to its unparallel favorable features like low cost, excellent castability and mechanical properties. In this study, three as cast SG iron samples of grades 420/12, 550/6 and 600/3 containing variable copper and manganese content were used. The wear behaviour of these different grades of SG iron were studied using ball on disc tribometer in which EN8 steel ball was used. It was found that the wear mechanism plays an important role in wear rate apart from hardness and microstructure. The pearlite phase content of samples 420/12, 550/6 and 600/3 increases as copper content increases from 420/12 to 600/3. The average coefficient of friction (COF) of 550/6 comes out to be highest among the three samples while lowest average COF was observed for 420/12. The specific wear rate decreases with increase in hardness and copper content of samples.
Keywords: SG Iron; Microstructure; Hardness; Coefficient of friction; Wear.

ITRS072

Investigation and characterization of machinability on Ti-6Al-4V alloy using biodegradable esterified nano cutting fluid

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Abstract: In view of the ability to withstand high temperature without losing properties, high corrosion endurance and high strength to weight ratio, Ti-6Al-4V is widely applicable in biomedical implants, aerospace, military, automobile and high-pressure cryogenic applications. However, machining difficulty occurs owing to the alloy's hardness, chemical reaction between tool and work-piece, formation of Built-Up Edge and high heat generated at the cutting zone. Further, the deformation mechanism during machining of titanium alloys is complex and results in saw- tooth chips, high temperature, high stress on cutting tool, high tool wear and undercut parts. Saw tooth-chips cause variation in cutting forces which results in high cyclic stress on cutting tools also. On the other hand, low thermal conductivity of titanium alloy causes high temperature and thereby provides a favorable environment for high tool wear. Hence, improvements in machining titanium alloy depend mainly on overcoming the complexities associated with the inherent properties of the alloy. The present investigation aims to develop a bio-degradable cutting fluid from esterified rubber seed oil using nano-additives, cerium oxide and molybdenum disulphide. The developed cutting fluid was used to evaluate the variation in cutting temperature, cutting forces and the surface roughness under various cutting parameters on machining Ti-6Al-4V. The feasibility of using the developed bio-esterified nano cutting fluid in machining Ti-6Al-4V alloy was also assessed. Machining was done under different modes of lubrication viz., conventional cutting fluid, plain rubber seed oil and rubber seed oil with nano additives added into it. It was observed that remarkable reduction in cutting temperature and cutting forces were achieved with the application of esterified nano cutting fluid. Further, it also reduced tool wear, minimized adhesion of the work material on the cutting tool during machining and improved surface finish.
Keywords: Machining; Biodegradable cutting fluid; Titanium alloy; Nano particles; Surface Roughness

ITRS073
Influence of heat treatment on progressive scratch behaviour of Fe-Cr-C hardfaced alloy

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Abstract: Fe-Cr-C based hardfaced coatings are applied on tribo-components used in mining, excavation, pulverization, coal and ash handling systems. These parts are subjected to dynamic stresses, thereby causing to surface deterioration of coatings over a period of time. Microstructural phases formed during weld deposit solidification is one of the factors would affect the tribo-performance. In this study, the influence of annealing and water quenching processes on progressive scratch behavior of Fe-Cr-C hard-faced alloy coating was compared with as weld state condition. The scratch tests were done at 2-20N load range, 10mm/min stylus speed and 10mm stroke length to know the variation in traction force, scratch depth and

coefficient of friction results prior to and post heat treatments. Scratch surfaces were observed to understand the worn mechanisms. During the progressive load scratch event, when loaded beyond critical normal loads, worn surfaces showed a number of failure proceedings namely ridge formation, pile-ups and delamination were observed. Ridge formation and pile-ups were observed in as received condition of sample; higher plastic deformation and delamination was seen in annealed condition and lower scratch depth and plastic deformation was evident for water quenched samples relatively.

Keywords: hardfaced alloy, progressive scratch, heat treatment, plastic deformation and delamination

ITRS074

Characterization of Wear Resistance and Corrosion during Magnetorheological Fluid Assisted Finishing (MFAF) of Ti-6Al-4V and Duplex Stainless Steel for enhanced biocompatibility

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Abstract: The sustainability of biomaterials relies on their interaction with the proteins, fluid, and cells present inside the human body. The biomaterials' enhanced surface roughness parameters and mechanical properties (i.e., wear resistance) are responsible for reducing degradation (i.e., corrosion rate) to increase its life span during musculoskeletal interaction. *Magnetorheological Fluid Assisted Finishing (MFAF)* process, capable of producing nano-level *average surface roughness (R_a),* is used to enhance the surface quality of the biomaterials. However, apart from R_a, two other surface roughness parameters, namely *skewness (R_{sk})* and *kurtosis (R_{ku})* analyze the characteristics of the irregularities formed on the polished surface. During the MFAF process, Trochoidal, a high-speed surface finishing toolpath, is used to map the workspace on the Ti alloy (Ti-6Al-4V) and *Duplex Stainless Steel (DSS)* biomaterials to enhance their biocompatibility with a reduced finishing time. However, the pin-on-disc method, where *Ultra High Molecular Weight Polyethylene (UHMWPE)* is used as the disc to mimic the interaction of bone with the implants to analyze the wear rate. The dependency of initial surface roughness parameters over the wear rate of the biomaterials is also analyzed in the paper. Similarly, the three electrode-based electrochemical tests with 0.5 M NaCl to replicate the human body fluid is used to analyze the corrosion rate of the biomaterials. This paper aims to investigate the biocompatibility difference between the two biomaterials (Ti-6Al-4V and DSS) polished through the MFAF process. The Trochoidal toolpath during the MFAF process can enhance the surface profile of the biomaterial as required in knee implants, hip implants, bone plates, etc., for their enhanced functionality.

Keywords: Magnetorheological Fluid Assisted Finishing, Trochoidal toolpath, Biomaterials, Biocompatibility, Duplex stainless steel, Ti-6Al-4V, Wear resistance and Corrosion

ITRS075

Tribology in the age of digitalization and green deal – Tribology as a Service

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Abstract: The potential for saving energy and reducing costs was the key reason to define tribology as its own scientific discipline. 55 years after the birth of tribology, digitalisation and the Green Deal are the drivers and challenges at the forefront of industrial development and take first place on the agenda of the European Commission. How can tribology position itself in the age of digitalisation? Which new digital tools and possibilities should be taken advantage of? What examples from other fields are there? In mobility, MaaS ("Mobility as a Service ") is a good example of employing digital technology to develop a service that satisfies the needs of the population as well as the demands of resource efficiency and CO_2 reduction. Additional requirements for the success of such services are a digital business model and the cooperation of different stakeholders. In the area of simulation and software, new business models and services are already well established – SaaS ("Software as a Service ") being a prime example. The trend goes away from one-time purchases towards needs-oriented usage and the appropriate payment systems.
With the European research project i-TRIBOMAT ("Intelligent Open Test Bed for Tribological Materials Characterisation"), the path towards **TaaS** – **T**ribology **a**s **a S**ervice – is presented.
i-TRIBOMAT develops new digital services which, already in the development stage, facilitate the rapid and cost-efficient selection of materials, as well as the prediction of the tribological performance of products regarding efficiency and lifetime. The project connects the entire tribological characterisation infrastructure of five European research centres and links it to an IT-platform using IoT technology. This allows the client to choose between over 100 different tribometers and additional characterisation possibilities. The data is centrally stored and further processed in a newly developed cloud-based tribological material database. The clients can access their data any time and can easily request a specific analysis or create their own reports. Without needing a particular expertise, clients can carry out simulations in virtual workrooms, allowing them to use their material data to predict operational characteristics rapidly and cost-efficiently without constructing a prototype. All digital services can be customised and booked by the client on the web-based platform.
The connection of infrastructures and the new digital services result in the emergence of Europe's largest tribology centre (a joint venture of research centres), which offers all services on a web-based platform.
This project has received funding from the European Union's Horizon 2020 research and innovation programme (innovation action) under grant agreement No. 814494 (Call: H2020-NMBP-TO-IND-2018). More details: https://www.i-tribomat.eu/.

Key words: Tribology, digital services, materials data base, Tribology as a Service, materials up-scaling, digital business model

ITRS076
Magnetorheological Fine Finishing of Steering Rack Bar for Improving its Functional Operation

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Abstract: Fine finished external cylindrical surfaces in automotive manufacturing plants are of great importance for improving their performance. The required surface roughness is to be as less as possible. A finely finished external surface of steering rack bar can lead to the decrease in its response time. Hence, to meet this requirement, the rotating core based magnetorheological (MR) finishing process is performed. In the present work, the process parameters are optimized to finish the external surface of the steering rack bar for improving the functional operation of steering rack bar workpiece. After the analysis of the experimental results using the response surface method, the optimum conditions of process parameters were depicted. The maximum contribution to the response variable % change in surface roughness value is found to be from current (15.28%) and rotational tool speed (8.66%). Using the optimum experimental conditions, the average surface roughness value of the steering rack bar external surface gets decreased from 550 nm to 30 nm in the finishing time of 90 minutes. The nano-finishing of the automobile steering rack bar results in the improvement of its functional operation. Thus, the present process is beneficial for fine finishing of the industrial components like the rocker arm shafts, vacuum pistons, and cylindrical punches.

Keywords: Magnetorheological finishing; cylindrical external surface; steering rack bar; surface roughness; magnetic field.

ITRS077

On the influence of axial distortions on lubricant film and friction force of top piston ring conjunction near to TDC

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Abstract: The purpose of this paper is to understand how axial distortions could affect on the tribological performance of ring-liner conjunction. If piston rings and cylinder bore wear out, it might be a potential threat to the engine. A detailed investigation of the worn area will help to diagnose and to correct the symptoms, assisting to mitigate the harmful effects such as Hydrocarbon (HC) and Nitrogen Oxide (NOx) emissions. The current model contains the effects of mixed-hydrodynamic regime of lubrication, axial distortions, and asperity contacts through computational fluid dynamics (CFD) predictions. The axial profiles were modeled using series of sinusoidal waves. The influence of different distortions on ring wear rate is determined, using the Archard's model. The ring friction and minimum lubricant film at maximum combustion pressure near to TDC are predicted for various worn ring and liner profiles. The study shows that, when the maximum pressure rises, the different wear identities affect the operation of the ring friction much more limited, while the number of sine waves are more pronounced. Finally, it is proved that, even the increase of oil film thickness, it does not presuppose the reduction of friction when it comes to shaping the surface of the cylinder.

Keywords: top piston ring, axial distortions, Archard model, friction, lubricant film

ITRS078
Importance of tribology in internal combustion engine – uses of boric acid in combustion engines.

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Abstract: Fuel economy is one of the most important factors for both people satisfaction and environmental protection. In order to improve fuel economy great efforts are being made to reduce mechanical losses by reducing friction loss and the weight of engine components, and tribology plays an important role in reducing friction. In terms of reducing friction and increasing the fuel economy, boric acid which help for overcoming this problem . A boric acid based fuel additive has led to reduced fuel consumption. The reduction was substantial, an average of 6 and 10% in passenger cars and diesel generators respectively. Boric acid is a biodegradable solid lubricant. Boric acid powders ability as the best solid lubricant available under extreme temperature & heat which also benefit this can pass on to our engine. All rotating parts in a car can be benefited by this like engine. This can also used in gear box and wheels to reduce friction and also lubricate to reduce wear of the engine components. It can be added in engine oil which is liquid lubricant. Boron particles stick to metal surface forming boric oxide this layer is so hard like diamond. tests proved it to be of 85% hardness of diamonds, this layer reduces friction by more than 80%, which reduced heat and also improves performance. Layers of boric oxide sticks permanently to engine surfaces. It also prevents corrosion and wear of metals because of reduced friction. When an engine opened it can be easily washed away with just water. For e.g. a mixture of 5% powder with engine oil made concentrated mixture of 175gramms powder with one litre of engine oil to be added in 3.0 litre of engine oil, stirred it for half an hour by hand mixture, then added directly to engine oil .It is found that engine noise so much reduced also engine running 5% cooler than before and reduce the fuel consumption ,it takes about 800 to 1600 km running for boron particles to stick to engine surface completely .The mixture can also added in gear box too with Castrol gear oil ,gear shifting will be smooth which reduce friction and it would feel like driving a new car. So, the impact of tribology is much useful in the combustion engines.

Keywords; fuel economy, lubricant, wear, friction, reduce cost

ITRS079
Effect of two different sulfide coated steel fiber in a disc brake pad towards tribo performance – An interface study

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Abstract: The purpose of friction brakes is to decelerate a vehicle by transforming the kinetic energy of the vehicle to heat, via friction, and dissipating that heat to the surroundings. The heat that generates at the interface causes the brake pad to degrade if there is no provision for its effective flow. In addition, the real contact between the pad and disc occurs at the primary plateaus formed by the fibers, and hence the heat generation is moreover there causing the destruction of plateaus/tribo films causing friction instability and increasing the wear. Hence a steel fiber coated with two different metal sulfides namely iron sulfide (FeS_2) and Tin sulfide (SnS) is used in a formulation and brake pads are developed and named DBF and DBS. An O.E brake pad with a similar formulation but with a mixture of steel fiber, FeS and SnS is taken as a reference for comparison purposes (DBO). All three brake pads were tested in an inertia brake dynamometer with a typical schedule. The coefficient of friction at 100 kmph/0.6g is slightly higher in DBS and DBF than DBO. In addition, the speed spread (100/50 Kph) 0.6g and effectiveness variation of all the pads falls in the required range. The fade I of DBO is 32.8% lesser whereas for DBS it is 10% more and for DBF it is 15.7% more than the standard values. In Fade II, DBF is 20% lesser than the required value. Recovery I & II is better in all the three pads. Only in the water fade rate, the DBS is 18.5% lesser than the reference value. DBS has the least wear in terms of thickness loss. DBF has 25.4 % more wear than DBS and DBO has 39.6% more wear than DBS. More consistent μ during single braking in the second effectiveness test for all the speeds evidenced for the increase in the life of the friction film formed by the sulfide coated fibres in DBS which increased its wear resistance (Max$\Delta\mu$ =0.13 for DBS, 0.29 for DBF, and 0.30 for DBO). It is also noted that the radial wear of all three brake pads was greater than the tangential wear. The ratio of the radial to tangential wear of DBS, DBF, and DBO are 1.36, 1.40 and 1.55 respectively. Considering the different performance in distinct parameters, optimization is carried out and observed that DBS is a better performer.

Keywords: Speedspread, fade, recovery, effectiveness variation, radial wear, tangential wear.

ITRS080

Surface Roughness and Hardness Investigation on Nickel-Cobalt- Iron Coating at Different Surface Pretreatment.

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Abstract: A common method to protect steel from rust is the use of protective coating. Electroplating is known as an effective coating process practiced in industry due to its excellent adhesion and large volume production. One of the crucial steps in the electroplating process is surface pretreatment. Surface activator solution is required to remove impurities, oil stain and

activate the surface of the substrate to ensure a homogeneous and smooth coating formation. The most common activator used for carbon steel is hydrochloride acid. The main objective of this study is to investigate the effect of different activation methods on the quality of cobalt alloy coating. This was done by dipping carbon steel washers in two different activation solutions (sulphuric acid and sodium chloride) and at different duration time (50s, 55s, and 60s). The quality of the coating was tested by using Vickers hardness test and surface roughness test after the electroplating process operated at 50 ° C for 20 minutes. The electrolyte containing sulphate solution was controlled not more than pH 3. A single layer of Nickel-cobalt-iron coating in micron size was formed on the washer. Vickers micro hardness testing shows that hardness of the coated product was increased when the duration of dipping time was longer. As for the surface roughness testing, the smoothness level of the coated surface was improved following increasing of time immersion. Lower pH value activator produced better surface roughness compared to higher pH value of activator. Based on the data and results obtained from surface roughness testing, washers that being activated by sulphuric acid shows better and smoother surface roughness rather than the washers that being activated by sodium chloride. The sulphate The results show that activation using sulphuric acid at 60s produced the highest hardness at 326.9HV and the smoothest surface at a surface roughness of 0.583µm. It can be concluded that a proper activation step is key for a quality coating product.

Keywords: Activator; electroplating; cobalt alloy; surface roughness; hardness; sulphuric acid; sodium chloride

ITRS081

Role of friction additives/sulphide mix and materials performing multi task towards brake performance and Environmental aspects – A Review

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Abstract: Friction materials play a crucial role in the safe movement of automobiles and the protection of human life. As the pad slides against its mating partner, kinetic energy is transferred into heat. This friction causes the vehicle to slow down as its momentum is dissipated as heat in the pads and rotors. The hotness thus developed causes the degradation of the binder and thus stability of the friction coefficient becomes questionable. This is where the role of solid lubricants comes into the scenario which tends to delay the thermal degradation of binder by increasing its oxidation resistance. Some renowned expert formulators have achieved this by blending various resins. Further, due to their excellent adhesion properties to the metal substrate, additives have good film forming ability and thus they reduce wear. This review first focuses on

the role of different friction additives and how they tend to stabilize the coefficient of friction is discussed. In the second part, role of ingredients performing multi-task is explained. Finally, the environmental aspects pertaining to the friction materials are briefed.
Keywords: Speedspread, fade, recovery, effectiveness variation, radial wear, tangential wear.
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ITRS082

Modelling and Parametric Analysis of Abrasive Wear Behavior of Eulaliopsis Binata Fiber Reinforced Polymer Composites Using Response Surface Method

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Abstract: Now-a-days environmental concerns motivate researchers to explore new avenues of natural substitutes to the synthetic fibers for polymeric composites. The present study is aimed at the potential use of a new natural fiber in polymer composites (Eulaliopsis Binata fiber) as a reinforcing material whose potential has not been fully realized till time to improve the tribological properties. The Eulaliopsis Binata (EB) fiber reinforced epoxy based composites were fabricated and two body abrasive wear test of the developed composites was conducted as per Response Surface Method (RSM) by considering fiber content, sliding velocity, normal load and sliding distance as process parameters. The results obtained from the experimental designs suggested that the inclusion of EB fiber has resulted in significant improvement in abrasive wear resistance of the developed composites. The order of influence of different process parameters was also determined. Further, the modelling of the abrasive wear performance of composite was proposed within the experimental range of the present investigation. The worn surfaces of tested samples are analyzed using field emission scanning electron microscope (FESEM) to find out the wear mechanism of the composites. The pullout of fiber and weakening of fiber-matrix interfacial bonding were found to be the predominant modes of failure during the abrasion of the composites. The results obtained in this investigation advocate the viability of EB fiber to be used as a reinforcement in PMCs to improve the tribological properties.

Keywords: Natural Fiber, Eulaliopsis Binata, Abrasive Wear, Response Surface Method, FESEM.

ITRS083

SURFACE COATINGS FOR PROTECTION OF CONCRETE IN MARINE ENVIRONMENT - PERFORMANCE EVALUATION THROUGH LABORATORY EVALUATIONS

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Abstract: One of the major problems of durability of reinforced concrete in marine environment is the corrosion of reinforcement and its consequent damage leading to early failure of reinforced concrete structures. Steel reinforcement in concrete remains protected against corrosion as long as it is passive. The two processes responsible for depassivation and subsequent corrosion of steel rabies are the carbonation leading to reduction in pH and ingress of chloride ions into the cover concrete. One of the methods in preventing the carbonisation or chloride ingress is through the use of surface coating to the cover concrete. Different types of concrete surface coating in resisting corrosion being a slow process, field exposure tests are time consuming and one has to wait for years to precisely assess the efficiency of surface coatings in resisting/ delaying the corrosion. In this connection a new method has been proposed by SERC where the coated concrete specimen containing rebar is subjected to polarisation under a constant voltage in a sodium chloride solution. During the polarisation, the current response is monitored with time and it is found that the current response with time follows that of a typical service life model indicating depassivation and corrosion propagation. For comparison uncoated specimens and also the time to exhibit cracking is observed in both coated and uncoated specimens. The ratio between the time period for coated and uncoated specimen gives the efficiency factor of the coating in delaying corrosion. The performance of a coating is assessed on three grades of concrete using this method and the efficiency factors are obtained. By this method different types of surface coatings can be evaluated and graded in resisting corrosion due to chloride attack in structures exposed to marine environment.

ITRS084

Influence of Organo-Sulfur Compounds with Overbased Calcium Compounds on Lubrication in Cold Forming

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Abstract: The authors analyzed the structures of sulfurized olefins using NMR spectroscopy and studied the effects of sulfur chain length and alkyl structure on the ironing performance. They found that branched chain olefins, which contain branched alkyl groups, show superior ironing performance to straight chain olefins, provided that their carbon numbers are relatively low. When the sulfurized olefins were used in combination with overbased detergents (calcium sulfonate or salicylate), they showed a higher performance in ironing than with sulfurized olefins alone. It was also found that lubricating films consisting of both iron sulfide and calcium carbonate seem to improve ironing performance.

Keywords: organo-sulfur compound; sulfurized olefin; cold forming; ironing; overbased detergent; calcium sulfonate; calcium salicylate.

ITRS085

Enrichment of hardness and wear behavior of severely deformed AA 5083: Prediction of wear response using supervised machine learning technique

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Abstract: The effect of severe plastic deformation (SPD) on hardness and wear behavior of AA 5083 covered with Cu laminates is studied in this work. The amount of effective strain induced in feedstock subjected to equal channel angular extrusion (ECAE) highly refined the grain sizes up to submicron level. The uniform distribution of effective strain developed the homogeneous ultrafine grains (UFGs) in severely deformed billets (in bulk form) shielded with ductile Cu laminates. The nano-indentation tests were conducted on the severely deformed alloy and observed the significant improvement in modulus and hardness values by 28% and 46%, respectively. The dry sliding wear tests were performed on ECAEd AA 5083 at different loads and sliding distances using pin on disc wear testing machine to study the effect of Cu shielding on the volumetric wear of AA 5083. The wear test results showed that the Cu shielding and the number of passes highly influenced the wear behavior of ECAEd alloy. The supervised machine learning algorithms with k-fold cross validation were deployed to predict the volumetric wear of severely deformed alloy using a data set consists of experimental measurements. A success rate of 90%, 93%, and 98% obtained from linear regression (LR), decision tree (DT) and xtra gradient boosting (XGB) algorithms respectively.

Keywords: SPD, ECAE, UFGs, AA5083, shielding, hardness, wear, machine learning.

ITRS086

Effect of heat treatment on wear behaviour of carbide-based coatings

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Abstract: In the present study, the wear behaviour of the heat-treated WC-Co coatings at various temperatures was carried out. The microstructural and structural characterization of the as-deposited coatings and worn-out coatings were examined by scanning electron microscope, X-ray diffractometer and Raman spectroscopy. The Vickers microhardness was used to measure the hardness of the as-deposited coatings and the heat-treated coatings. The results revealed that the microhardness of the coatings was increased after heat treatment. Heat-treated coatings provide

better wear resistance than as-deposited coatings.

Keywords: WC-Co coatings, Wear, Microhardness, Heat-treatment, Raman spectroscopy.

ITRS088
ABSTRACT

K S Sridaar

Abstract: Environmental Factors in Atmospheric and Marine Corrosion in terms of construction safety and durability, corrosion of metals exposed to the atmospheric and marine environments is costly to our civilizations. The effects of environmental conditions on atmospheric and marine corrosion, as well as the consequences, are discussed in this work. Models that accelerate the effects of relative humidity, temperature, Sulphur dioxide, and other factors have been discovered. The key influencing factors in air corrosion are chlorine and chloride. In general, the rise in these elements will result in an increase in corrosion rate, as well as accelerated impacts. In the vast majority of cases, nonlinearity is present. There are interactive effects between multiple factors and the outcome.

ITRS093
Ship Hull Corrosion and The Effect of Lack Of Maintenance On The Impressed Current Cathodic Protection

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Abstract: This article presents a case study of corrosion of a ship hull that began after continuous failure of the impressed current cathodic protection system. The purpose of this text isn't to question or criticise the planning, installation, maintenance, or operation of the cathodic protection system, but only to point out through the inspection carried out that the most aspects of the corrosive process that occurred when it had been anchored for quite six months. In order to go away the ship in normal operating conditions, repairs were conducted that consisted of cleaning with pressurised water blasting, welding repair of corroded plates, paint application, and installation of zinc anodes in cathodic protection replacement. Cathodic protection (CP) has been successfully used, together with organic coatings, to stop ship hulls and ballast tanks from sea water corrosion. Although CP technology has been developed significantly within the past decades, some problems remain associated with the CP materials applied to ship hulls and ballast tanks. In an impressed current CP system for ship hulls, auxiliary anodes are one among the crucial components, which should have high electrochemical activity and long service life. Impressed current anode with mixed metal oxide (MMO) coated titanium has been widely applied. However, the performance of MMO anode still must be improved especially when performing at an outsized current density and in coldness seawater. Sacrificial anodes like zinc or aluminium alloys are wont to protect ballast tanks, where the electrochemical properties of those anodes will degrade with cyclic exposure to atmosphere and seawater. Moreover, high strength steels are often used for structural components of high-performance vessels, which suffer from hydrogen embrittlement if inappropriate CP potential is applied. These challenges and solutions of CP for marine ships are reviewed and discussed during this paper.
Keywords- Cathodic protection (CP), Impressed current cathodic protection (ICCP), mixed metal

Oxide (MMO), Corrosion.

ITRS103
Tribology And Dentistry

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ABSTRACT: Since 1996 the term "TRIBOLOGY" has integrated different topics like friction, lubrication, and wear. After a few years, interest in this type of phenomena rapidly spread out around the world of biology and medicine, determining a new research area defined as biotribology. In the masticatory organ it is possible to identify structures .The teeth are surely the most important parts related to biotribology and play a fundamental role in our life, connected to functions like pronounciation, facial aesthetics and social relationship. All of these under neuromuscular control. This abstract is conceived within this framework with the aim of underlining the close link between tribology and dentistry regarding both physiological and restorative issues. The contact between teeth requires investigation into their tribological behaviour focusing on the enamel wear process against natural teeth or artificial teeth, allowing us to obtain useful information on the tribological behaviour of restorative materials.Thus ,tested materials may be natural teeth, restorative materials like metal, alloys, ceramics, composites or both. This works aims to make a contribution to underlining the need for greater standardisation of tribological experimental procedures as well as to obtaining more homogeneous and indicative results on the tested tribo systems

Keywords: Biotribology; dentistry, wear, lubrication, enamel.

ITRS104
Magnetorheological Finishing of Internal Tapered Flat End Blind Hole Type Circular Mould-Cavity and its Performance Analysis

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Abstract: Moulds are used for the manufacturing of plastic parts. The fine finished internal surfaces of the mold cavities are necessary to achieve the appealing surface appearance of the end products and their dimensional accuracy. In this paper, fine finishing of the longitudinal and

tapered flat end surfaces of the real-time AISI 5140 cylindrical blind hole (CBH) type mould cavities for manufacturing of front windshield wiper spray water nozzle washer jet using the magnetorheological polishing (MRP) fluid-based grinding wheel (MRPGW) type finishing tool. To achieve fine finishing on the AISI 5140 samples, the process parameters such as current, workpiece rotational speed, tool rotational, and reciprocation speed are optimized. Experiments are carried out over samples with longitudinal and flat end surfaces to obtain the optimized parameters. After obtaining the predicted optimum process parameters, the finishing is performed on the final real-time mold cavity. The significant improvement in final roughness values demonstrates the fine finishing over the longitudinal and the tapered flat end surfaces of the CBH type mould cavity. From the microscope images, the surface characteristics are visually investigated. Thus, the fine finished longitudinal and tapered flat end surfaces of the CBH type mold cavity using the MRPGW tool can improve the functional performance in manufacturing the plastic parts like front windshield wiper spray water nozzle washer jet with reduced frictional force.

Keywords: Fine-finishing; Magnetorheological polishing fluid; Magnetic field; Surface roughness; Cylindrical blind hole; Tapered mould cavity.

ITRS105
A Comprative Study of Mechanical And Tribologcial Properties Of H-Ammc Reinforced With Mwcnt Sintered By Conventional And Microwave Hybrid Heating

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Abstract: Nano-sized particles are use more frequently because they strengthen Metal Matrix Composites (MMCs) and keep the matrix alloy ductile. In the current work h-AMMCs, (A390+15wt. % SiC+1 & 2 wt. % MWCNT) have been fabricated successfully with the help of Microwave Hybrid Heating (optimizing process parameters Power: 900 Watt, Exposure Time: 350 seconds) as well as Conventional route of heating (Muffle Furnace). The Microstructure, compression Physical, Mechanical and Tribological behavior of A390+SiC+MWCNT h- matrix composites were studied as a function of MWCNT content and preparation methods. The tribological behaviour of h-AMMC sintered materials has been studied by using a Pin on Disc sliding wear Tribometer. The graphical analysis of Coefficient of Friction (CoF) using Windcom software and Vicker's microhardness tester for microhardness for both conventional as well as microwave technique. The results reveal the viability and significance of microwave material processing over conventional methods for the fabrication of h-AMMC.

Keywords: Microwave heating, sintering, h-AMMC, MWCNT, Tribology.
Abbreviations: h-AMMC – Hybrid Aluminium Metal Matrix Composite, SiC – Silicon Carbide, MWCNT – Multi-wall Carbon Nanotubes

ITRS106
Air Lubrication Systems

(Cdt Nikhil Singh Sumbria N35005)

Abstract: Air Bubble Lubrication System is one of the promising technologies which will help ships to improve their efficiency and reduce energy losses. Air Lubrication System is a method to reduce the resistance between the ship's hull and seawater using air bubbles. The air bubble distribution across the hull surface reduces the resistance working on the ship's hull, creating energy-saving effects. With the right ship hull design, the air lubrication system is expected to achieve up to 10-15% reduction of CO2 emissions, along with significant savings of fuel. The Air Lubrication System works on the simple principle of trapping a layer of air bubbles beneath the ship's hull. An air blower or a dedicated system is used to generate air bubbles to pass them continuously beneath the ship's surface. Air bubble outlets are created at different locations along the bottom of the hull, symmetrically on both the sides of the ship's center line. The air is blown at a constant rate to form a layer of bubbles, which reduces the drag and resistance between the ship and the seawater

ITRS107

Performance Improvement of EN-8 Steel Alloy Cylindrical Mould Using Rotating Magnetorheological Honing Process

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Abstract: The cylindrical mold is a key element utilized in many sectors for manufacturing the different cylindrical components. Fine finishing of the cylindric mold with good surface integrity has several benefits such as good fits and tolerance for components. The rotating magnetorheological honing (RMRH) process is used to fine-finish the inner surface of a real-time plastic bottle cap mold manufactured of EN-8 steel alloy material in this study. The present work describes the effect of the rotating magnetorheological honing (RMRH) process on the surface characteristics of the EN-8 steel alloy material. Further, the effects of different process parameters of the RMRH process on the percentage improvement in the surface finish (% ΔRa) of EN-8 steel alloy material have been studied and optimized using the response surface methodology. After 40 min of MR finishing, a substantial surface finish of 60 nm was achieved from an initial roughness value of 430 nm. In addition, circularity, waviness, and surface morphology tests are carried on the mold surface. Results reveal the capability of the present process for providing effective finishing with the enhancement in surface characteristics and improved functional efficacy of the EN-8 steel alloy material of plastic bottle cap mold's internal surface. Further, to study the wear rate while finishing operation, the hardness test has been conducted in this study.

Keywords: Cylindrical mold, rotational magnetorheological honing, polishing fluid, fine-

finishing, surface roughness, waviness, circularity, hardness, wear-rate.

ITRS108
Halogen-free Ionic Liquids as Lubricant Additives: A Review

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Abstract: Conventional metal working fluids are based on petroleum based mineral oils. These oils are non-biodegradable, detrimental to environment and causes sever health concern to the operators and society. Therefore, environmentally friendly metal working fluids are the need of today's time. Ionic liquids (ILs) have emerged as a potential environmentally friendly lubricant or lubricant additives because of their attractive characteristics such as oxidation and high thermal stability as well as low volatility. Ionic liquids (ILs) are room temperature molten salts, combination of cationic and anionic components with a definite set of properties. Ionic liquids show great lubricity for metal pairs due to halogen constituents in their molecular structure. However, the presence of halogen in ILs leads to form highly toxic and corrosive acids when exposed to moisture. Therefore, researchers have shifted focused to halogen-free ionic liquids, which are considered as more environmentally friendly than their halogenated counterparts. Halogen-free ionic liquids as lubricant additives in several systems (i.e., machining) significantly reduce friction and provide remarkable protection against wear. This work reviews the past and current status of halogen-free ionic liquids as lubricant additives with an effort to correlate among the cationic and anionic structures, physicochemical properties, oil-solubility, wettability, lubricating behavior and tribological performance. Performance of halogen-free ILs for machining applications such as drilling, milling, turning and grinding are discussed. Literature gaps and future trends are also suggested.

KEYWORDS: Friction; halogen-free; ionic liquids; lubricant additives; machining forces; metal working fluids; wear.

ITRS109
An Investigation of Magnetorheological Finishing on Tribological and Functional Performance of Polymer Gears

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Abstract: Polymer gears are extensively used in various industries because of their characteristics such as low weight and good dampening resistance. The fine finishing of polymer

gears (PGs) is critical in determining the functionality of various industrial components. The high-grade finish on the polymer gear surface enhances component reliability, reduces wear, and improves operational efficiency. A novel magnetorheological bevel gear finishing (MRBGF) process is used in this study to finish the entire polyamide gear surface in the minimum amount of time. After experimentations, the average surface roughness value of the overall polymer BG got reduced to 90 nm from 390 nm in 120 min of finishing. Further, to analyze the effectiveness of MR finishing on the polymer gears' functional efficacy, the gear testing setup is developed and demonstrated. This study describes a new gear testing design and methodology for evaluating the wear rate and performance of initial ground and final MR finished polymer gears. One of the unique characteristics of the presently developed gear testing rig is that it constantly monitors the temperature, which is critical for understanding polymer gear behavior. In the present work, loads are varied for the same number of running cycles at constant rotational speed for initial and final MR finished polymer gears. Extensive experimental tests have been carried out to investigate the initial ground and final MR finished polymer gear performance. Further, to analyze the efficacy of MR finishing on the polymer gear surface, a comparative study of temperature variation performance, tribology performance is done. The results reveal that the MR finished gear surface shows better tribological and temperature variation performance as compared to the initial ground gear surface. Furthermore, laser Raman analysis revealed that no noticeable chemical changes were caused on the sub-surface level as a result of the MR finishing. All these results signify that MR finishing is feasible for enhancing the functional efficacy of polymer gears in industries.

Keywords: Polymer gears; magnetorheological finishing; surface roughness; wear; tribology; temperature; Raman analysis.

ITRS110

Influence of Nano and Extreme Pressure (EP) additives on the Lubricating Performance of Karanja oil

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Abstract: It is crucial to focus on the anti-wear and load-sustaining abilities of the lubricating oils, as they are an essential part of their operation. This study explores the anti-wear and extreme pressure (EP) abilities of the plant-based karanja oil. A four-ball testing machine was used to perform the experiments following the ASTM-D4172 and D-2783 standards. The karanja oil was mixed with Graphene and Molybdenum disulfide nano-additives at various percentages to enhance its lubricating performance. The nano-additives were found to be very effectual in reducing the wear but could not improve the EP properties of the karanja oil. Nonetheless, the intrusion of Garlic oil proved to be efficient in elevating the EP properties of the karanja oil. The weld point of the karanja oil was increased by 4 levels, while as the Load Wear index was enhanced by 153.67%. The wear scars on the test balls were inspected using FESEM and an

optical microscope. The surface topographic analysis was done on a 3D profilometer and the roughness parameters were also calculated. The results clearly showed improvement in the lubricating performance of karanja oil as the comparatively smoother surfaces were observed following the intrusion of the nano-additives and garlic oil. This improvement was attributed to the development of tribo-layers on the sliding surfaces which constraints the direct metal contact. It can be deduced from this study that the Garlic oil has a great potential to enhance the EP properties of the bio-oils without hindering their biodegradability.

Keywords: Karanja oil, Wear, Extreme pressure, Molybdenum disulfide, Graphene, Garlic oil.

ITRS112
A comparative study on the lubricant properties of epoxidized and transesterified vegetable oils

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Abstract: The biodegradability, renewability, low toxicity, and excellent lubricating performance of vegetable oils are the main reasons behind the research on vegetable oils as an alternate source for lubricants. But the poor oxidative stability is one of the major drawbacks of vegetable oils. Based on the free fatty acid content, two distinct vegetable oils were selected for the present study i.e. Rice bran oil (RBO) and Karanja oil (KO). RBO has a low concentration of free fatty acids, while KO has a high content of free fatty acids. The main aim of the present work is to improve the oxidative stability of RBO and KO, using the transesterification and epoxidation method. The physicochemical, tribological, thermal and oxidative stability of pure and modified oils were evaluated as per ASTM and Indian standards. The confirmation of transesterification and epoxidation reaction was done using the Iodine value test and Fourier transform infrared spectroscopy. The chemically modified oils have shown improved oxidative stability, tribological and physicochemical properties compared to the pure vegetable oils. The thermal stability in terms of mass degradation was found to be better for epoxidized oils. The study also revealed the effectiveness of the epoxidation and transesterification process on the selected oils.

ITRS113
Evaluation of the physico-chemical, tribological and oxidation stability of multistage chemically modified Calophyllum inophyllum oil

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Abstract: The present trend of using non-edible vegetable oils as a potential base stock for industrial lubricants is increasing due to environmental issues and fossil fuel depletion. Calophyllum inophyllum oil (CIO) is a non-edible tree seed oil that is widely available in different parts of the world. The major disadvantage of CIO is its high acid and peroxide value, which leads to poor oxidation stability. Various chemical modification processes such as epoxidation, trans-esterification, etc. are commonly implemented to improve the oxidation stability of vegetable oils. The fatty acid profile of the base oil was evaluated using Gas chromatography and mass spectroscopy (GC-MS). Research related to multi-stage chemical modification of vegetable oils is very limited. This study focused on the multistage chemical modification of CIO by the transesterification process followed by the epoxidation processes to improve its oxidation stability. The unsaturation reduced during the chemical modification was confirmed using Iodine value test. The lubricant properties such as chemical, tribological, rheological and oxidative stability of pure and modified CIO have been evaluated and compared in the present study. The experimental results indicated there is a significant improvement in the chemical properties and oxidative stability of CIO after chemical modification. The chemically modified CIO can be considered as a potential base-stock for bio-lubricant formulations.

Keywords: Oxidative stability, Multi-stage modifications, Calophyllum inophyllum oil, Bio-lubricant, tribological properties.

ITRS114

A preliminary study on the tribological properties and oxidation stability of rice bran oil with black pepper oil as a bio-additives

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Abstract: Around the globe, the majority of industries are using mineral oil-based lubricants because of their cost, availability, and compatibility with different engineering materials. The non-degradable and toxic nature of commercial lubricants depends on the base oil and additives used. Vegetable oils are considered as a potential base-stock for bio-lubricant formulation due to their desirable lubricant properties, such as high flash point and high viscosity index. However, they also have certain limitations, such as poor oxidation stability and poor cloud and pour point characteristics. The work related to the usage of naturally occurring products such as herbal oils as a bio-additive to improve the lubricant properties of vegetable oils is very limited. This preliminary study focused mainly on evaluating the tribological properties and oxidation stability of vegetable oil with black pepper oil as an additive. The base vegetable oil selected in the study

was rice bran oil. The experimental study initially investigated the influence of different weight percentages of black pepper oil on the tribological properties of rice bran oil using a standard four-ball tester. Then the hot oil oxidation test was conducted to evaluate the oxidative stability of the rice bran oil with optimum additive concentration. The experimental results have shown the effectiveness of black pepper oil as a potential additive for vegetable oil-based lubricants.

Keywords: Bio-additives, Herbal oils, Black pepper oil, Rice bran oil, Oxidation stability, Tribological properties,

ITRS116
The Use of Artificial Intelligence in Tribology—A Perspective

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Abstract: Artificial intelligence and, in particular, machine learning methods have gained notable attention in the tribological community due to their ability to predict tribologically relevant parameters such as, for instance, the coefficient of friction or the oil film thickness. This perspective aims at highlighting some of the recent advances achieved by implementing artificial intelligence, specifically artificial neutral networks, towards tribological research. The presentation and discussion of successful case studies using these approaches in a tribological context clearly demonstrates their ability to accurately and efficiently predict these tribological characteristics. Regarding future research directions and trends, we emphasis on the extended use of artificial intelligence and machine learning concepts in the field of tribology including the characterization of the resulting surface topography and the design of lubricated systems.
Keywords: artificial intelligence**;** machine learning**;** artificial neural networks**;** tribology

ITRS117
Evaluation of tribological characteristics of alumina coated aluminum alloy using Finite Element Method

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Abstract: Material loss due to relative motion between the contact surfaces causes functional degradation leading to premature failure of engineering systems. Of the several techniques to improve wear resistance of rubbing components, the process of providing a hard protective surface coating without affecting the bulk properties of the materials has gained significant attention of late. Sol-gel coating is a widely accepted surface coating techniques for aluminum alloys, where its tribological characteristics such as coefficient of friction and volumetric wear losses are evaluated using pin on disc tribometer. Finite Element Analysis (FEA), introduced in early sixties, plays a vital role in bringing approximate solution to various engineering and non-

engineering problems using mathematical formulations. This paper concentrates on alumina coated aluminum alloy and the reliability of the coating against uncoated samples is estimated by evaluating its tribological characteristics. Here, pin on disc tribometer is modelled in design modeler of Ansys workbench based on Archard wear model. The tribological characteristics like sliding status, coefficient of friction, wear, contact pressure, frictional stress, penetration and heat flux associated with frictional sliding of continuous sliding motion is studied. The comparative studies regarding the estimated properties with uncoated samples are analyzed and also point outs future scopes for researchers to come.

Keywords: Surface Engineering, Alumina coating, Tribological properties, Finite Element Modelling, Finite Element Analysis.

ITRS118

Role of nano particles in aqueous lubrication

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Abstract: It is well accepted that oil and oil-based lubricants are neither environment friendly nor good for human health. Nature has suggested that water-based lubrication is best, but it is still difficult to make artificial water-based lubricants. To understand this, the concept of green lubrication has emerged. Water has poor tribological properties because of low viscosity, corrosiveness, vaporization at elevated temperatures, etc. The development in oil-based lubricants and nano-oils suggests that nano-additives are very helpful in improving tribological performance. With the understanding of the role of nano-additives in oil-based lubrication, it can be sought that the tribological performance of water-based lubrication will be aided by nano-additives. This will help in a sustainable environment and human health. To overcome the limitations of water-based lubrication, nano additives can be used. In the present work, friction and wear analysis has been done to compare the nano additives-based aqueous lubrication to pure water-based lubrication. Reduced Graphene Oxide (rGO) and alumina are used as nano-additives to pure water. Surface and interface characteristics are important for wettability and hence for lubrication. The effect of the concentration of nano additives on wettability and surface tensions has been studied. The tribological and surface tension study suggests that there is the optimality of concentration. Tribological evaluation of different fluids was done using a four-ball tester. Wettability, Surface and interface characteristics were studied using Goniometer. The study suggests that the lubrication characteristics of water can be significantly improved by using rGO and alumina nano-particles. The tribological performance of rGO as friction and wear reducing agent is found to be better than that of alumina-nanoparticles.

Keywords: nano-additives, nano-particles, rGO, alumina, sodium oleate, coefficient of friction, wear scar, frictional torque.

ITRS119
Impact of Various Surface Friction Conditions on Joint Performance During Ultrasonic Welding Between Al-SS Sheets

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Abstract: The multi-material design of advanced automotive structures for lightweight and lower-cost solutions certainly involves the dissimilar joining of aluminum alloys with steel. Unfortunately, the conventional fusion welding process could not presently meet industrial requirements for dissimilar metal joining due to high energy consumption, poor mechanical strength, and formation of intermetallic compounds (IMCs). These IMCs arise due to the higher rate of intermetallic reaction in the liquid phase, which leads to poor properties and low joint strength. Ultrasonic metal spot welding (USMW) is a proficient solid-state joining process that can potentially substitute for resistance spot welding, and it can also reduce the propensity for intermetallic formation. It is an emerging joining process with low energy consumption, shorter weld time, no shrinkage, and distortion problems. The current research presents a study between ultrasonically welded aluminum (Al) and stainless steel (SS) sheets at various surface friction conditions. The impact on bond strength due to three different surface conditions such as normally cleaned surface, electrolytic polished surface, and emery polished surface are analyzed during this study. Tensile shear and T-peel failure loads tests are employed to evaluate the mechanical changes of the USMWed joints. The microhardness test is also performed to study the effect of natural aging and softening across the weld zone at the different joint surfaces. The fracture surface analysis with varying interface morphologies and properties are also inspected on the weld region.

Keywords: Ultrasonic metal spot welding, Surface conditions, Tensile shear failure load, Micro-hardness, Fracture surface

ITRS120
Lubricity enhancing ionic liquids and nanoparticles for environmentally friendly lubricants

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Abstract: Constantly decreasing fossil resources, increasing energy demand, and pollution makes pressure on the world's community to find rational ways to solve these problems. Reduction of friction caused energy losses and usage of environmentally friendly lubricants and additives can help to save natural resources and reduce pollution. Water-based lubricants are known for a long time. Particularly large quantities are used in the metalworking industry and hydraulics. However, environmentally harmful additives such as chlorine, sulfur, and phosphorus are still used to improve the lubricity of water-based lubricants. Generally, ionic liquids are considered excellent lubricants. However, most of the ionic liquids, which tribological properties

were investigated, contain halogens or other hazard elements. Therefore they cannot be considered environmentally friendly. Only a few authors are presenting results with totally organic additives. Therefore, there is a lack of information on the tribological properties of fully organic ionic liquids and their use in improving water-based lubricants. Nanoparticles, on the other hand, also are promising lubricity improving additives. Some of them are considered to be harmless to the environment. Recently the synergy between ionic liquids and nanoparticles became an interesting topic. Ionic liquids can enhance lubricity and suspension stability, while nanoparticles improve lubricity in high loading applications. In the current study, we investigate protic ionic liquids and nanoparticles as potential additives for water-based lubricants. We are using ionic liquids based on tert-octylamine and diethanolamine in combination with carboxylic acids. Graphene, silicon oxide, and titanium oxide nanoparticles are selected. Suspension stability, physicochemical and tribological properties are investigated. The ball-on-plate reciprocating tribo-tests were performed. It was found that these additives can greatly improve the lubricity of deionized water. However, the effect is strongly related to the suspension preparation method. We also have found that these additives can serve as corrosion inhibitors for ferrous materials. Moreover, they can improve wettability.

Keywords: lubricants; additives; ionic liquids; nanoparticles; suspension; friction; wear.

ITRS121

Effect of Fiber Orientation on Tribological Performance of Abaca Fiber Reinforced Epoxy Composite Under Dry Contact Conditions

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Abstract: Today, natural fibers and their composites are increasingly present in the industrial production of various materials, ranging from the textile industry, through construction, all the way to the automotive and aerospace industry. Their wide application is justified by the replacement capabilities of composite materials reinforced with synthetic fibers. This paper presents tribological research of abaca fiber reinforced epoxy composite material. Fiber orientation and its effect on the tribological performances of the composite was analyzed. The extremely low viscosity epoxy resin reinforced with NaOH treated long abaca fibers is investigated under the different operating conditions. The unidirectional abaca fibers reinforced the epoxy resin and formed composite specimens with fibers in three directions, Parallel (P-O), Anti-Parallel (AP-O), and Normal (N-O), respecting the sliding direction. The specimens were fabricated by fiber volume fraction of 30 wt% using the vacuum infusion technique. The block-on-disc (BOD) apparatus was employed to exhibit the tribological tests. To conduct the test, a normal load of 35N and 45N was applied. The experimental results showed that the presence of abaca fiber significantly improved the wear characteristics of the matrix than the neat epoxy. An increased coefficient of friction was observed in samples with anti-parallel oriented fibers at an

applied load of 35N. The conducted research showed that the use of abaca fibers as fillers could improve the tribological characteristics of the epoxy resin-based composite material.

Keywords: epoxy resin, abaca fibers, fiber orientation, natural composites, friction, wear

ITRS124
TRIBO-CORROSION

Abstract: Tribo-corrosion is the term which describes the synergy between tribological and electrochemical processes. An apparatus was designed and built to study the tribo-corrosion behavior of biomaterials. Electrochemical set-up with three electrodes is used for controlling the potential of the surface of a conducting material subjected to classical wear testing. Using this equipment, it is possible to carry out friction and wear tests in electrolytic solution under well-defined electrochemical conditions determined by the applied electrode potential. In this paper, this apparatus was described and the tests of deposited TiN on pure Ti for corrosion and tribo-corrosion behavior under simulated body fluid were conducted. The presence of TiN layer on the surface of Ti has increased the open circuit potential. The charge transfer resistance (Rct) determined using electrochemical impedance spectroscopy (EIS) was higher for the nitrided surfaces than for the Ti substrates. However, after wear test, Rct was significantly reduced because the protective layer was damaged.

Keywords: Tribo corrosion, Ti, wear, EIS.

ITRS125
Tribology In Bio-Medical Applications

Abstract: The study of wear, friction and lubrication is a tribological research. Today' Bio-tribology is one of the most inspiring and rapidly growing areas of tribology. This paper presents a complete review of bio-tribology in engineering and medical applications during past decade. It covers recent publications related to bio-tribology focusing on the areas such as non-smooth surface morphology of creatures, applications related to tribology in medical field and biomaterials. Tribological studies associated with biological systems include continuing research in technology from biological perspective. It serves as an innovative idea for material scientists and tribologists to move away from conventional methods and look for inventive techniques that serve better results. The applications discussed in this study shows endeavour of researchers to understand the tribological happenings in nature and their efforts to mimic it.

Keywords: bio-tribology; biomimetic, surface morphology; biomedical devices; biomaterials.

ITRS132
New methods for Fe based coatings; Process parameter, influence on tribological properties and challenges

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Abstract: Coatings involve the heating of materials to a molten state or semi molten state, so that they can fuse and can be coated over a surface to enhance the properties of surface without compromising its own properties. Different metals have been used as base in coatings and have been tested for different parameters. The growing demand in Fe based coatings have led the researchers in a journey to develop the efficient and reliable methods for coating generation. Fe is readily available and economically sustainable, and this has led researchers to explore Fe with other materials. To enhance the electro-chemical and tribological properties of tribo-pairs or surfaces in interaction, various materials are used in combination with Fe such as polymers, ceramics, oxides, sulfides to meet the desired requirement as per the application. This review is based on the systematic literature survey of coating methods which have been readily used by the researchers to develop such combinations. Followed by this, a state of art review has been carried out to explore the mechanical, tribological and electrochemical properties of the Fe based coatings. Recent developments in the field have been also addressed. Also influence of different process parameters on tribological and electrochemical properties have been explored.

Keywords: HVOF, coating, wear, corrosion, CoF

ITRS133

Effect of Weight Percentage of WC Particles on Cavitation Erosion Behavior of NiCrSiC-WC Composites Clads Developed Through Microwave Cladding

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Abstract: The current study reports the tungsten carbide (WC) particles reinforced NiCrSiC composite clads, on austenitic stainless steel (AISI-316) substrate, utilizing microwave as a heating source for cladding, investigated the relationship between the cavitation erosion behavior and the variation in weight percentage of WC particles, compared with an SS-316 and pure NiCrSiC clad. The clad was developed using electromagnetic radiations (EM) of 900 W power and 2.45 GHz frequency. The developed clads were characterized using various techniques like SEM/EDS, XRD, Vicker's microhardness, inverted metallurgical microscope, and vibratory cavitation erosion tester. The stand-off distance was chosen in the cavitation tests as 0.5 mm, the amplitude as 60 μm, immersion depth as 100 mm, and the test duration for an individual test as 540 minutes. It has been revealed that with an increase in the weight percentage of WC particles, the composite's wear rates decreased drastically initially, but later significant change was not observed. The change in the mode of damage from ductile to brittle with an increase in weight percentage of WC particles is also observed in worn surface analysis.

Keywords: Cavitation Erosion; Microstructure, Microhardness, Microwave Processing, WC

ITRS134

Investigation on tribological behaviour of Ti-6Al-4V laminates produced for Ti/GFRP stacked composite

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Abstract: Laminates of Titanium alloys find its wide application as a input material for stacked composites to be used in area of aerospace. Presently rolling process is used for making these laminates, but the multistage deformation of process make it not very desirable process. The present investigation is aimed at checking the viability of an alternative single stage process for laminates fabrication of Ti64 alloy for stacked composites. Therafter, sliding wear behaviour on Ti-6Al-4V laminates fabricated prior to stacking with GFRP is investigated. Laminates are fabricated at different strain rates in dry conditions in a single pass of processing. Sliding wear analysis is performed using a tribometer. Morphology of tested samples is characterized by scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), and X-Ray Diffraction (XRD). Micro-hardness of fabricated strips is examined on Vickers Hardness tester, and roughness tester is used for roughness measurement of the fabricated laminates. Hardness measurement revealed a increase of ~ 30-55% in the hardness value of fabricated laminates in comparison to the bulk material. This increase in hardness may be attributed to grain refinement resulting from high deformation induced by the process. The roughness values of the laminates decreased with an increase in strain rate. Progressive wear rate was analysed at loads 10N, 30N, 50N by keeping the sliding velocity constant 1 m/s for all the produced laminates. Wear rate is observed lower in all laminates as of parental material.

Keywords: Titanium G5, shear deformation, texture, machining, Sliding wear

ITRS135
Economic modeling and energy assessment of machining tool steel under MQL environment using environmentally friendly cutting fluids

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Abstract: Tool steel is used to make various dies as well as in parts of high performance equipment's needed in automotive, medical and aerospace industries. However, machining of tool steel is difficult and result in severe tool wear due to its high hardness (above 50 HRC). Therefore, cutting fluids are used to reduce friction and improve tool life during machining of tool steel. Conventionally, cutting fluids are made of petroleum based mineral oil which are harmful for environment, society and can cause serious health issues in operators due to prolong exposure. Therefore, enhanced cooling strategies and environmentally friendly cutting fluids are need of today's time. Minimum quantity lubrication (MQL) with environmentally friendly cutting fluid is one of the most viable and effecting solution. However, its initial setup cost is high due to addition requirement of equipment's. Also environmentally friendly cutting fluids are costly compared to mineral oil. Therefore, study of economic feasibility and overall energy

requirement to find the breakeven point is necessary. In this study, economic cost modeling and energy assessment for machining tool steel under MQL environment with environmentally friendly cutting fluid is carried out. Machining experiments are carried out in three different environments, i.e., dry, flood and MQL. Machining forces, tool life and machined workpiece surface finish were measured. Moreover, economic costs modeling which includes five variable cost parameters were assessed. Energy consumption under all three environments were studied and analyzed. Analysis of results shows that the MQL machining using environmentally friendly cutting fluids increased productivity, reduce tool wear and improved machined workpiece surface roughness compared to dry machining. Also, it is an economic alternative due to saving in terms of tool cost and productivity compared to machining under dry and flood environments.

Keywords: Cost; economic modeling, energy consumption, environmentally friendly cutting fluids; machining; minimum quantity lubrication; productivity.

ITRS136

Effect of Particle Size Variation on Structural and Tribological Behaviour of AA2014 Reinforced with Al2O3 Particles.

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Abstract: The effect of variation in reinforcing particle size has a significant impact on the characteristics of AA2014–Al2O3p composite. The purpose of this research is to investigate and compare the effects of alumina particle size changes on the structure and wear behaviour of aluminium composites reinforced with different proportions of (9-15%) Al2O3. Composites containing different size range (88 μm and 53 μm) of Al2O3 reinforced in AA2014 alloy were prepared by liquid metallurgy route. The microstructural characterization of the produced composites was carried out by Scanning Electron Microscopy, X-ray diffraction and EDAX studies. Using pin-on-disc wear testing machine, wear tests were carried out at different sliding speeds, distances and loading conditions. The results suggest that, the wear rate of alumina reinforced composites with a particle size of 53 μm is low as compared to composites reinforced with 88 μm alumina particles at all tested conditions. It was also discovered that composites reinforced with a particle size of 53 μm had superior wear resistance and coefficient of friction than those reinforced with a particle size of 88 μm and the AA2014 matrix alloy, while the inclusion of alumina particles improved tribological properties further. SEM/EDX microanalysis was used to describe the worn surfaces. The examination of the worn surface and debris shows that the creation of a Fe-rich oxide layer between the mating surfaces during sliding increases tribological properties.

Key words: AA2014 alloy; Particle size; Microstructure; Wear; Friction; Wear Debris;

ITRS137
Prediction of Dry Sliding Wear Behavior of AA7075-B_4C Composites

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Abstract: Wear is one of the most predominant aspects to be considered while selecting material for automotive and aerospace applications. A novel aluminium metal matrix composites (AMMCs) offer better wear resistance for various tribological applications. Hence, in the present work deals with the effect of boron carbide (B_4C) reinforcement on hardness and wear behavior of AA7075 metal matrix composites. The varying weight percentage of (0, 4, 8 and 12 wt.%) B_4C reinforced composites were prepared by stir casting method. The developed composites were subjected to carried out the hardness test as per the ASTM standard. A pin-on-disc apparatus was used to performing the wear tests under dry sliding conditions. The wear rate of the composites was measured from mass loss pins and co-efficient of friction (COF) was recorded during the test. The experimental results understood that the inclusion of B_4C particles improved the hardness of AA7075 matrix. The higher value of hardness 168 HV was obtained at 12wt.% of B_4C addition. It was also observed that the wear rate and COF of the produced composites were gradually decreases with an increase in weight percentage of B_4C reinforcement content from 4wt.% to 12wt.%. From the studies, it can be clearly understood that the addition of B_4C reinforcement content improved the hardness and wear resistance of the developed composites. Hence, the developed AA7075-B_4C composite can be used for the applications in automotive and aerospace engine components such as cylinder liner, piston, bearings, gears and sprockets, etc.

Keywords: AA7075, B_4C, Stir casting, Composite, Hardness, Wear rate, COF.

ITRS140
On the Contact Pressures Predictions for Evaluation of Fretting Wear Mechanism

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Abstract: Fretting is a common occurrence in engineering between two contacting bodies when an oscillatory tangential load is compounded with a normal load. It may be caused by vibration, cyclic temperature changes, cyclic loading in gears, bolts, human joints, bearings, etc. Fretting wear and fretting fatigue are two main tribological failure causes.

In this paper a procedure is proposed and presented in order to compare the contact pressures of the normal load between two contacting bodies based on the Hertzian, Johnson Kendal and Roberts (JKR) and Derjaguin-Muller-Toporov (DMT) theories. Given that there are many different parameters that affect wear and friction, e.g. surface roughness, load, surface material and lubricants result in a large number of variables. Therefore, it is impossible to cover all possible load cases, which are a combination of input parameters. For this reason, a database will be created where all the calculated loading cases will be stored for several metallic pairings – mating surfaces. Then, a Machine Learning Technique (Regression and Support Vector Machines (SVM)), will be used to build a model that improves most load cases.

In conclusion, in this work, attempts will be made to automate the calculations and create too many (thousands) of load cases that will constitute a database, which can then be used as a training set in a machine learning technique to build an artificial neural network (ANN), which is an ongoing project that will easily and quickly can make a decision about the probability of wear and evaluate the force of friction.

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Keywords

Contact, Pressure, Fretting Wear, Machine Learning, SVM, Regression

ITRS141

Assessment of halogen free phosphonium based ionic liquid as lubricant additives for tribological and machining applications

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Abstract: Recently, ionic liquids have emerged as potential lubricant additives for metal working fluids. Studies shows that ionic liquids have improved physical and chemical properties of metal working fluids used for tribological and machining applications. However, most of the ionic liquids are based on halogen anions which are susceptible to moisture and can produce halogen acids. Halogen-based ionic liquids can corrode the workpiece surface and are detrimental to environment. In this work, halogen-free phosphonium based ionic liquids are studied. One percent of halogen-free phosphonium based ionic liquids was blended with environmentally friendly canola oil to use as metal working fluids during machining of EN 31 steel. Initially, viscosity and contact angles were measured. Friction and wear test were carried

out using pin-on-disc tribometer to study the effect of phosphonium based metal working fluids with high speed steel pins and EN-31 steel disc. Surface morphology of worn-out pins and counter disc were analyzed under scanning electron microscope and 3D surface profilometer. Further, turning experiments were carried out and tool-chip interface temperature as well as machined workpiece surface roughness was measured. For comparison, all tests were also carried out with pure canola oil and two halogen-based ($[BF_4]$ and $[PF_6]$) ionic liquid blended with canola oil as well as under condition. Analysis of results show that the sliding friction, wear, and pin surface temperature were reduced for phosphonium based ionic liquids blended with canola oil due to its better lubricating ability and spreading tendency. Pin and counter disc surface morphologies showed low abrasion wear. During machining, the average cutting temperature and machined workpiece surface roughness reduce up to 44 % and 63 % compared to dry machining.

Keywords: Sliding friction; Halogen-free; Ionic liquids; Tribology; Wear; Cutting temperature; Surface roughness.

ITRS142
Automobile engine tribology - approaching the surface

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Abstract: There has been relentless pressure in the second half of the 20th century to develop ever more fuel efficient and compact automobile Engines with reduced environmental impact. From the viewpoint of the tribologist this means increasing specific loads, speeds and Temperatures for the major frictional components of the engine, namely, the piston assembly, the valve train and the journal bearings, and Lower viscosity engine oils with which to lubricate them. Inevitably, this leads to decreasing oil film thicknesses between the interacting Surfaces of these components and a more crucial role for the topography and surface profile of the two surfaces in determining Tribological performance. This paper reviews the nature of the surfaces encountered in the piston assembly, valve train and journal Bearings of the internal combustion engine and how mathematical models of engine tribology are endeavouring to cope with the extreme Complexities the incorporation of surface topography potentially brings. Key areas for future research and the implications for design are Highlighted.

Keywords: Automobile; Engine; Tribology; Piston; Piston ring; Cylinder; Engine bearings; Cam; Follower; Valve train; Friction; Lubrication; Wear

ITRS145
Development of Cera-metallic friction material for tractor applications – An interface study

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Abstract: Cera-metallic friction material is used for higher driveline energy transmissions for stable performance coupled with long life. A new cera-metallic friction pad (CMDE) is developed through Powder metallurgy route and validated through controlled environmental laboratory test (Chase Testing machine using SAEJ 661 protocol) followed by the field test. For comparison purpose, an OE cerametallic pad is also tested (CMOE). In the chase test, it was observed that CMDE fared poorly in fade 1 by 25% with respect to the reference value. In fade II both the parts fulfilled the requirements. Recovery μ is also above 90% in the cera metallic pads. Further friction stability is checked by comparing the friction value at same temperature in the fade and recovery mode and found CMOE is better. From wear point of view, CMDE is better than CMOE. Hence, from the controlled environment test, CMOE fared better than the CMDE with respect to tribo performance.
The tractor level severe test is carried out for 25,000 cycles for understanding the engagement characteristics and thereby predicting the useful life in several engagements. Considering the wear in the field test, CMDE has 11.1% more wear than CMOE unlike the laboratory test. In addition, the mating part wear is 20% more in CMOE, than CMDE, which indicates the counter friendliness of CMDE. The surface roughness of the mating part before test is 5 Ra. After testing, with CMOE it reduced to 2.53 whereas with CMDE it is 1.26, which indicates the engagement and wear pattern characteristics by deforming the contacting asperities. Both sintered friction pad and pressure plate showed adhesive wear scoring marks along the sliding direction as observed through the SEM images. The pressure plate showed a transfer layer of oxides and carbon with less scoring marks. Hence, CMDE can be an alternative of CMOE considering the performance and the cost criteria.

Keywords: Clutch; cera-metallic friction; wear, surface roughness and material.

ITRS146

Investigations on the effect of tungsten carbide-cobalt particles on the hardness and wear properties of aluminium composite materials

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Abstract: Aluminium matrix composites (AMCs) have found uses in aircraft, architecture, automotive, energy, infrastructure, marine, military, sports and recreation because of its high

strength and sensible wear resistance features. The experimental results of Al7075-WC-Co composites' mechanical and tribological properties are provided in this article. The matrix is Al7075 and the reinforcement is planetary ball milled WC-Co in cermet form with a particle size range of 30-40 μm. Liquid metallurgy was used to develop Al7075 composites containing 6, 9, and 12 wt.% of WC-Co. The tests were carried out on Al7075 and composites in accordance with ASTM specifications. According to the experimental results, the hardness of Al7075-WC-Co composites is discovered to be raised by increasing the volume percentage of cermet phase. The wear attributes of the WC-Co containing composite were superior in terms of wear resistance. The manufactured composites were studied using scanning electron microscope and energy dispersive microscopy images before and after the wear morphology during the wear test.

Key Words: Aluminium, tungsten carbide, metal matrix composites, hardness, wear.

ITRS147
Analysis of Optimized parameters of HVOF spray coating by Taguchi Method and ANOVA analysis in coatings

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Abstract: The effective coatings using HVOF process depends upon several parameters which include oxygen flow rate, fuel rate, power feed rate, spray distance, etc. The influence of these parameters on the mechanical and tribological properties of the coatings has been studied by many researchers. The main aim of this work is to study the literature wherein the impact of different parameters on the tribological properties of the coatings have been studied. This work will bring forth the best possible combinations of the parameters for obtaining the enhanced results. Also the analysis of these parameters carried out in this work will depict the best possible parameters for enhancing the tribological properties of the coatings, which can help in achieving high quality and low cost coatings. Different optimization techniques have been used in this paper like Taguchi and ANOVA analysis for depicting this result. As Taguchi method involves reducing the variation in a process through robust design of experiments, our objective of attaining high quality coating is covered through it.

Keywords: HVOF, Taguchi Method, ANOVA, Coatings, optimization

ITRS148
Surface characterization and corrosion study of ZrSi(N,O) Nano Composite Coating on Ti6Al4V

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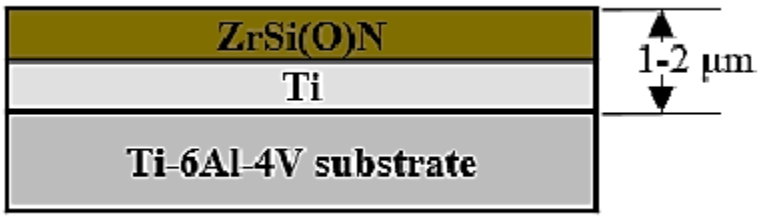
Abstract: Retrieval studies of the CoCrMo hip implant showed that, the corrosion happens at both tribological and non-tribological contacts [1]. Due to increased modularity, the contact area

of interfaces is prone to degrade by mechanically assisted corrosion and fretting corrosion [2]. Further, the release of toxic metallic and polymeric particle causes Adverse Local Tissue Reaction (ALTR) and leads to total hip implant failure due to combined effect of corrosion and aseptic loosening [3]. Therefore, it is necessary to explore new tribo-pair with good mechanical properties and corrosion resistance. Ti6Al4V alloy is being investigated for major interfaces in modular hip implant [2] due to good corrosion resistance compared to CoCrMo. However, it is prone to corrosion due to the rupture of TiO2 passive layer. This issue can be resolved by depositing hard PVD coating over Ti6Al4V with good surface characteristics and superior corrosion resistance. Silicon and zirconium nitride coatings provide higher stability in corrosive environment and improves grain refinement, friction and wear performance [4]. Thin transition metal oxynitride coating showed superior wear and corrosion resistance due to the presence of oxide and nitride mixture [5]. Therefore, the present study assesses the corrosion performance of the ZrSi(N,O) oxynitride coating. The proposed nano composite oxynitride coating along with Ti interlayer is shown in figure 1. The fabricated coating will be characterized for adhesion strength, hardness and roughness using scratch test, micro-Vickers hardness tester and AFM techniques respectively. Phase analysis and surface morphology are evaluated by XRD and FESEM respectively. Finally, the corrosion performance of the coating is assessed by electrochemical test (OCP, Polarization). In post-test analysis the tested samples are investigated for the change in surface morphology using SEM and EDS.

Keywords: Corrosion, Hip implant, Nano composite coating, Ti6Al4V, wear.

Figure 1. ZrSi(N,O) Nano composite coating



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ITRS149
Lubricant performance against white etching area formation in bearing steel under impact sliding loading

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Abstract: Premature bearing failures are commonly occurring in applications that involve tribological elements to operate under severe conditions. The lubrication engineers and tribologists are confronting a key challenge on these bearing failures associated with microstructure decay of microstructure: i.e., White Etching Cracks (WECs) and White Etching Areas (WEAs). Lubricant degradation is one of the critical factors for the subsurface decay in the bearing steel. This work aims to investigate the performance of mineral oil (heavy paraffin oil) and synthetic oil (Poly Alkylene Glycol: PAG) against WEA formation under pure sliding with impact loading. Using the dynamic load Pin-on-Disc (PoD) tribometer, the experiments were conducted at two different contact pressures, 1.45 and 2.03 GPa, with a sliding speed of 0.2 m/s and 270 loading cycles per minute. The WEAs evolution behaviour PAG and paraffin oil were studied in detail using various metallographic inspection techniques. Evaluation and analysis of the lubricants were carried out using Infrared Fourier Transform (FTIR) and Electron Spin Resonance (ESR) spectroscopy. This study found that WEA formation in the bearing steel was delayed in the PAG tested samples compared to paraffin oil. Lubricant analysis outcomes reveal that the free radical formation rate was less for PAG than paraffin.
Keywords: bearing steel, degradation, free radicals, lubricants, white etching area

ITRS150
Tribo-corrosion investigation on ultrafine grained laminates of Ti fabricated using LSEM

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Abstract: Titanium is most sough of metal in the aviation field. Commonly used applications for different Ti alloys includes body of aircraft and other structural components. In addition, Ti laminates are finding their wide use in making stacked composites these days. The main aim of the present research seeks to manufacture the laminates of Titanium (Ti) by a single stage deformation process known as the Large Strain Extrusion Machining (LSEM) process. Material used for the investigation was Commercial Pure Titanium (CP Ti). After the formation of the Ti laminates, mechanical and microstructural characterization was done to examine the effect of strain rate on fabricated laminates. Hardness of fabricated laminates was examined through Vickers microhardness tester. From the hardness measurement results, it was found out that the hardness values in laminates was higher than the parent metal, and the maximum increase in the hardness value at the optimal condition is observed to be ~51%. The surface roughness was analysed through surface roughness tester. The roughness analysis revealed that the roughness

value is reduced with increase in strain rate. Moreover, after reaching a minimum value at optimal condition, it further start increasing. Corrosion testing was done to check the corrosion rate of fabricated laminates by the Gamry corrosion tester. Surface roughness topography, wear and corrosion effects on fabricated laminates are analysed by Scanning Electron Microscopy (SEM). Lesser corrosion rate was observed in laminates with smooth surface having lesser roughness values. Furthermore, sliding wear behaviour analysis of fabricated laminates shows an improved wear performance in comparison to parent material.

Keywords: Titanium, Hardness, Surface Texture, Corrosion, Wear

ITRS152

Effect of room and high temperature on dry sliding wear characteristics of stir casted LM13/B_4C composites and LM13/ilmenite composites

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Abstract: The wear properties of LM13 alloy composites were studied by using the B_4C and ilmenite as reinforcement. Different weight percentage of both the reinforcement (i.e. 5 wt.%, 10 wt.%, and 15 wt.%) were added in the LM13 alloy by using the stir casting process. The comparison of B_4C reinforced LM13 alloy (LB composites) and ilmenite reinforced LM13 alloy (LI composites) were done on the basis of interfacial bonding, refinement and morphology of eutectic silicon, friction and wear behaviour (at room and high temperature conditions). Microstructural analysis revealed the uniform distribution of ceramic particles in the LM13 alloy at any reinforcement level. Further, a significant reduction in grain size and change in morphology from flake to globular was obtained for LB composites. XRD analysis of composite revealed formation of secondary phases due to interfacial reaction was made by ilmenite particles with matrix. Moreover, high hardness, lower wear rate (at room and high temperature) and high COF value was shown by LB composites. The decrease in COF (at room and high temperature) for LI composites corresponds to the lubricant effect shown by ilmenite particles. Further, a transition temperature was observed for base alloy, LI composites and LB composites. The addition of B_4C and ilmenite increased the transition temperature of base alloy from 150 ℃ to 200 ℃. At room temperature, wear track and debris show a change in wear mechanism from abrasive to delamination wear with increase in load from 10 N to 50 N, respectively. However, at high temperature condition, these mechanisms were combined with oxidation wear.
Keywords: High temperature properties, wear property, hardness, aluminium matrix composites, ceramic particles

ITRS154

Nano-indentation of Highly Crosslinked Polymer Networks: A Molecular Dynamics Simulation Study

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Abstract: Polymers have been around since the early start of life in the form of natural rubber, starch, and cellulose. Polymers are commonly used as advanced materials to mimic the lubrication and confinement mechanics of biological materials. The main groups of soft bio-materials include cartilage (healthy or diseased), the cornea, tendons, and the liver. An in-depth understanding of mechanics of soft materials is crucial for designing synthetic replacements for cartilage, contact-lens materials, or soft coatings for medical devices. The nano-mechanics during the indentation test of Highly Crosslinked Polymer (HCP) is a less explored area of mechanics. In this work, we study nano-indentation using the molecular dynamics simulations to investigate the mechanical behavior of the HCP network as a function of the degree of crosslinking, strain rate and indenter-geometry. Force-against-depth plots will be plotted for each of the above mentioned cases. We have modeled polymer networks using the generic bead-spring approach and considered the breakable quartic bonds in our study rather than the usual FENE bonds.

Keywords: Cross linking, Force-against-depth, HCP, Hardness, Indentation, MD Simulation.

ITRS155
Significance of biotribology in advanced biomedical applications: A Review

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Abstract: Medical devices such as implants, prosthetics etc. are becoming a great tool in modern day science to aid people suffering from any type of physical disability either by birth or accidental. Generally, medical devices are made up of biomaterials and operate in an environment where there is continuous interaction between devices surface and human body (internal/external) parts is present. Thus, making friction, wear, lubrication and all other tribological factors an important aspect. As these factors does not only affect the function and performance of medical devices but also the potential health and recovery of the surrounding natural tissues. Biotribological studies are combined with clinical studies to improve medical devices performance, biocompatibility and to avoid possible causes of failure such as deterioration, implant loosening, post-surgical infections etc. So, study of biotribology of the medical devices has become an important criteria for their design and development. These key factors are believed to be directly linked to their overall success of any medical device in the market. Thus, in recent times many researchers have shown keen interests in exploring various aspects of biotribology of medical devices. In this light, this review article tries to cover the major recent advancement in the field of medical devices considering biotribology as primary point of view.

Keywords: Biotribology, Implants, Prosthesis, Medical devices, Biomaterials, Joint replacement etc.

ITRS156
Effect of ECAP on structural and wear properties of pure Cu

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Abstract: The objective of this paper is to convey the significance of multi pass equal channel angular pressing (ECAP) in the formation of ultra-fine grains and its effect on mechanical and wear properties of commercially available Cu. The work material of length 100 mm and 16mm X 16 mm square billets after annealing at 530^0 for 1 hour are pressed through a specially designed die having square channels of 16mm X 16mm with channel angle of 105 and the outer corner radius of 6mm in routes B_C and C. The effect of ECAP has been investigated on microhardness and wear rate of the feedstock processed for 10 passes (N) in B_C and C routes. It is observed that the more refinement of grain size in extruded samples using Field emission - scanning electron microscope. The obtained mechanical properties such as micro-hardness clearly supporting the existing literature as the formation of ultra-fine grain structure in the processed material according to hall-petch equation. We also investigated the wear behaviour of ECAPed samples under different loads and the reduction in wear rate is observed as the number of passes increases in both the routes. The results practically implicated that the significance of ECAP is more on microstructure and mechanical properties of the processed materials as compared to unprocessed samples.

Keywords: SPD, ECAP, Linear intercept distance, microhardness, wear

ITRS158
Wire Electrical Discharge Machining of SiC Reinforced Magnesium matrix composite produced by powder metallurgy route

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Abstract: The demand for the composite materials are increasing in industry due to their improved mechanical properties. The present research work aims to study the machining behaviour of the magnesium matrix composites (MMC) reinforced by silicon carbide (SiC). Wire cut Electrical Discharge Machining (WEDM) is widely used in the die-making and tool-making industries, aerospace, aeronautics and nuclear industries. In this work, machining characteristics of the Magnesium-Silicon carbide composites were examined using WEDM. A zinc coated brass wire electrode was used to carry out WEDM on the produced composite. The parameters pulse current, pulse on-time and pulse off-time were used as input parameters, while surface roughness (SR) was used as a performance metric for the machining process. For the newly developed magnesium metal matrix composite, this paper examines how the WEDM parameter impacts surface roughness (Ra).

Keywords: Composite, Magnesium, Silicon carbide, Powder metallurgy, Machining.

ITRS159
Tribological performance comparison between biogrease and mineral grease lubricant with nanoparticle additives: A review

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Abstract: The harmful environmental effect of the widespread use of mineral oil as commercial greases has been raising concerns in the community. Many had reported on the benefit of mineral grease, however the toxicity and an increase of cost of mineral grease had led to the interest in developing sustainable and environmentally friendly grease lubricants. Biogreases is the alternative of lubricant that is biodegradable and harmless to humans and the environment. There is an increase in demand for biodegradable lubricants especially in agriculture and open machinery where the lubricant is highly exposed to labour and environment, and the waste is prone to be discharged into the environment and subsequently cause pollution. Biogrease from the vegetable oil-based is a great substitute to mineral-based lubricant as it has better physical properties such as high lubricity and high flash points. Many had reported the uses of nanoparticles as an additive in lubricant due to wear resistance properties and reducing the coefficient of friction. The nanoparticles have a unique mechanism to enhance the tribological properties of vegetable grease such as surface mending, load bearing and forming a nanoparticle protective film between the contact surfaces. This article provides an overview of the tribological performance of several nanoparticle additives used in bio and mineral grease. In addition, suggestions are proposed for future improvement of biogrease.

Keywords: Bio lubricant, Grease, Nanoparticle, Nanolubricants, Tribological performance

ITRS161
Experimental Investigation on the performance of phosphonium phosphinate ionic liquid against scuffing

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Abstract: Scuffing is surface damage in a dynamic tribological contact caused by the shearing of welded metallic junctions when the lubricant separating the surfaces fails. It is usually accompanied by dramatic friction increase and rapid temperature rise that accelerates lubricant film breakdown. The contact and rubbing of the scuffed surfaces may cause vibration and noise, or even seizure of the interface.
Investigations on the potential use of ionic liquids (ILs) as additives in lubricants have increased in the recent past. Ionic liquids are proven to form thick and smooth tribofilm and more effective than conventional additives in severe boundary conditions. In this study, it is aimed to understand the effect of Trihexyltetradecyl phosphonium bis (2,4,4-trimethylpentyl) phosphinate ionic liquid as an additive in synthetic base oil PAO for the scuffing aspect.
Researchers are working on new materials with better tribological performance which can be used in severe conditions. The performance of ionic liquids with different materials is a very less explored area. In this work, balls made of different materials such as AISI 52100 bearing steel, alumina, and zirconia are rubbed against AISI 52100 steel to understand their scuffing performance. The effect of ionic liquid additive on these materials is compared with the effect of traditional additives such as ZDDP using a linear reciprocating tribometer. Friction and wear studies along with film formation is evaluated using post–test analysis methods like SEM, EDS, optical profilometer and FTIR.

Key words: Ionic liquid, scuffing, reciprocating tribometer, additives, ceramic

ITRS162

Revealing the nanoscale wear behavior of interior and edge of CVD grown monolayer MoS2 flake

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Abstract: Bulk solid lubricants are considered to reduce friction and wear at macroscale; however, their application is limited at small-scale. Evolution of two-dimensional (2D) materials has brought a new range of solid lubricants for the micro and nano scale applications. In this study, nanoscale wear behavior of chemical vapor deposition (CVD) grown molybdenum disulfide (MoS2) was systematically evaluated using atomic force microscopy (AFM). Experiments were performed at very loads in a controlled manner in the interior and at the edge of a monolayer MoS2 flake using a diamond-like-carbon (DLC) coated silicon AFM probe. The

critical load to initiate wear in the interior region of MoS2 flake was found to be significantly higher than the edge. The observed difference in the wear behavior can be attributed to the presence of structural defects.

Keywords: MoS2, Solid lubricant, 2D materials, Tribology, Atomic force microscopy

ITRS164

Magnetorheological Fine Finishing of Spline Shaft Surfaces forImproved Performance

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Abstract: The pressure distribution on the spline shaft surface influences the life span during their functional application. The uniform fine finishing on the teeth surfaces of the spline shaft is of great advantage for uniform pressure distribution. This helps to overcome the stress localization that typically decreases the wear rate and improves the spline shaft's life span. In this work, fine finishing of the spline shafts surface is done using a novel magnetorheological (MR) method. A single electromagnetic based MR finishing setup is used to finish both the external and internal profile surfaces of the spline shaft with two different detachable finishing tool cores. Further, the response surface methodology is used to achieve the optimum process parameters for fine finishing of the spline shaft surfaces. From the initial value of 0.27 μm and 0.3 μm, the surface roughness value of the overall external and internal profile surfaces of the spline shaft is reduced to 0.02 μm and 0.029 μm respectively. Further to analyse the efficacy of the present process, surface characteristics, and microhardness tests are conducted over the spline shaft. Also, the wear rare of the spline shaft is analysed in terms of the hardness. The result shows the present MR finishing process tends to improve the pressure distribution, and service life of the spline shaft.

Keywords: Magnetorheological finishing; spline shaft; process mechanism; microhardness; magnetic field; surface roughness.

ITRS168

Stability analysis of Finite Textured Journal Bearing with the Effect of Lubricant Slippage

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Abstract: Recent studies shows that the presence of non-wettable effect on the selected areas of journal bearing surface are effective in improving its load carrying capacity and its coefficient of

friction. It has been observed that when the lubricant is passing from the interface of non-wettable and wettable region then due to change in boundary condition from slip to no-slip at this location, the significant improvement in lubricant pressure is achieved. In the present work, the influence of this wettability gradient on the dynamic characteristics of partial and fully textured journal bearings has been investigated. The modified Reynold equation with considering the couple effect of non-wettability and variation in viscosity by rise in temperature has been solved for knowing the lubricant pressure in journal bearings. Further, the linearized equation of motion with assuming free vibration mode has been solved for calculating the dynamic stiffness and damping coefficient. The dynamic analysis of rigid rotor/journal -bearing system shows that the partial textured bearing with non-wettability effect up to the location of minimum-lubricant film thickness has been effective in improving the direct stiffness coefficient. Whereas, the direct and cross damping coefficients of bearing are showing opposite effect with the lubricant slippage on textured bearings. However, Slip boundary condition is not efficient on the full textured bearing surfaces.

Keywords: Elrod Cavitation Algorithm, Stiffness Coefficient, Damping Coefficient, Cylindrical Textures, Slip.

ITRS169

Dry Sliding Tribological Behavior of Aluminium based Silicon Carbide Metal Matrix Composite (Al-SiCp) for high temperature applications

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Abstract: A review from past few years, material analysis and development has been shifted towards composite materials, as a result of highest strength to weight and stiffness to weight ratios In present work the tribological performance of aluminium based silicon carbide metal matrix at elevated temperature condition were studied. Recently a new trend is to use metal matrix composite brake pad materials that provides additional economical advantages. To develop brake pad material for the fulfillment of demand several factors are taken like stable coefficient of friction, lower wear rate at different operating speed, contact pressure, temperature etc. The LM-25-SiC Composite were developed by stir casting method by addition of reinforcing particles SiC with varying weight percentage with base aluminium. Samples were tested on pin on disc tester at elevated condition for friction and wear analysis for different load and sliding distance In the existing analysis work an effort has been taken to pick a suitable material that removes limitations occurred in brake pad application. the current investigation has been done to review the impact of various input process parameters specifically weight percentage of silicon carbide, Normal pressure and sliding speed or sliding distance and temperature on the

tribological properties Also the attempt has been created to examine the wear rate of specimen at elevated t temperature. DOE is employed for optimization of process parameters

Keywords: Aluminium alloy, Coefficient of friction, Stir Casting, Taguchi technique, Taguchi Design

ITRS170
Thermal Analysis of Textured Parallel Plate Bearings with Controlled Slip/No-Slip Boundary Condition

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Abstract: In micro-scale channels, a thin layer of low surface energy coated materials is effective in updating the boundary condition at the liquid-solid interface. Recent experimental investigation indicates that these low surface energy coatings are oleophobic in nature and shows slip boundary condition at the contact point of liquid and solid. Previous studies shows that this effect of liquid slippage is highly efficient in improving the tribological performance of hydrodynamically lubricated conformal contacts bearings. The last two decades of experimental and numerical studies shows that the presence of micro-scale regular textures on hydrodynamic lubricated conformal contact bearings are also helpful in overcoming its tribological challenges. Therefore, In the present work, the static performance characteristics of parallel plate bearing with considering the combined effect of chevron shape texture and slip boundary condition has been investigated. Both modified Reynold and energy equation has been solved for knowing the variation in lubricant pressure with effect of liquid slippage on the textured bearings. To accurately consider the effect of micro-cavitation with textures, the Reynold equation is further updated by using the Elrod cavitation algorithm. It has been observed that with combine slip and texturing, as the dimensionless texture depth increases up to 0.2, the tribological performance of parallel plate bearing are increases.

Keyword: Chevron Texture, Oleophobic Coatings, Parallel Plate Bearing, Micro-Cavitation, Load-Carrying Capacity

ITRS171
A Theoretical Study of Friction by Tribotronics and controlling the friction with ionic lubricant additive and external electric field

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Abstract: Tribology is the study of interacting surfaces in relative motion. This theory discusses about the electric or magnetic field interaction between those surfaces relative to each other.cFriction can be easily defined now-a-days with the lubricants but the lubricants have to be monitored periodically which is not a big advantage. Controlling and tuning the friction of fluids is a hot topic in current scenario which can be done by adding ionic additives and controlling them by external electric or magnetic field. This leads us to a brand new topic of study in tribology that is “tribotronics”. External application of electric or magnetic fields, achieve “active” or “smart” control of friction at a molecular level in this field that is known as

"tribotronics". In this topic, the friction subjected materials can be controlled by adjusting at molecular levels. For an instance, a lubricant mixed with silica and alumina nanoparticles additive can be controlled by electric field gives the output of controlled co-efficient of friction. The friction co-efficient can be increased or reduced as per the requirement. Specifically, A electric field of 100 N/C is applied to a lubricant mixture having negatively charged TiO2 with 40 nm diameter and positively charged Al2O3 with 30 nm diameter forms electrophoretic forces in that lubricant mixture which is useful in controlling and tuning the lubricant. In this ionic lubricant, the surface performance between the relative motions is theoretically an atomic smooth surface by non-equilibrium molecular dynamics but experimentally surfaces were rough. This is a future development which can be achieved by designing custom atomic scale of ionic lubricant system.

Keywords: Tribology, Tribotronics, Nanoparticles, Electrophoretic forces, Friction co-efficient

ITRS172
Review on Optimization Techniques of Brake Friction Composite

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Abstract: This review paper aims at collecting all the information needed for the researchers regarding the optimization techniques of the brake friction composites. Optimization techniques, involving formulation and processing, are the analytical methods which are used to find out the most suitable parameters for efficient working of brakes. It involves the complex analyses of different variables and parameters generated during the testing phase. As we know brake pad is one of the critical components of the car and if not working properly, it can risk the passenger's lives. Hence it designed to give good mechanical strengths, wear-abrasion resistance, low density, squeal reduction, constant C.O.F and high temperature performance even under extreme environmental conditions. Therefore, in order to achieve maximum performance of the brake friction composites, the optimization of the given parameters is necessary. Different optimization techniques discussed are used for different purposes like Grey Relational Analysis is used for process parameter optimization, Artificial Neural Network and Taguchi's Method (consisting of orthogonal arrays thereby reducing the number of experimental configuration) for formulation adjustments, Genetic Algorithm (gives value of design parameters from optimized model) and Response Surface Methodology and Complex Eigen Value Analysis (used to check stability of the system) were used for optimization of brake squeal reduction, Signal to Noise Ratio is a component of parameter design used to determine robustness, CATIA, ANSYS & SolidWorks were used as design and analysis tool for mass, volume, stress & strain parameters optimization of brake pads, Analyses of Variances and Multiple Regression Analyses were used to analyse the results, Relational Grade Analyses and Golden Selection Approach for selection of optimum materials, Finite Element Method to create optimum model and to perform various thermo-mechanical analyses over it and VIKOR (multi criteria decision making technique) for selection of optimum friction composite .Therefore, one such approach to discuss the various optimization techniques of the brake friction composites that already have been used by the researchers to get

the optimum results is described in this paper.

Keywords: Brake Pads; ANOVA; Optimization; Taguchi Method; FEM; VIKOR

ITRS176
Anti-friction lubricant for damping and sealing on solenoid armature

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Abstract: Molykote coating on solenoid armature is to act as anti-friction lubricant that is used for damping and sealing. In solenoids, the armature is movable: therefore, as voltage is passed through the coils, the armature moves to increase the flux linkage. It does this by closing the gap of air between the two cores. Hence it is recommended for a dry lubrication. Molykote coating is generally different from the other coating process since it comes under special process with the special application. Moreover, normal coating process doesn't really bother much about the roughness values. However, the requirement on Solenoid armature is much different than that of other application because of roughness value to be maintained. Meantime, there is a requirement as only specific portion of the component to be coated that leads to masking of the part before coating. There are many variables which may really influence the roughness values that impact the coating thickness as well. In order to meet the roughness requirement of the component, there are different trails carried out to evaluate the options related to the base preparations of surface, masking and coating parameters. The input parameters include the pressure of the molykote, the viscosity setup time, process time in base preparation and the roughness of input component (R_z). Taguchi L27 array with three levels and four parameters is selected to identify the optimum input parameters to get the required coating thickness and the roughness values.

Keywords: Molykote, coating thickness, roughness, viscosity, solenoid

ITRS177
A Model for Static Friction of a Soft and Hard Solid Interface

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Abstract: Prediction of static friction of sliding surfaces is of both fundamental and practical importance. In this article, we present a friction model to predict static stress at a soft and hard solid interface. Unlike the friction model of Singh and Juvekar (2021), the proposed model takes

into account the age of the bonds, which form during application of shear rate on the sliding mass. The model is, in turn, validated with static friction of wet granular layers on a smooth rock surface. Scaling laws of the friction parameters are also obtained by regression analysis of static stress vs. time experimental data with the friction model to justify the present observations.
Keywords: Soft solid; Static friction; Friction model

ITRS178
Effect of Titanium Nitride particles on wear behaviour of Mg ZK60A alloy composites processed by P/M route

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Abstract: This research work focuses on the effect of titanium nitride (TiN) ceramic reinforcement on the wear characteristics of Mg ZK60A composite produced by powder metallurgy (P/M) route. A pin-on-disc wear testing machine was used to conduct the dry sliding wear test for the developed composites by the load of 20 to 80 N at different sliding velocities in the range of 2 to 4 m/s. The wear resistance of proposed composites were better than those of base matrix alloy under several test conditions. For the load range of 40N, at a sliding velocity of 2m/s with 4wt.% of reinforcement addition shows drastic reduction in wear rate to that of unreinforced alloy. Substantial anti-wear ability was observed with increase in Titanium nitride content from 4wt.% to 12wt.% of magnesium alloy composite and the wear rate was found to decrease considerably. At a sliding velocity of 2m/s and load of 80N, the wear rate was reduced from 11.6 mm^3/km to 8.1 mm^3/km upon increase in reinforcement content from 8wt.% to 12wt.%. However, an increase in wear rate with increase in sliding velocity and increase in load was observed in both unreinforced alloy and reinforced composites. The worn surface morphology of composites were examined using scanning electron microscope (SEM). It was clearly revealed that an increase in load changes the wear mechanism from abrasion to particle cracking induced delamination.

Keywords: Magnesium alloy, TiN, Composites, Powder metallurgy route, Pin-on-disc, wear.

ITRS180
Abrasive Tribo Behavior Assessment of Abaca Natural Fiber Composite

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Abstract: Scientific development indulges in successive development and finding of new

materials. Abaca fiber is such high strength natural fiber whose potential in the field of tribology is not explored till date. This fiber is naturally associated with a very high rough surfaces, adequate carbon and high cellulose percentage. That makes it suitable for reinforcement in polymer composite. This study involves the fabrication of Abaca woven fiber reinforced epoxy composite. Composite is fabricated with abaca fiber (A), glass fiber (G) and epoxy matrix in a sequence of AAAA, AGAG and neat epoxy. Tribological behavior is carried out on a pin-on-disc test rig as per ASTM G99 standard. A rectangular block specimen is used as pin having the exposer of all layers of fiber. Abrasive wear behavior has been examined by height loss method with 1 m/s, 2 m/s and 3 m/s sliding velocities on load cell of 10 KN, 20 KN and 30 KN. Sliding distance maintained as 3000 m throughout the test. The study reveals AGAG hybrid composite sequence showing the highest abrasive wear resistance. Scanning electron microscopy (SEM) is used for the determination of the failure mechanism of abrasive surfaces of the composite.

Keywords: Composite, Abrasive wear, Abaca natural fiber, Glass fiber, SEM

ITRS181

Abrasive Tribo Behavior Assessment of Abaca Natural Fiber Composite

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Abstract: Scientific development indulges in successive development and finding of new materials. Abaca fiber is such high strength natural fiber whose potential in the field of tribology is not explored till date. This fiber is naturally associated with a very high rough surfaces, adequate carbon and high cellulose percentage. That makes it suitable for reinforcement in polymer composite. This study involves the fabrication of Abaca woven fiber reinforced epoxy composite. Composite is fabricated with abaca fiber (A), glass fiber (G) and epoxy matrix in a sequence of AAAA, AGAG and neat epoxy. Tribological behavior is carried out on a pin-on-disc test rig as per ASTM G99 standard. A rectangular block specimen is used as pin having the exposer of all layers of fiber. Abrasive wear behavior has been examined by height loss method with 1 m/s, 2 m/s and 3 m/s sliding velocities on load cell of 10 KN, 20 KN and 30 KN. Sliding distance maintained as 3000 m throughout the test. The study reveals AGAG hybrid composite sequence showing the highest abrasive wear resistance. Scanning electron microscopy (SEM) is used for the determination of the failure mechanism of abrasive surfaces of the composite.

Keywords: Composite, Abrasive wear, Abaca natural fiber, Glass fiber, SEM

ITRS184

Influence of process variables on tensile behaviour of 316l stainless steel samples fabricated via selective laser melting process

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Abstract: Selective laser melting (SLM) is one of the promising method of additive manufacturing which has the benefits of design flexibility and customization. These features make it suitable for biomedical and aerospace applications. In this work, the tensile behavior of 316l stainless steel samples has been studied using the varying process variables (laser power, scan speed and hatch spacing). Laser power of 250 to 350W, a scan speed of 900 to 1100mm/ s, and hatch spacing of 80 to 100 μm are considered while the layer thickness of 60 μm and stripe scan strategy kept constant for all nine experimental runs. The tension test was performed at 2mm/min crosshead speed. Fractographic analysis has been done to check the microstructure, pore morphology and mechanical properties. The parameters are optimized by Taguchi design and results are validated by analysis of variance. High laser power, low scan speed, and hatch spacing produce the highest ultimate tensile strength. The findings suggest that further parameters should be explored in order to better understand SLM physical metallurgy.

Keywords: Selective melting process, 316l stainless steel, process variable, tensile behaviour, fractrography analysis

ITRS185
Tribological assessment of 316l stainless steel fabricated by selective laser melting process

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Abstract: Selective laser melting (SLM) is one of the widely used process based on the melting of powder material through a high laser beam. In SLM, process parameters have a major influence on the microstructure texture and mechanical properties. In this work, a comprehensive study has been done to assess the tribological behavior and microstructure of 316l stainless steel samples by considering a combination of different process variables such as laser power, scan speed and hatch spacing. The wear test was performed according to the ASTM G99 test standard on the dry sliding wear testing machine while keeping the wear machine parameters (load, speed, wear track diameter and time) fixed for the all samples. Taguchi statistical design of experiment was used to optimize the selected parameters and validated by Analysis of variance (ANOVA) to develop a linear correlation between the selected parameters. Density was estimated using the Archimedes method. As a result, scanning electron microscope analysis shows the columnar and cellular microstructure of samples before the test as well as shallow ploughing groove, delamination and cracks observed in worn-out samples after the test. This paper presented with the display of results, discussion, and conclusions drawn.

Keywords: Selective laser melting, 316l stainless steel, microstructure analysis, tribological behaviour, optimization

ITRS190

Swirling jet erosive wear progression on AISI 310 stainless steel at 400 ° C

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Abstract: In this work, the progression of wear of AISI 310 stainless steel subjected to erosion by solid particles was characterized using impinging swirling jets at room temperature and 400 °C. Three angles of incidence were tested 90 °, 60 ° and 30 ° with an average speed of 60 m/s. Silicon Carbide (SiC) abrasive particles with an average size of 300 μm were used. The maximum exposure time was 4000 seconds. The results showed that the incubation period is repetitive since the constant flow of abrasive on the sample generates progressive wear, where the primary impacts generated plastic deformation on the surface and the secondary impacts detachment of the deformed material. This repetitive process promotes periods of stagnation during the progressive erosive wear process. The wear rate in swirling conditions is low compared to the non-swirling condition. However, the erosion wear rate showed similar trend in both cases, exhibiting a ductile behavior at both temperatures.

Keywords: Swirling jet flow, erosion, wear mechanisms, solid particle, high temperature.

ITRS195

Duplex treatment, as an effective tool in improving the adhesion and wear behaviour of DLC and CrN hard ceramic coatings deposited on automotive tool steel.

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Abstract: Duplex surface treatment can be any heat treatment method combining two or more different surface technologies to build a two or multi-layer composite surface structure on any substrate material with the purpose of improving the loadability and durability of the component surface not achievable by neither individual processes alone. It is a combination of surface modification and surface coating. Surface coatings prepared by physical vapour deposition (PVD) or plasma enhanced chemical vapour deposition (PECVD) technique have been successfully used in mechanical engineering industries. They have proved beneficial in increasing the productive service life of the components. Diamond-like carbon (DLC) and Chromium nitride (CrN) coatings are extensively used in industrial applications owing to their excellent adhesion, low friction coefficient, wear resistance and corrosion resistance. In the present work our aim is to characterize the frictional and wear behaviour of the two hard ceramic coatings deposited on X42Cr13/W (DIN 1.2083) plastic mould tool steel. Two different surface conditions are examined: first after the bulk heat treatment i.e. precipitation hardening and tempering sample S1 is plasma nitrided and thereafter coated and second S2 simply coated

without nitriding. The hardness is determined using the micro-Vickers test (HV0.05). Instrumented scratch test (SP15) is used to evaluate the adhesion between the coating and substrate. Friction and wear resistance of the coatings is evaluated by a ball-on-disk test (UNMT-CETR). The damage modes during scratching and failures during wear test are presented by optical microscopic images. Surface profilometry measurements on each wear tracks gives information about the volume of material loss, which helps in determining the wear rate. The research work successfully demonstrates the beneficial effect of duplex treatment on the scratch and wear resistance of the two ceramic coatings.

Keywords: Duplex treatment, scratch test, adhesion, wear test, optical microscopy.

ITRS198

Surface Engineering of Ti6Al4V Alloy for Tribological Applications: A Review

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Abstract: Ti6Al4V, regarded as the 'all purpose' titanium alloy, has been used extensively in aerospace, marine, and chemical industries. It has also found significant roles in biomedical applications because of its unique properties, viz. high strength, excellent corrosion resistance, and good biocompatibility. Nonetheless, overcoming the tribological limitations of Ti6Al4V is a timely task, which presents a major theoretical and practical challenge. Especially in sliding contact, poor tribological properties of the alloy present themselves in the form of high and unstable friction coefficients, severe adhesive wear, susceptibility to fretting wear, and a solid tendency to seize. The poor tribological behaviour of Ti6Al4V is related to its inherent characteristics, especially the surface nature. Presumably, a potential solution is to modify or change the features and response of the surface through surface engineering (surface treatment/modification), which provides the most promising way to improve its tribological performance. Hence, this manuscript critically reviews the competency of the various surface treatment and surface modification techniques used to enhance the tribological performance of the Ti-6Al-4V alloy. Detailed discussions on distinct surface treatment/modification techniques, viz. thermal oxidation, gas nitriding, surface severe plastic deformation methods, ultrasonic nanocrystal surface modification, plasma electrolytic oxidation, heat treatment, solution treatment, annealing treatment, electrical discharge machining, plasma spray technology, chemical vapor deposition, and sol-gel process forms a significant part of this work. These surface modification processes evidently can modify the surface and properties of Ti6Al4V. Finally, superior improvements in surface roughness, wear resistance, corrosion resistance, mechanical properties, metallurgical, and tribological competency are achievable through proper selection and monitoring of control parameters of the various surface modification processes.

Keywords: Ti6Al4V, Surface Modification, Friction, Wear.

ITRS199

DRY SLIDING WEAR BEHAVIOUR OF AA6082 REINFORCED WITH SIC PARTICLES THROUGH EX-SITU CASTING TECHNIQUES

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Abstract: Aluminum alloys were widely used in the automotive industries because of their light weight, low cost, corrosion resistance, ductility and strength. AA 6082 is a family of aluminium having moderate strength, good wear, corrosion resistance and excellent machining performance. AA 6082 alloys were used in the structural and transport applications where high stress resistance is required. In the high stress resistance applications, the available strength is not sufficient. To enhance the required mechanical properties in the alloys for the fabrication of structural and transportation applications, carbides / oxides were added commonly with the base metal. In this paper, AA6082 MMC is manufactured through an ex-situ casting process with the Silicon Carbide (SiC) reinforcement of 2.5 & 5 wt%. The dry sliding wear behaviour, microstructure, and hardness of the MMC has been investigated. In the microstructural characterization, as MMC showed uniform particle distribution of the matrix and SiC materials. The uniform particle distribution of SiC in the casted MMC evidence the enhancement of the particulate-matrix bonding and higher strength. The hardness of the tested bar of AA6082 sample was found to be 85 HV which has been increased to 97 HV and 112 HV with the dispersion of 2.5% and 5% SiC respectively. The pin-on-disc test was carried out to test and analyse sliding wear characteristics of the MMC considering the sliding velocity, load and temperatures as variable. The results of wear rate, coefficient of friction and wear debris were studied and analysed on the MMCs in respect of variation in the input parameters within the range considered. The results of abrasive wear tests on the MMCs showed that the wear loss of MMCs with 5% SiC was decreased by 10% compared to the bare AA8082 samples.

Keywords: MMC, SiC, Dry sliding wear, Frictional coefficient, wear rate.

ITRS200
Numerical Simulation of Erosive Wear

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Abstract: The aim of this work is to obtain the correlation between experimental erosion results and numerical results from tools of Computational Fluid Dynamics (CFD). A commercial software is used to predict erosive wear, to obtain an integral evaluation and deep knowledge of the phenomenon. The reference experimental work consists of two parts: The former comprises a solid particle erosion study where the angle of impact is varied at 30°, 45°, 60° and 90° and a slurry erosion study at 90° impact. The studies were carried out in a jet impingement test rig. Thus, all impact conditions and types of erosion were simulated in a transient state with discretization. According to the results, it was found a good consistency with the experimental radial velocity. Also, particle tracking in a one-way coupling has shown good physical sense, therefore the distribution of them, led to a good shape profile correlation with the current state of the art of erosion analysis based on CFD literature. Lastly, the erosion rates are calculated, and some erosion models are compared and finally is verified that numerical prediction of erosion wear shows a less relative error with the Oka's Model.

Keywords: Numerical simulation, Fluid erosion, solid particle, wear rate, impact angle.

ITRS201

Role of surface waviness on the performance of hydrodynamic journal bearing

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Abstract: Journal bearing performance can be improved by providing the waviness on the bearing liner surface. It has been observed that the plain circular bearing when operate under low load has unstable motion due to whirl action which effects the performance of bearing. The performance of journal bearing can be enhanced by providing the waviness on bearing liner in circumferential direction, axial direction or in both the directions. The effect of waviness can be studied by using the non-dimensional form of Reynolds equation and finite element method. Various wave profile i.e sinusoidal, saw-tooth wave etc can be provided on to inner liner of bearing surface. It has been observed that due to waviness the load-carrying capacity (LCC) of the bearing enhances and Coefficient of Friction (COF) decreases. Various studies had been conducted to analyze the influence of waviness in circumferential, axial and in both the directions of journal bearing and performance is calculated. It has been observed that the circumferential waviness on bearing liner will enhance the load carrying capacity (LCC), but has adverse effect on Coefficient of friction (COF). The number of circumferential waviness shall not be more than nine. Further it has been observed that waviness in axial direction does not much improve the performance of bearing as it has harmful effect on LCC and COF. By using combined waviness in circumferential and axial direction has great effect on LCC and COF and improve the performance of bearing only when waviness in circumferential direction is less than nine and waviness in axial direction is kept less than two. The various design parameters for surface waviness are wave amplitude of the wave, number of the waves and the position angle of the wave. By considering various geometrical shapes of waviness at various wavelengths the performance characteristics of the journal bearing can be analyzed.

Keywords: Waviness; Journal bearings; Load carrying capacity; Coefficient of friction; Finite element method.

ITRS202
Effect of Friction Modifiers Compositions on Tribological Properties of Al/Al_2O_3 Brake Composite Material

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Abstract: The braking system in automobile is very important part, which is used to stop the vehicle either by the application of mechanical or hydraulic in brake pads. Due to continue operation of engagement or disengagement of brake pads; the surfaces of brake materials are deteriorating after some times. This ultimately affects the performance of the brake system and ultimately led to catastrophic failure. Therefore, it is very important to develop a new composition of brake materials, which provides optimum coefficient of friction as per the industry standard (~ 0.3-0.45) [1] and high wear resistance property.
Hence, in this paper aluminium with silicon carbide as a base material, aluminium oxide as an abrasive material with varying volume percentage of fillers and friction modifiers have been used to formulate a new composition of brake material using powder metallurgy method.
The experiments are carried out using pin-on-disc (PoD) tribometer rig to investigate their frictional and wear behaviour the proposed novel composite brake material. The fabricated brake composites are used as pin, while commercially available grey cast iron (GCI) with Grade J431 as disc sample. Furthermore, surface morphology of fresh composites surface and worn-out composite surfaces are investigated using scanning electron microscope (SEM) followed by elemental analysis using electron dispersive spectroscopy (EDS). The mechanical and thermal stability tests are, also, performed to evaluate the hardness, elastic modulus, compressive strength and stability against the temperature.

Keywords: Brake Material, Aluminium Composite, h-Boron Nitride, Friction, Powder Metallurgy, Scanning Electron Microscope, Thermo-Gravimetric Analysis, Wear.

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ITRS203
Bio-tribological Performance of Heat Treated and DLC Coated Ti6Al4V forEdge and Average Loading Conditions of Hip Implant

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Abstract: DLC coating are being studied for various tribological applications such as piston-ring cylinder liner system, ball bearing components and other orthopedic research areas. Although, DLC coating shows significantly reduced frictional behavior, its wear resistance can be compromised due to the reduced adhesion strength at the coating interface. Such reductions are the result of high mismatch of the Youngs modulus (E) and hardness (H) values between coating and substrate [1]. Subsequently, the DLC coating, along with the interlayer, fails due to delamination under the lubricated interface.

The mismatch between DLC coating and substrate can be improvised using the incorporation of oxidizing or nitriding processes prior to the DLC deposition. Combination of plasma nitriding and coating showed beneficial effects in terms of adhesion and wear resistance due to hard nitride zone beneath PVD coating [2]. However, the process is complex and costly due to the involvement of vacuumized systems and sophisticated plasma generating technologies. On the other hand, the same effect of obtaining an underlying hard layer can be truly achieved using heat treatment process. This simple process prior to the DLC deposition can significantly improve the adhesion

strength. Further, oxide scale and the underlying diffusion layer formed during the heat treatment at 600 oC can be advantageous for gradual transition of Youngs modulus (E) and hardness (H) rather than the detrimental mismatch of E and H at the coating substrate interface. Therefore, this study aims to improve the adhesion strength and overall bio-tribological performance of DLC coatings over TI6Al4V surface with the incorporation of heat treatment process prior to the deposition. Ti6Al4V surface is heat treated at 600 oC for 48 hours inside muffle furnace under atmospheric condition. Further, the DLC coating is deposited over heat treated Ti6Al4V surface with a chromium interlayer under the heated environment. The coatings are characterized for roughness, hardness, adhesion strength and wettability. The tribological tests are performed under edge and average hip implant loading conditions to evaluate the frictional and wear behavior of these coatings. Post test analyses are carried out to analyze the worn-out surface morphology using

SEM and EDS.

Keywords: Bio-tribology, coating, DLC, Heat treatment, Ti6Al4V, Wear.

Reference:

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ITRS204

Tribological Properties of Bio-degradable Lubricants Containing Graphene and Bacterial Nanocellulose

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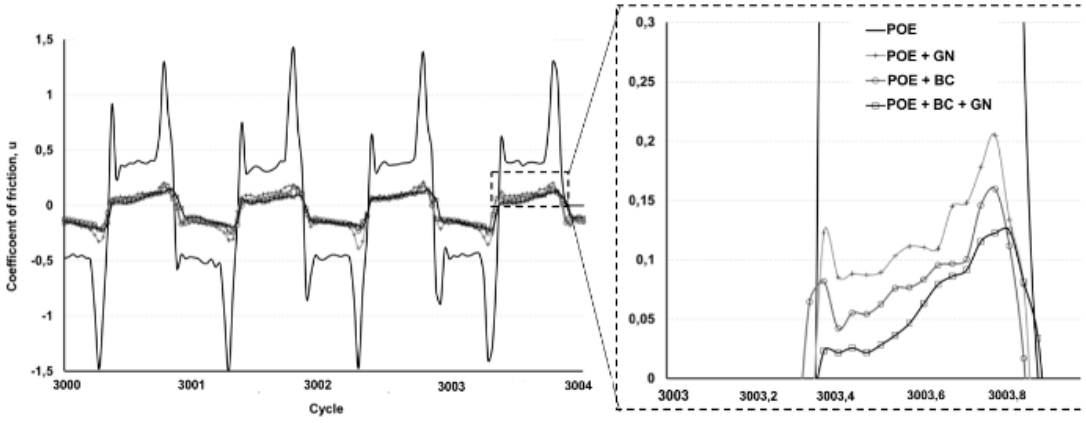
Abstract: Researches on the application of bio-degradable oils as the base oil for environmental-friendly lubricants have been increasing nowadays due to environment and health issues. One of the methods to improve the tribological performances of the base oil is by using nanoparticles as additives. To maintain the bio-degradability of base oil, it is necessary for the additives to have bio-degradable properties. Among such nanoparticles are Bacterial Nanocellulose (BC) and Graphene Nanoplatelets (GN). In this study, the tribological properties of Polyol Ester (POE) oil as a bio-degradable lubricant were improved using BC and GN. The investigation were conducted using a reciprocating tribometer at extreme contact condition (1 GPa initial contact pressure) at the temperature of 65o C and self-mated AISI52100 steel as the tribo-pair. It is found that the friction and wear of the tribo-pair decreased significantly with the presence of BC in the base oil, with a specific wear rate (SWR) reduction of 30%. The performance of the BC containing POE was further enhanced by the addition of GN. In this case, the friction coefficient and SWR reduced by more than 50%. Analysis conducted to wear scar revealed that high friction and wear was attributed to the presence of oxygen rich tribofilm on the contact interface. The presence of both BC and GN in the base oil has significantly reduced the oxygen element in the tribofilm. It seems that high friction and wear was caused by the tribo-oxidation process. Here, the presence of BC and GN seems to have prevented the tribo-oxidation process, resulting in friction and wear reduction.

Fig 1. The presence of Bacterial Nanocellulose and Graphene Nanoplatelets in Polyol ester base oil reduced the friction coefficient of the tribo-pair



Keywords: environment-friendly lubricant, tribofilm, friction, wear, tribo-chemical process

ITRS205
Dry Sliding Tribological Behavior of AZ31-B_4C Nano Composites

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Abstract: The current research work deals with the characterization and tribological behavior of AZ31-B_4C nano-composites fabricated through a ultrasonic assisted stir casting route. B_4C with varying weight percentage (0.5-2.0 wt %) is reinforced in magnesium alloy to produce different composites. Optical microscope (OM), scanning electron microscope (SEM) and energy dispersive x-ray analysis (EDX) are utilized to characterize AZ31 alloy and fabricated composites. The microhardness of developed composites is obtained through Vickers's micro hardness tester. Hardness shows increasing trend with increased wt% of B_4C nano particles. Dry sliding tribological behavior is mainly investigated at room temperature on a pin-on-disc tribo-tester. The characterization illustrates the presence of boron carbide and its effect on the grain refinement of composites. AZ31-B_4C composites exhibit better hardness with compared to the base alloy. SEM and EDX analyses are investigated for the worn-out surfaces in order to predict the wear mechanisms based on different sliding parameters. Wear behavior of base alloy and nanocomposites was investigated under applied load of 10-40 N and sliding speed of 0.1 to 0.4 m/s. The nano-composites shows better wear and friction behavior. The wear morphology of pin samples reveals abrasion, oxidation, and delamination mechanism on pin surface.

Keywords: AZ31-B_4C nano-composites; Magnesium; Ultrasonic assisted stir casting; wear, friction;

ITRS206

Analysis of rough surface multi-lobe journal bearings operating in turbulent regime

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Abstract: This paper deals with theoretical investigation of rough surface circular and multi-lobe journal bearings operating in turbulent regime. The lubricant is assumed to shear thinning in

nature and is described using cubic shear stress fluid law. A generalized Reynolds equation incorporating the parameters for turbulent flow, micro-roughness and non-Newtonian flow index is used to numerically simulate bearing. Pressure flow factors as proposed by Patir and Chang has been used to describe fluid transport phenomenon in rough bearing surfaces. Effect of turbulent flow is considered by using linearized turbulent theory as proposed by Ng and Pan. Reynolds equation has been converted to set of algebraic equations by finite element formulation (weighted residual method). Newton-Raphson's method is employed to computed film pressure over bearing domain. The values of film pressure are used to compute minimum film thickness, frictional power loss, stiffness and damping coefficients of bearings. It has been noticed that shear-thinning lubricant has adverse effect on the minimum film thickness and frictional power loss. However, turbulent condition is noticed to enhance the minimum film thickness, stiffness and damping coefficients of bearings. The presence of transverse roughness vis-à-vis longitudinal roughness (and smooth surfaces) significantly enhance steady-state and rotor-dynamic performance of bearings. Lastly, two lobe bearing configuration offer higher value of minimum film thickness and better rotor-dynamic performance as compared to other configurations of bearing investigated in the study.

Keywords: Journal Bearing, Multi-lobe bearings, Turbulent regime, Surface roughness, Shear thinning lubricant.

ITRS207

Evaluation of Frictional Behavior of AA 2024 based Hybrid composites and Prediction using ANN model

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Abstract: The purpose of this study is to investigate the friction behavior of Zirconium dioxide (ZrO2) and Graphite reinforced AA 2024 hybrid aluminum matrix composites. The hybrid composite is fabricated by stir casting technique by using constant 6 wt. % of ZrO2 and varying wt. % (1.5, 3.0 and 4.5 %) of Gr. The test specimens were fabricated in the form of pins for friction testing by using Pin-on-disc tribometer under dry and lubricated condition. Tests were conducted at 15 N load, 2000 m sliding distance and varying sliding speed of 1 m/s, 2 m/s, 3 m/s and 4 m/s. COF increased with the increase in sliding speed for both dry and lubricated conditions but hybrid composite with 3.0 and 4.5 % showed a decrease in COF at 4 m/s sliding speed under lubricated conditions. At higher sliding speed, greater amount of frictional heat is developed which leads to the softening of Gr particles and a solid lubricant layer of Gr along with PAO oil reduces the metal-to-metal contact and thus reduces the COF. Maximum value of COF observed for 1.5 % Gr reinforcement under dry condition and under lubricated condition maximum value observed for pure AA 2024. ANN technique was used for predicting the friction behavior at next sliding speed and the confirmatory tests revealed that the error in predicted and experimental results is in the acceptable range.

Keywords: Coefficient of Friction (COF), Dry Condition, Lubricated Condition, Artificial Neural Network (ANN)

ITRS208
A SCHEMATIC APPROACH FOR TOOL WERA OF 440C STEEL IN INCREMENTAL SHEET METAL FORMING

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Abstract: Unique forming technique of thin metal sheet came into light in past years names as Incremental sheet metal forming (ISMF). In this forming method, a simple forming tool is needed to transform the metal sheet into end product. The ISMF is suitable for the development of customized part, prototypes, and small batch size. Tool life in manufacturing processes is an important consideration for productivity. In ISMF, the small contact zone of forming tool and metal sheet along with other forming parameters decreased the tool life rapidly due to excessive tool wear. The study implies a schematic approach to measure the tool wear with the use image processing techniques. Real time images are transformed into histogram for further analysis. Currently, the complex histogram plot is recorded and those are studied therefore to predict the tool wear, prediction model are utilized for the measurement of tool wear of 440C steel in the ISMF of Al-Mg alloy and Cu-Zn alloy. The maximum tool wear of 0.0663mm is found in the trail run 05 with an error of 0.0104mm for Cu-Zn alloy whereas in case of Al-Mg alloy, it is noted as 0.0330mm in trail run 03. The best-fitted value of the FFB model is observed at the epoch 05 with overall coefficient of performance i.e. R^2 of prediction model is reported as 0.918 with the mean square error (MSE) of 0.004 which shows a good agreement of the prediction model.

Keywords: ISF, Tool Wear, Image, Input Variables, ANN

ITRS209
Performance of porous surface hydrostatic thrust bearing operating with non-Newtonian lubricant

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Abstract: This paper presents theoretical investigation on performance of porous surface hydrostatic thrust bearing operating with non-Newtonian lubricant. Cubic shear stress fluid law has is used to describe the shear-thinning lubricant in the bearing. Pressure flow factor based on Patir and Cheng average flow model has been used to describe flow of lubricant in longitudinal, isotropic and transverse rough bearing surfaces. Finite element method (weighted residual approach is used to convert non-Newtonian Reynolds equation into a set of algebraic equations. The global set of algebraic equations obtained after weak formulation, is solved using Newton-Raphson method to compute fluid pressure. Gauss Legendre quadrature is used to compute load supporting capacity, lubricant flow rate, stiffness and damping parameters of the bearing. The influence of porosity of porous layer, flow index of non-Newtonian lubricant, and recess shape are investigated on bearing performance parameters. It is noticed that the porosity and shear-thinning of lubricant have adverse effect on the bearing steady-state and dynamic performance. However, these adverse effects can be partially mitigated by judiciously selecting recess shape and roughness orientation on bearing surfaces.

Keywords: Hydrostatic thrust bearing, shear-thinning lubricant, Porous layer, Recess shape, FEM.

ITRS210

Electrical discharge coating of MoS_2+SiC powder for enhanced wettability and tribological performance

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Abstract: Recent developments in the field of surface coating have led to a renewed interest in electrical discharge coating (EDC) which uses electrical discharges process to deposit coating material on the substrate surface. EDC is performed by adapting the electrical discharge machining (EDM) process with green compact tool electrode (prepared by powder compaction in hot mounting press) and workpiece. In the present work, Cu–MoS_2/SiC hard and solid lubricant coatings with various contents of Cu, MoS_2 and SiC powder were prepared by electrical discharge coating (EDC) process. The process is explored as a function of powder mixing ratio, duty factor (30%-90%), and current (4–10 A). The coating morphologies, comprising of hard phases and soft phases are characterized with the help of different techniques, such as, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and X-ray diffractometry (XRD). Further, the effect of the SiC powder concentration on the coating's morphology and mechanical properties were also investigated. The morphology of MoS_2/SiC coating contains negligible pores and cracks at high content of SiC in coating. The microhardness of MoS_2/SiC coatings increases with the increasing content of the SiC powder in the coatings. The tribological behaviour of MoS_2/SiC coatings was evaluated by the dry sliding

wear test. Results shows that MoS_2/SiC composite coating has better wear resistance than the parent material. Moreover, the water contact angle is raised to a hydrophobic state (119.4°-130.9°) from a hydrophilic state of mild steel (78.7°). It is aimed that the enhancement in hardness and wear resistance of hydrophobic coating by using SiC powder in EDC process will be useful for the extensive application of hydrophobic surfaces in industrial use.

Keywords: Ceramic, EDC, Deposition, Wear, Tribology, Hydrophobicity.

ITRS211

Study of Sinter Return Fines Generation and Their Effective Utilization: A Comprehensive View for Sinter Making in Rourkela Steel Plant

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Abstract: The sintering process of iron ore fines is an essential part of modern iron-making. Sintering prepares ore for a blast furnace by causing the metal in the ore to agglomerate. The characteristics of the agglomerate greatly affect the operating conditions of the blast furnace. In this process, iron ore fines is mixed with fine particles (-3mm) of flux (limestone and dolomite), (-3mm) coke, and returned sinter; and the heat from the burning coke causes agglomeration. The input raw material for this sinter making is called as base-mix. The sintered ore is then broken up into smaller pieces and fed into the blast furnace. An important parameter of the sintering process is the burn-through point (BTP), which is defined to be the first position on the sinter strand where the ore is completely sintered. The stability of the BTP directly influences the quality and quantity of sintering agglomerate. If the BTP occurs before the optimum position, the area of the sintering machine is not used effectively; so the utilization factor is too low. This directly reduces the quantity of agglomerate. On the other hand, if the BTP occurs after the optimum position, some ore remains unsintered; so the agglomeration rate is too low. This degrades both the quantity and quality of agglomerate, and increases the amount of returned sinter. In addition, frequent changes in the BTP shorten the lifetime of the sintering machine. A key problem in the control of a sintering process is effective tracking of the BTP to keep it at the optimum value. Sintering is a complex, nonlinear process with coupled parameters. Many factors affect the BTP: the sinter strand velocity, the ignition temperature, the chemical composition of the raw material, the flow rates of the fresh-air blowers, etc. Since most of these factors change freuently and unpredictably, it is difficult to establish a practical, precise mathematical model of the sintering process. In this paper, a detail study is carried out to estimate the tribological challenges, predict the burn-through point for better sinter quality and study the return fines generation and their effective utilization in sinter making.

Keyword: Sinter, Basicity, Burn Through Point, Available Lime, Sinter Return Fines

ITRS212

Research on Tribological Performance of Piston Ring/Liner Conjunction Considering Non-Gaussian Roughness and Cavitation

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Abstract: The tribological performance of piston ring-cylinder liner conjunction (PRCLC) notably depends on thesurface finish of cylinder liner. This study investigates the mixed lubrication condition near dead centres considering non-Gaussian roughness and cavitation. The average Reynolds equation is modified by incorporating the pressure and shear flow factors for non-Gaussian rough surfaces. Whereas, the Weibull probability distribution function is employed to model the asymmetry in asperity heights. It is found that surfaces with more negative skewness exhibit lower engine frictional force in the vicinity of the dead centres. No substantial effect of the skewness and surface roughness is observed in the mid-stroke of the piston. The effect of piston ring geometry on tribological performance of PRCLC is also discussed in detail.

Keywords: mixed-EHL regime; cavitation; non-Gaussian surfaces; piston ring/liner conjunction; minimum oil film thickness

ITRS213
Investigation of Wear behaviour of Hybrid LM30 Metal MatrixComposites (MMCs) Fabricated through Stir Casting Rout

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Abstract: In industries like food processing, thermal power plant, mining industries via pipes and pumps high velocity gases, solid, liquid, liquid-solid mixture is passed which results in wear in these machine components. Wear is the material removal phenomena that occur when two bodies come in physical contact with each other and have some relative motion. Since the wear out component loses its functionality therefore it needs to be repaired or replaced, hence wear drastically increases the expenditure of industry. So, there is the need to effectively control or curbs the wear. In the current research work, firstly Metal Matrix Composites (MMCs) have been fabricated using stir casting rout. Three different composite materials named Composite A, Composite B, and Composite C have been fabricated by reinforcing the different material such as Zircon (ZRO2), Rice Husk Ash (RHA) and Tungsten Carbide (WC). Secondly, three different slurry have been prepared by different concentration (25%, 50% and 75% by weight percentage) and investigated the wear behaviour of all the three composite material. It was observed that slurry erosion wear is minimum in case of composite (LM30/5%WC/5%ZRO2/10%RSH) compared to composite B (LM30/10%WC/5%ZRO2/10%RSH) and composite C (LM30/5%WC/10%ZRO2-/10%RSH) followed by slurry erosion and slurry abrasion test.

Keywords: Wear, Metal Matrix Composites, Composites Materials, Stir casting, Slurry erosion test, ASTM G105

ITRS214
Performance Evaluation of Wire-EDM process of EN-31using multiple electrode material

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Abstract: Electrical Discharge Machining (EDM) is advanced thermal erosion method used to extract material through a higher spark frequency, repetitive electrical discharges and high current between the wire as tool electrode and workpiece which is connected to anode that is positive terminal. The removal of material in EDM is based on erosion of electric sparks taking place amid two electrodes. There are numerous theories has in attempts to clarify the complicated phenomenon of erosive spark. EDM is advance machining process used to erode material through a large number of small-duration, recurring electrical discharges and large current density between the workpiece and wire. In the current research work an effort is made to evaluate the performance of W-EDM by machining of EN-31 steel using the different electrode wire, namely Copper and Brass. EN-31 having good mechanical and corrosive properties, so they are widely used in various field such as automobile, aerospace, agriculture tool etc. Experiment were design with the help of Taguchi by considering the parameters such as Electrode type(Copper and Brass), Discharge Current, Ton and Toff. Experiments have been conducted to optimize the W-EDM machining parameters in order to achieve the minimum tool wear, maximize MRR with minimum SR. It has been found that electrode material and discharge current were the mainly significant factors affecting MRR and SR, respectively. Study shows that brass electrode have the higher MRR when comparing with copper electrode material.

Keywords: WEDM, Copper, Brass, Electrode, Tool Wear, EN-31, MRR, SR, SN Ratio, ANOVA,

ITRS215
Crack detection in a shaft-rotor-bearing system based on frequency domain responses

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Abstract: A multi degrees of freedom (DoF) model of a cracked shaft rotor system supported on ball bearings is presented. The model is based on finite element (FE) method. The crack model is based on fracture mechanics approach, whereas modelling of support ball bearings using linear stiffness and structural damping coefficients, is based on non-linear Hertzian contact theory. From the system model, Eigen value problem formulation is carried out and solved. The resulting whirl frequencies and critical speeds determine the system characteristics. Further, modal analysis is done to obtain the system frequency response functions (FRF's). The results of this paper provide useful insights into the change of critical speeds as well as the magnitude of the FRF responses due to initiation of crack in a shaft-rotor-bearing system. The FE model is

also validated with a benchmark problem, prior to analysis. Also, a local flexibility coefficient of crack is validated using published results. The developed methods and results indicate the potential use of critical speeds and frequency responses as indicators of fatigue cracks in rotor systems.

Keywords: cracked shaft rotor bearing system, FE Analysis, critical speeds, frequency response functions, rolling element bearing.

ITRS218
Industrial application of tribology on aluminium rolling mill (hot rolling process) for sustainable hazardous waste management

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Objective: Equitable consumption and resource conservation are fundamental to the Aditya Birla Group. As the metal flagship company of the Group, Hindalco continues to lead with its efforts towards building a sustainable ecosystem. Hot rolling process emulsion is being used as coolant. Filter paper is used in emulsion filtration unit for maintaining the quality of emulsion by removing sludge through filtration unit. Due to this filtration process, waste filter paper is generated. This paper is contaminated with oil & sludge and categorized as hazardous waste. Objective is to reduce the hazardous waste.

Methods: Filter paper movement is being done by level-based logic system by filter skimmer. This inhibits unnecessary filter paper movement which resulted in lowering the consumption of filter paper. Earlier we used to operate two-line filtration unit simultaneously which led to more consumption of filter paper. We have taken successful trial of using only one side filtration system instead of both sides. Observed emulsion chemical & physical properties were intact. Magnetic rod was installed in both HRM & HFM clean tank to collect MS Particles.

Results: Less consumption of filter paper as well as energy saving.

Conclusions: Obtaining lower amount of hazardous waste in terms of weight.

Keywords: Hot rolling process, emulsion, coolant, filter paper, hazardous waste

ITRS219
An Experimental Investigation on Tribological Behaviour of Polyalphaolefin(PAO4) Oil Modified With Cu / MnS Nanocomposites

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Abstract: This paper presents the experimental investigation on the tribological behaviour of polyalphaolefin oil (PAO4) with the addition of Cu/MnS nanocomposites and compared with the behavior of the base oil operating with individual Cu and MnS nanoparticles. Cu/MnS nano composites with an average size of ± 100 nm were synthesized and added as additives in the PAO4 base oil in different compositions like 0.2, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.4 Wt. %. The friction and wear properties of lubricating oil with Cu/MnS nanocomposites were investigated between steel/steel contacts by using a typical four-ball tribo testing machine. The coefficient of friction (COF) is calculated using the friction torque data acquired. The Wear Scar Diameters (WSD) of the balls is observed using a Scanning Electron Microscope (SEM), and installed with an Energy-Dispersive X-ray spectroscope (EDX). The investigated results reveal that the tribological behavior of PAO4 oil with Cu/MnS composites is better than the oil with mono nano particles. Also, among all samples, base oil with 0.6 wt. % concentration of Cu/MnS nanocomposites yielded good results. The COF is decreased by 69.7%. The decrease in friction coefficient is due to the formation of a protective layer as a result of nanoparticle deposition on the rubbing surfaces. The wear behaviour was changed due to the change during friction process from sliding friction to rolling friction.

Keywords: Cu/MnS Nanocomposites, Cu & MnS Nanoparticles, friction, wear, lubrication

ITRS220

Hybrid models for optimization of process parameters influencing the quality of multi-stage, deep-drawn cylindrical cups from uni-directionally rolled copper strips

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Abstract: In this work, methods like Finite Element Analysis (FEA), Response Surface Methodology (RSM), Levenberg-Marquardt ANN (LM-ANN), and Bayesian Regularization (BR-ANN) are separately coupled with Genetic Algorithm (GA) to form hybrid models which are used to estimate the optimum process parameters affecting the quality of a multi-stage, deep-drawn cylindrical copper cups, manufactured from uni-directionally rolled copper strips. The FEA is used to estimate the responses and the influence of design variables on uni-directionally rolled strips subjected to 200% thickness reduction or a true-strain of -2.78. The material properties used for the analysis are taken from actual test results conducted on materials used. The responses analyzed include spring-back (elastic recovery), and the axial resultant tool-force used for forming the deep-drawn cups. R^2, RSME, MAPE, MSRE, and NSE are used as a measure to compare the error-prediction of hybrid models. The RSM Central Composite Design (CCD) model is found to be more fitting than other models hence, it was used for the experimental design, and the responses were simulated using FEA. Models of all types were are optimized using GA. Comparing the results of various hybrid models, it was found that, BR-

ANN resulted in the most accurate prediction indicated by highest desirability index.

Keywords: directional rolling, deep drawing, FEA, CCD, LM-ANN, BR-ANN, GA, quality cups.

ITRS221

A Comparative Investigation on Wear Characteristics of Polymer and Biopolymer Gears

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Abstract.
Purpose- Plastic gear applications are rapidly increasing in power and motion transmission systems in automotive industry, domestic and kitchen machineries, etc. Biopolymer gears are now being preferred over polymer gears due to its biodegradable properties. Hence, the purpose of this article is to make a comparative investigation of wear characteristics between polymer and biopolymer gears.

Design/Methodology/Approach- Injection molded biopolymer PLA (Polylactic Acid) gear and polymer ABS (Acrylonitrile Butadiene Styrene) gear have been fabricated with proper injection molding parameters required as per the mechanical property of the selected material. Test gears are experimentally tested on gear test rig with running period of three hours at three different rotational speeds (500, 1000 & 1500 rpm) under loading and without loading conditions. A load of 1kg on drive gear is used for loaded conditions.

Findings- Wear debris formation, weight loss occurred due to gear wear, thermal damage and microstructure surface condition monitoring have been investigated to analyze the wear failure characteristics of test gears. PLA presents better adhesive wear resistance and shows thermal deformation and tooth breakage.

Practical implications- Biopolymer gives better thermal and wear resistance than polymer gear. And due to its bio-degradable property, it may bring a huge replacement in plastic gear power transmission systems.

Originality value- At low rotational speed of 500 rpm under without loading condition, both PLA and ABS shows higher weight loss and wear rate due to thermal damage occurred due to gear pump effect. Whereas when load is applied, PLA shows wear loss at all rotational speeds due to inferior thermal conductivity and ABS shows wear loss at high rotational speeds of 1000 rpm or 1500 rpm due to loading effect.

Keywords: Adhesive wear, Biopolymer, PLA, ABS, Gear tooth tip

ITRS222

Synergistic effect of surface texturing and nano graphene platelets based nano-lubricant on the tribological improvement of spark plasma sintered aluminum-silicon alloy

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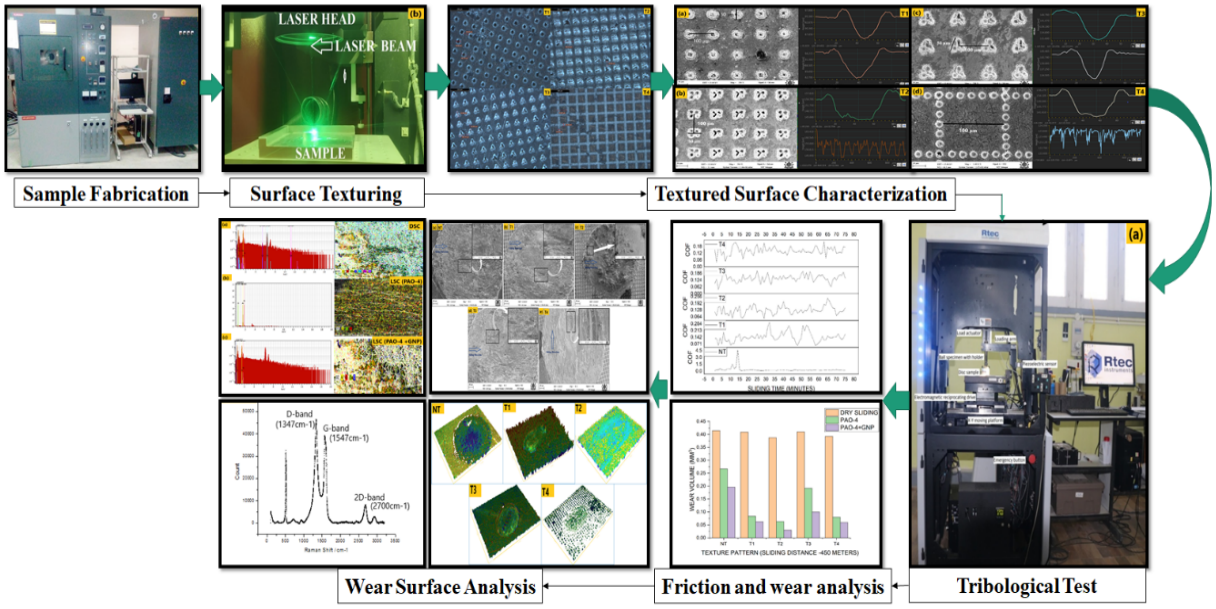
Abstract: In the present work, modification of aluminum-silicon (Al-Si) alloy surfaces is performed using laser texturing (LT). An investigation is carried out to study surface texturing (ST) effects on friction and wear reduction mechanism. LT with different patterns, i.e., dimple (T1), square (T2), triangular (T3), and line hatched (T4) texture are done on the alloy surface. The tribo tests are carried at 10 N load, Hertzian contact pressure (P_{max}) 708.7 MPa, 1 mm stroke, 50 Hz frequency for sliding distance up to 450 m. The friction and wear behavior of the non-textured surface (NTS) and textured surface (TS) are analyzed under dry sliding conditions (DSC) and lubricating sliding conditions (LSC) [i.e., virgin PAO-4 and PAO-4 + 1 wt. % graphene nanoplatelets (GNP)]. T2 texture reveals a 31.51%, 74.93%, and 69.58% decrease in COF and 6.49%, 76.23% 84.69% decrease in wear volume than the NTS for DSC, virgin PAO-4 and PAO-4 + 1 wt. % GNP, respectively. Results show that ST improved friction efficiency, and shortened the running-in period. The current study results help to provide in-depth interpretation of micro-texturing and its relationship w.r.t. tribological characteristics.

GRAPHICAL ABSTRACT



Keywords: aluminum-silicon alloy, laser surface texture, friction, wear, lubrication**.**

ITRS223

Study on Tool Wear and Tool Life during Milling on Unidirectional CFRP

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Abstract – This paper study on the influence of machining parameters (spindle speed ,feed rate and depth of cut) on the tool wear during milling on unidirectional Carbon Fibre Reinforced Plastic (CFRP). The milling process is performed based on the machining parameters values of spindle speed 2000rev/min to 8700 rev/min , feed rate 500mm/min to 1000mm/min and depth of cut 1.0 to 1.5mm. Uncoated solid carbide cutting tool with 8mm in diameter acted as cutting tool to cut the CFRP panel with dimesion 300mm in length , 200mm in width and 3mm in thickness. The machined surface of CFRP panel are in 0 degree and 90 degree fibre orientation individually. Based on the result obtained, it was found out that tool wear is higher at lower spindle speed, higher feed rate and higher depth of cut for both fibre orientation. The black surface on the wear region is the abrasive wear which was caused by the abrasive nature of carbon as well as the sliding mechanism of chips during milling processs.

Keyword : CFRP , Tool Wear , Tool Life , Fibre Orientation , Carbide Cutting

ITRS224

Modelling and optimization of wear performance of AISI 1040 steel using AI-GA methodology and investigation of corrosion resistance

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Abstract: AISI 1040 steel offers a wide range of industrial applications due to its mechanical characteristics and applicability. The present work investigates the wear performance of AISI 1040 steel under dry sliding conditions and its optimization using AI-GA methodology. Sliding wear test were carried out on a pin-on-disc tribometer by varying the load (10-100 N), sliding speed (0.5-1.5 m/s) and sliding distance (400-1000 m). The test parameters were varied at three equally spaced levels. Experiments were carried out following combinations in Taguchi's L_{27} orthogonal array. Artificial neural network was used to model the process parameters with wear rate. The trained network was optimized using genetic algorithm (GA) to predict optimal wear. This methodology has been termed as AI-GA method. A significant reduction in the wear rate could be realized due to optimization using AI-GA method. The variation of wear rate with the process parameters was also investigated using 3D surface and contour plots. Mid-value of load (50 N), lowest value of speed (0.5 m/s) and higher sliding distance (1000 m) resulted in enhanced wear rate. This was supported by wear mechanisms and wear debris observed under scanning electron microscope (SEM). Energy dispersive X-ray spectroscopy (EDS) revealed the formation of oxide layer. Statistical analysis revealed highest contribution of applied normal load followed by sliding speed and sliding distance. This work also examined the corrosion behaviour of AISI 1040 medium carbon steel when exposed to various concentrations of sodium chloride (3.5 % NaCl), sodium hydroxide (3.5 % NaOH), sulphuric acid (0.5 M H_2SO_4) and (3.5 % NaCl + 0.5 M H_2SO_4). A nobler corrosion potential was obtained in 3.5% NaOH. Investigations of corroded samples under SEM showed pitting corrosion in 3.5% NaCl, 0.5 M H_2SO_4 as well as combined chloride and sulphate attack. On the other hand, negligible corrosion was observed in 3.5% NaOH.

Keywords: AISI 1040 steel, wear rate, AI-GA, Optimization, Corrosion

ITRS225

AN EMPIRICAL ASSESSMENT AND PERFORMANCE ANALYSIS OF WIRE ELECTRICAL DISCHARGE MACHINING CHARACTERISTICS OF HARD TI–6AL–2SN–4ZR–2MO

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Abstract: Ti–6Al–2Sn–4Zr–2Mo (Ti 6242) are widely used in compressor disc and power generation equipment's. It is noticed that as not easy to machine the Ti alloys using traditional machining process, because of its fast tool wear and worst surface finish. Henceforth, advanced machining process is recommended for machining of Ti 6242 alloy. In non-traditional machining technique, wire electrical discharge machining (WEDM) has shown auspicious results in machining rate and surface finish. This investigation focuses on WEDM of Ti 6242 with copper as a wire electrode. Pulse on time, Pulse off time, wire feed and wire tension are accounted as process parameters; and material removal rate (MRR) and surface roughness (SR) are considered as performance parameters. The main objective of this work is to obtain maximum MRR and minimal SR and also to find out the significant process parameters by adopting statistical modelling with L27 orthogonal arrays by varying parameters and experiments are accomplished. It has been observed that pulse on time is the most significant parameter, which effects both the response machining parameters. In addition to that, craters, recast layer and cracks are identified in the machined surface using Scanning Electron Microscope (SEM).

Keywords : Wire EDM, Titanium, SEM,MRR, surface roughness

ITRS226
Assembly interface design for high contact performance

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Abstract:

High contact performances are desired for crucial assembly interfaces in equipment in engineering practice. The uniformity of the contact stresses is measure to the contact performance. Traditional methods, such as optimizing the layout of the fasteners and the assembly process, have limited effects on improving the uniformity of the contact stress. The interface shape and the material stiffness, as two factors strongly influencing the contact stress distribution [1-4], are often ignored during the existing engineering design. This study aims to develop interface shape and material stiffness optimization methods for improving the distributing uniformity of contact stress.

For the interface shape and the material stiffness optimization, the gap distance and Young's modulus are treated as the design variables respectively, while objective functions are both the variance of contact stress. One of the design cases is the single bolted joint model as shown in figure 1. After the interface shape optimization or the material stiffness optimization, the uniformity of the contact stress is improved significantly, as shown in figure 2.

It's found that both the interface shape design and material stiffness design are proved to be

effective on homogenizing the contact stress field. For the material stiffness optimization method, the results indicate that the influence of the friction behavior on the optimization result is problem-dependent.

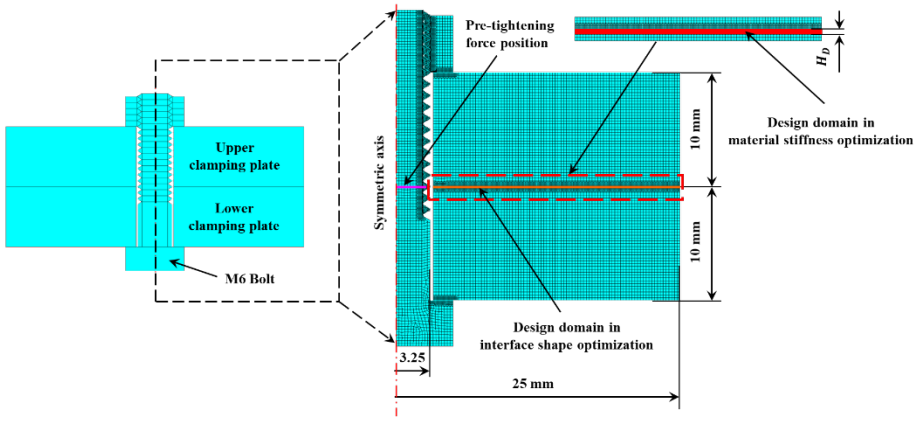

Figure 1: A single bolted joint model.

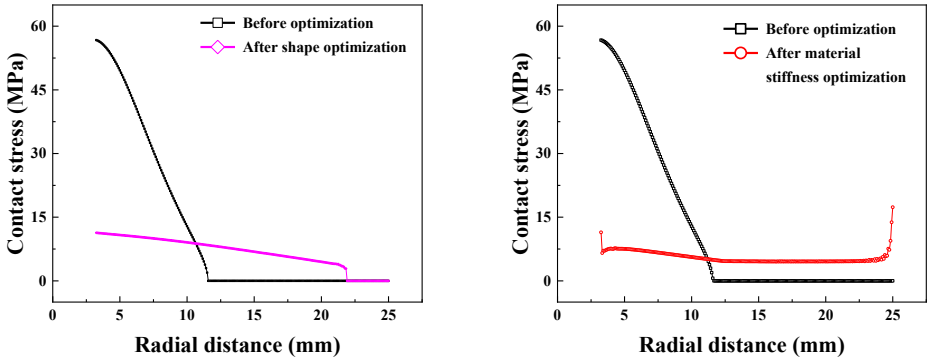

Figure 2: Contact stress distributions before and after interface shape optimization (left) and material stiffness optimization (right).

Keywords: Contact stress, distributing uniformity, interface shape, material stiffness, friction behavior

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ITRS227

Tribological Behaviour of Copper Ferrous Spinel Nanoparticles as an additive in Lubricant SN 500

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Abstract: The objective of the Research Work is to determine performance behaviour on Four Ball Tester of lubricant SN 500 using Copper Ferrous Spinel ($CuFe_2O_4$) Nanoparticles as an additive in various proportions. Copper ferrous spinel nanoparticles were prepared in-house by co-precipitation method. The characterization of nanoparticles is done using Scanning Electron Microscope (SEM) and X-Ray Diffraction (XRD). Value of Average particle size found indicates it to be designated as Nanoparticle. The Nanoparticles were added in weight for selected volume of base Lubricant SN 500. The experimentation was done for plain lubricant SN 500 and blended lubricant ranging from 1% to 5% (weight of Nanoparticles to volume of Lubricant). The Wear tests were performed as per Standard ASTM D4172 and Coefficient of friction tests are were performed as per Standard ASTM D5183. The Test results were encouraging leading to lower wear scar size, reduced coefficient of friction and increase in incipient seizure load as compared to the plain lubricant SN 500.

Keywords: SN 500, Copper ferrous spinel nanoparticles, Incipient seizure load, Four Ball Tester, ASTM D4172, ASTM D5183.

ITRS229

Dry Sliding Wear behavior of Al/Kyanite Metal Matrix Composites

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Abstract: In this paper, effect of reinforcement kyanite in wt.% on the dry sliding wear behavior of Al/Kyanite metal matrix composites (MMCs) prepared by stir casting method produced by using electrical resistance furnace was studied with varying wear parameters. The aluminum metal matrix composites (AMMCs) are produced as LM6 matrix metal and kyanite particulates of an average size of 25 μm as reinforced particles through stir casting. Dry sliding wear behaviour for Al/Kyanite metal matrix composites has been studied using pin-on disc wear testing machine & reported. Alloy composition, normal pressures, sliding speeds and sliding distances on Al/Kyanite was studied for varying percentages of kyanite reinforcement and

corresponding wear losses were measured. The study indicate that, wear rate of LM6 alloy increases with increase in normal pressures, sliding speed and sliding distances in all the cases studied and decreases when Kyanite in weight percentage of 1 to 6% in steps of 1% is added to LM6 alloy. The decrease in wear rate after addition of kyanite is mainly due to increase in hardness & improvement in mechanical properties. Further, worn surface study indicates that, the formation of iron-rich oxide layer between the mating surfaces during sliding improves sliding wear performance of composite

Keywords: Wear rate, LM6 alloy, Kyanite, microstructure, Worn surface

ITRS230

Advancement in Chemical Mechanical Planarization (CMP) Equipment for Tribological Research and Analysis

Wan Nazrul Imran Wan Kamaruzaman

Abstract: Chemical Mechanical Planarization (CMP) is a process highly related to Tribology topic as it involves the wear and tear of wafer in nanoscale level. It is a high precision material removal process utilized to produce polished wafer for the fabrication of Integrated Circuit (IC). CMP is a very complicated process as a lot of parameters have to be controlled depending on factors such as wafer's material and topography. This leads to a lot of research need to be done before a certain CMP process can be applied for mass production of wafers. However, the current development of CMP process has shown little interest on the production of CMP machine solely for research purposes. Other than that, existing machines for CMP process are high in cost which is economically undesirable for study basis. This inhibits the opportunity for researchers to study the process and tribology mannerism involved. This paper will elaborate the important specifications and design for a CMP machine that are sufficient enough to be utilized for the study and understanding of CMP process. This includes the design of control system, wafer carrier and loading process. The parameters need to be controlled and factors to be considered and their importance to the process will be discussed thoroughly in the paper. Other than that, the mechanisms on how CMP process and tribological characteristics can be monitored and analyzed using the machine to oversee the CMP process will be explained to ensure that the understanding of excellent and precise CMP process as well as tribology knowledge is well-delivered. This paper could be beneficial for early progress of research-based CMP machine which can eventually help the industrial sector especially semiconductor companies. Companies that manufacture wafers andslurries could utilize this development for the advancement of their product as it could offer lower cost in product development before moving on with mass production. This follows the development of new potential wafer's materials that has been emerging due to the increasing demand in semiconductor industry. Interesting factor that could be added is that the low-cost machine could be utilized in universities to enhance student's understanding on tribology and CMP process as it is not a well-established topic in academic stage. To conclude, CMP process and it's tribological characteristics should be more understood in every stage including academic level to ensure that the process could be continuously developed for a faster and better process that can improve the semiconductor industry. Other than that, a well-established CMP machine for study and research purposes are needed and this

paper could be utilized for the purpose.

ITRS232

Implementation of an elasto-hydrodynamic non-newtonian lubrication numerical solver

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Abstract: In the framework of the elasto-hydrodynamic lubrication simulation algorithms of lubricated coupled surfaces, a key role is the used deformation model, since its choice affects the surfaces' separation which guarantees the existence of a thin lubricant film thickness, even when the tribo-system is subjected to high loads. The aim of this paper was to merge a finite element linear deformation model based on linear tetrahedra, previously developed by the same authors, within the Reynolds equation solver in the elasto-hydrodynamic mode, with reference to a generic ball in socket lubricated tribo-system. The implementation of the finite element deformation model allowed the authors to relate the deformation vector to the pressure one through an influence matrix which takes into account the spherical motion of the ball with respect to the socket. The computer code for the problem solution was written in Matlab environment and simulated particular conditions, in terms of eccentricity and angular velocity vectors, in order to calculate the meatus fluid pressure field, surfaces' separation, shear stresses, deformation and wear depth. The integration over time of the output fields led to the time evolution of the load vector, the friction torque vector and the wear volume. The obtained results showed a satisfactory agreement with others classical approaches found in the scientific literature.

Keywords: Lubrication model; Finite element; Ball and socket; Deformation; Wear.

ITRS233

The influence of nano- additives on the steady state performance of journal bearing.

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Abstract: The present need of the industry to use the machine tools at very high speed. While working at the higher speed the temperature of the machines increases which in turns decreases the viscosity. Any variation t in the value of viscosity of the lubricants affects the performance of the journal bearing. The nanoadditives find their application in lubricants as they have show good resistance to wear and friction as reported in many studies. The nano additives find their application in lubricants showing favourable conditions with repect to low rate of wear and

friction as reported in previous studies. The addition of additives enhances the thermal properties of lubricant. The present work is based on the investigation on the influence of nano- additives on steady state characteristics like load carrying capacity, coefficient of friction, attitude angle, etc. on journal bearing. The range of temperatures 30°C-90°C at weight fraction of 0.1%- 0.5% have been chosen as a part of study by applying the regression analysis model. For computing the performance parameters the Reynolds equation is solved by using FEM and the computer code is developed in MATLAB. Results shown that the load carrying capacity increases with increase in the eccentricity ratio but at higher range of temperature it decreases with an increase in the weight fraction of nanoparticles.

Keywords: Al□0□ and CuO additives, load carrying capacity, eccentricity ratio, surface texture, bearing

ITRS234

Effect of heat treatment on the dry sliding wear properties of solid lubricated hypereutectic aluminum alloy based composites (AMCs)

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Abstract: The present work describes the effects of heat treatment on the dry sliding wear properties of ilmenite reinforced aluminum alloy (LM30) composites. The composites samples were prepared through liquid metallurgy (stir casting) route. To understand the effect of heat treatment, T4 and T6 approaches were employed. Heat treatment consists of the heating of composite samples to 540 °C for 0.5–2.0 h, followed by water quenching. Further in T4 process, samples were aged naturally for 10–30 days at ambient temperature. While in T6 process, samples were artificially aged at 150–250 °C for 1–5 h before air cooling. Optical microscopy results revealed the homogeneous distribution of ilmenite particles and redistribution of silicon around the ceramic particles in the metallic Al matrix. Hardness results suggested the superior values of T6 treated composite samples as compared to T4 treated and untreated samples due to enhanced interfacial bonding between reinforcement and the matrix. Further, dry sliding wear testing exhibited the maximum improvement in the wear resistance of T6 treated composites which was well supported by scanning electron microscopy results. Finally, a comparative study revealed the superior wear resistance (against EN31 steel disc) of T6 treated Al composite sample than grey cast iron (traditional material) for brake drum applications.

Key word: Hypereutectic alloy, Ilmenite, Wear rate, Heat treatment, SEM

ITRS235

Synergic effect of CuS/TiO_2 nanostructures for enhanced photocatalytic activity

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Abstract: In the recent past, metal oxides have attracted the researchers because of their applications in energy and environmental application domains. In the present work, hydrothermal technique used to prepared the CuS/TiO_2 nanostructures and the effect of the different molar concentrations of copper and sulfur source on the TiO_2 nanostructures and their crystal phase, morphology, and degradation of pollutants of the coupled material have been investigated. The structural, morphological, surface composition, optical and photocatalytic behavior of the synthesized nanoparticles were studied by X-ray diffraction (XRD), Transmission electron microscope (TEM), Raman, X-ray photoelectron spectroscopy (XPS),UV-Vis absorption and BET. XRD pattern revealed that tetragonal structure of anatase phase of TiO_2. TEM analysis showed the formation of nanoparticles with spherical like morphology with good crystallinity. UV-Vis spectra, it is observed that optical absorption edge gets red shifted. The photocatalytic activity of the synthesized nanoparticles has been investigated against methylene blue (MB) under visible light irradiation. Experimental results suggested that the higher rate constant of about 0.03361 min^{-1} for CST2 against MB dye solution.

Key words: Hydrothermal method, anatase TiO_2, red-shift methylene blue, photocatalytic activity

ITRS236
Experimental Investigation of SAE20W40 Lubrication Bearing Under Different Loading, Speed and Pressure Parameters

Abstract. Rotating machinery develops vibrations and noise when working at high speed. To have a smooth running without vibration, different types of bearings are used worldwide. Also it can re-duce wear rate of movers. This paper experimentally investigates the performance of SAE20W40 lubrication by changing loads with varying speed and vice versa. Every possible combination is tested under observation. After investigation, it is observed that, in journal bearing as load increases at constant speed maximum pressure in bearing increases and hence minimum clearance between casing and journal decreases. From second result it is found that in journal bearing as speed increases at constant load, maximum pressure in bearing decreases and hence minimum clearance between casing and journal increases. From third observation, it is observed that, it is observed that SAE20W40 bears less maximum pressure among three oils and hence minimum clearance is more and less chances of damaging of casing and journal by making contact. And hence it has a high load bearing Capacity. Hence, SAE20W40 is best suitable lubricating oil for journal bearing.

Keywords: Lubrication bearing, experimental investigation, SAE20W40, etc.

ITRS238
Wear and Hardness of Multiwalled Carbon Nanotubes Reinforced Copper

Nanocomposites: An Experimental and Statistical Analysis

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Abstract: Carbon nanotubes (CNTs) are considered as suitable nanoreinforcement for metal matrux composite materials due to their extraordinary mechanical, electrical and thermal properties. In this experimental investigation the wear and hardness behaviour of copper is studied after reinforcing the copper with multiwalled carbon nanotubes (MWCNTs). The multiwalled carbon nanotube reinforced copper (MWCNTs/Cu) nanocomposites are fabricated using powder metallurgy process followed by hot pressing. Two categories (i) Hot pressed (HP) MWCNTs/Cu nanocomposite and (ii) Non-hot pressed (NHP) MWCNTs/Cu are subjected to wear and hardness testing. Pin-on-disc and micro-Vikers hardness tester are used to conduct the wear and hardness tests respectively. The doping weight percentage of MWCNTs in copper matrix is 0.5. 1.0 and 1.5 wt.% by copper weight. The hardness of HP MWCNTs/Cu nanocomposites is higher than the NHP MWCNTs/Cu nanocomposites irrespective of the MWCNTs doping weight percentage. Further, the wear rate of HP MWCNTs/Cu nancomposite is lower than the NHP MWCNTs/Cu nanocomposites irrespective of MWCNTs content. However, the effectiveness of the MWCNTs content in the Cu matrix becomes less as the sliding speed increased. The two-parameter Weibull statistical analysis showed good repeatability in the experimental results. Further, the experimental results showed a good correlation with the theoretical values calculated using two-parameter Weibull distribution.

Keywords: Copper, MWCNTs, Powder metallurgy process, Hot pressing, Hardness, Wear, Two parameter Weibull distribution

ITRS239

A comparative assessment of performance behavior of Mineral and ester base engine oils with or without containing metal oxide nano-particles

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Abstract: The efficiency and reliability of the engine depends on the performance of engine oil. Thus it is necessary to monitor the condition of the lubricant by tracking the changes in oil parameters that affect the functional properties and service life of the oil. In this regard, the degradation parameters like oxidation, soot content, wear metals, change in acidity, and

alkalinity are monitored with respect to running time of the engine to predict the oil drain interval. However, there is still a need for developing lubricants which are suitable show robust performance and meeting the stringent operating conditions. Therefore, the research efforts for further improving the product performance is focused on the development of sustainable and environmentally acceptable lubricants.
In this context, nano-fluids and renewable ester based (biodegradable) lubricants are emerging as suitable options for enhancing the performance of engine oils in the direction of sustainable lubrication. The improved thermal behavior/stability and the higher oxidative response of biodegradable esters make it a suitable candidates for development of sustainable and environmentally acceptable lubricants. While nano-fluids have been proven their performance benefits in a variety of lubricant applications by the addition of metallic and non-metallic types of nano-particles. the limited dispersion stability of nano-fluids plays a major role in the development of nano-fluids. Thus in the present paper, we have approached two ways to enhance the performance behavior of SAE grade 15W40 engine oil. First, by changing the mineral-based to ester-based and secondly by the addition of functionalized ZnO nano-particles dispersing in mineral oil engine oil. The two-step method was used to prepare the Zinc Oxide nano-additives and disperse them in base engine oils. The performance of mineral and ester-based engine oil and their corresponding nano-fluids were conducted on Heavy-Duty Diesel Engine forklifts in actual field operation. The used oil samples were collected every 50-100 hours of forklift running and tested for condition monitoring using standard test procedures on parameters like oxidation, nitration, soot content, TAN, TBN, and wear metals. The finding reveals that ester-based engine oil shown improved performance as compared to mineral-based engine oil however the addition of nano-particles further enhanced the life of engine oil. This comparative assessment confirmed the ZnO nano-additive and biodegradable ester can be used for enhancing the service life of the engine oils.

Keywords: Mineral and Biodegradable base engine oil, ZnO nano-additives, Heavy Duty Diesel engine Forklift, Condition Monitoring and Field Trial Analysis.

ITRS240

Title Page

A novel conjugate heat transfer (CHT) approach to determine the temperature distribution in single point cutting tool under different conditions

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Abstract: Thermal modeling to determine the temperature distribution across the surface has always been an approach to estimate the major physical properties associated with temperature. Measurement of accurate temperature of the tooltip, rake face, and flank face during the machining operation has always been difficult and a topic of interest among researchers. An increase in the cutting temperature leads to higher tool wear and poor surface finish. Therefore,

various attempts have been made to predict the temperature during machining operations. The exact determination of temperature can predict the tool wear and minimize the tooling cost and ideal time in the metal cutting industries. The present work describes the development of an alternative approach towards the measurement of online tool temperature. The paper enlists four different conditions namely dry cutting, dry cutting with air cooling, flooded water cooling, and the mist flow environment that has been used in turning operation. Furthermore, Computational fluid dynamics (CFD) analysis was used to determine the temperature distribution on tool insert under such different machining environments. The finite volume method has been used in the discretization of the governing equations. The nature of the problem compels the decoupling of energy conservation equation from the mass and momentum conservation equations, this approach also simplifies the complexity of our problem. Therefore, a model is developed to predict the temperature across the profile through different numerical equations. Furthermore, the simulated data has also been validated through experimentation in turning operation using carbide tool and stainless steel AISI 304 as work material. The experimental results show the close values with simulated results and a variation of 25% to 35% has been observed, in all the machining environments. In both cases, the lowest temperature has been recorded in flood water cooling followed by the machining under a mist environment as compared to dry conditions.

Keywords*:* Thermal modelling, CFD, Single point cutting tool, FEM, Turning

ITRS242
Use of Algae In Several Fields

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Abstract: As it is evident, how non-biodegradable materials effecting the environment. Therefore, development of sustainable composites, which are renewable, recyclable and biodegradable, and also having environmental acceptability and commercial viability, is the need of present time. More precisely if we see the problem of plastic pollution, algae is potential biomass to counter this problem. We can produce based composites, which can replace plastic. What makes it potential biomass is not just the environmental friendly characterstics and biodegradability but also the easy availability of algae. We can use algae as filler material in several matrix, example PLA, PHA, etc. polymer like PLA as matrix embedded with algae as filler, are compatible with many processes like injection moulding, solvent mixing, melt mixing etc. unlike other bio-plastic sources such as corn, flax, jute and other plant based, algae does not require land mass for its cultivation. As we know land is limited and because of increasing population it is already been challenge to grow food and accommodating such large population. Besides developing the bio composites using algae biomass, another way to counter the plastic pollution is ‘plastic biodegradation using algae’. Algae can colonize on the surface like poyethene and its adhesion will initiate the biodegradation because of the production of enzymes like ligninolytic and exopoly saccharide. Application of algae is not limited to only bio composites, algae has potential to contribute in electricity generation also. According to the research the calorific vale of dehydrate algae is approx 12MJ/kg, which is considerable. Other

applications of algae bio mass are wastewater treatment and sequestration of the carbon.

ITRS243
Reciprocating wear characteristics of AISI 1040 steel at varying relative humidity and operating temperature

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Abstract: AISI 1040 steel is medium carbon steel. It is used in heat resistant structures and cold welded parts such as keyways, axles, bolts, studs, shafts. The present work focuses to investigate the reciprocating wear characteristics at varying load (10-100 N), operating temperature (ambient-200°C) and relative humidity (30-70%). Taguchi's experimental design is adopted to reduce the number of trials. Reciprocating wear occurs due to small amplitude vibration between mating parts which may cause fretting fatigue and catastrophic failures. A ball-on-plate configuration tribometer is used to carry out the tests with E52100 as the counterface ball. Stainless steels balls are preferred over ceramic balls because of brittle nature of ceramics under high load and sliding velocity which can cause fracture whereas stainless steel balls can yield before failure. The stroke length and frequency is kept constant during the tests. The mass loss of AISI 1040 steel is obtained pre and post tribological tests from which the wear rate is calculated. The coefficient of friction (COF) is also measured on-time. Optimization of wear rate and COF is carried out using grey relational analysis. The predicted optimal tribological behavior is obtained at 10 N load, 200°C operating temperature and 70% relative humidity. The highest significance is observed for operating temperature followed by normal load and relative humidity. All the worn specimens were observed under optical microscope to investigate the wear mechanism. At higher temperature, presence of oxide glaze is seen. This is concluded to be the reason for optimal tribological behavior at high temperature. The high relative humidity also aids the formation of oxide glaze at optimal condition and is expected to provide a lubricating effect. The dominant wear mechanism is found to be abrasive and adhesive within the experimental domain.

Keywords: AISI 1040 steel, Reciprocating wear, High temperature, Relative humidity.

ITRS244
Experimental Investigation of the Effects of Engine Cylinder Honing as Tribological

Aspect on Performance, Wear and Lubrication

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Abstract: The Piston Ring -Cylinder Liner contact is the single largest contributor to frictional losses in an internal combustion (IC) engine, causing 20-40% of all mechanical losses. If these mechanical losses can be reduced by 10% then vehicle fuel efficiency could be increased by approximately 1.5-2.5%. In order to reduce losses through friction, a frequent strategy involves modifying the topography of the contact surface between the cylinder bores and the piston rings. In order to minimize such losses, it is important to optimize the liner surface topography by a consistent and more productive finishing process such as honing. Thus, fuel and oil consumption and greenhouse gas emissions are decreased with increasing engine life and its durability. According to the literature survey, various honing techniques have been used and the generated surfaces with various surface roughness parameters have been characterized using numerical calculation but the tribological properties and advantages of different honing angles have not been yet investigated in the literature using pin-on-plate tribometer friction tests. In this original and innovative work the Diesel engine cylinder liner surface was honed with cross-hatch angles such as (20°, 30°, 40°, 45° and 60°) then they have been cut precisely (10X13X10 mm). Taking into account formal test conditions, their tribological performance was evaluated through a very sensitive reciprocating tribometer, using steel ball (100 Cr6) on a variable honed cylinder liner using 5W-40 engine oil to investigate their wear and friction behavior in boundary lubrication regime. The optimum angle and micro-nano roughness behavior with lower friction improving lubrication, reducing of friction and wear is determined and the rubbed surfaces as well as all additives were analyzed through 2D-3D roughness digital optical microscopy, SEM-EDX and AFM analysis.

Keywords: honing, optimum angle, topography, lubrication

ITRS245
Dry Sliding Wear Behavior of Magnesium Metal Matrix Composites: A brief review

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Abstract: Magnesium is the lightest metal, 33% lighter than aluminum, and 75% lighter than stainless steel, and it is the sixth most abundant element in the earth's crust. Magnesium has recently received greater attention because of its low density, high specific strength, and high damping capacity, as well as its outstanding castability, recyclability, and biodegradability. However, the poor corrosion resistance and Low wear resistance hinder their applications. Many studies have focused on improving the corrosion resistance and wear resistance of magnesium by adding alloying elements and ceramic reinforcement particles. However, the wear behavior of magnesium and its composites is not well understood. The current study summarizes the research

related to the tribological performance of the magnesium metal matrix composites. The effects of particle size and quantity of various reinforcements such as SiC, TiC, SiO2, Boron Nitride, Al2O3, TiB2, CNT, graphene nanoplatelets (GNP), and graphite on tribological behavior are explored. In addition, the effect of dry sliding wear parameters such as applied load, sliding speed, and sliding distance on wear, and coefficient of friction or discussed. to and how factors such as reinforcement materials, applied load, sliding speed, and sliding distance affect wear behavior have presented.

Keywords: Magnesium metal matrix composites, Dry sliding wear, Wear rate, Coefficient of friction, Wear Mechanism

ITRS246

Tribocorrosion of Magnesium and its alloys in Biomedical Applications: Overview and Current status

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Abstract: The future of biomaterial design will rely on temporary implant materials that degrade as the damaged tissue regenerates, releasing no toxic species during degradation and no residue after complete regeneration of the targeted anatomic site. In this aspect, Mg and its alloys are receiving increasing attention because of their similar mechanical strength that of human bone and biodegradability. Yet, their use as biomedical implants is limited due to their poor/uncontrollable degradation. Several parameters influence implant degradation and performance; however, the literature showed that wear, corrosion, and combined action of wear and corrosion, nominally known as tribocorrosion of implant materials, are the primary concern and driving mechanisms in the degradation processes. After successful in-vivo implantation, the implant metals are constantly exposed to tribological events in the presence of corrosive solutions, that is, body fluids lead to Tribocorrosion. This synergism (Tribocorrosion) results in degradation and, hence, loss of material that is often much larger than expected by simply summing up the degradation due to individual processes. Tribocorrosion has been proposed as one of the crucial degradation mechanisms of implants and recently saw significant progress in mechanistic understanding and modeling. There has been promising research on the wear and corrosion of Mg materials and their mechanisms. However, there has been no systematic literature review on the tribocorrosion of magnesium and its alloys. This review provides the reader with an overview of current biomaterials, their stringent mechanical and chemical requirements, and Mg alloys' potential to fulfil them. The current study explains the insight into synergy between tribology and corrosion and further explains the electrochemical techniques and evaluation methods used in tribocorrosion research.

Keywords: Magnesium, Wear, Corrosion, Tribocorrosion, Orthopaedic Implants

ITRS247

Insitu imaging to identify scratch damage of BCR 692 reference DLC coating

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Abstract: Coatings is one of the widely used surface modification method which enhances the tribological performance of a system. Though distinct changes in acoustic emission (AE) and frictional force (FF) indicate damage events during scratch, visual inspection using microscopy is the most reliable way to determine the failure mechanisms of the coating. In this study we report the scratch damage mechanisms of a certified reference material, DLC coating (BCR 692), developed by the Institute of Reference Materials (IRMM) and Measurements, European Commission Joint Research Center, Belgium. Friction force and acoustic emission were acquired in real time during the scratch test combined with integrated imaging of the entire scratch track. Data from al the sensors as a function of scratch length were superimposed on the stitched scratch image to identify and measure the cohesive and adhesive failure modes and critical loads. Initiation of edge cracks marked the first critical failure for BCR 692 sample and this correlated well with the acoustic emission signal thereby unambiguously establishing formation of edge cracks. Further progressive damage with increasing loads lead to edge spallation and central cracking which could be simultaneously identified from the image, acoustic emission intensity as well as change in traction force. The critical failure loads for the cohesive (Lc1) and multiple adhesive failures (Lc2 and Lc3) were determined by measurement of the location from the origin of the scratch. In-situ images correlated well with the Lc1, Lc2 and Lc3 failure atlas for BCR 692. The reported failure loads for all three scratches on BCR 692 were within the precision limits reported by the standard.

Keywords: Scratch, Adhesion Strength, In Situ Imaging, Acoustic Emission,

ITRS248
Repeatability of Friction and Wear of Different MaterialPairs at 1000 °C under Unidirectional Sliding Motion

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Abstract: High temperature tribology (>600 °C) influences operations in metals, energy, mining and transportation industries. Tribometers are used to study the impact of different factors on friction and wear at high temperature. Temperatures up to 1000 °C pose a significant challenge in terms of stress on the test instruments and stability of the tests results. There is no agreement to date to assess the quality of data generated at high temperature and how the repeatability of such harsh tests should be determined. In this study we analyzed the friction and wear behavior of six tribopairs at high temperature, considered as possible reference material for high temperature tribology. The samples used were in the form of balls (silicon nitride, sapphire, alumina) and disks (Inconel 725, gas pressured sintered silicon nitride). The tests were conducted in a unidirectional sliding motion (rotation), under a 5 N load, both at ambient temperature and 1000 °C. At ambient temperature, friction followed an increasing trend for all tribopairs, whereas at 1000 °C the increase in friction over the test time was minimal. In the case of alumina ball on

IN 725 disk, the wear on the ball increased at high temperature; in all the other cases, the wear on the ball was lower at 1000 °C. The repeatability of friction and wear results varied with the test temperature: at room temperature, friction showed greater repeatability than wear (average coefficient of variation of 15.77% and 38.97%, respectively); at 1000 °C, the average coefficient of variation for friction decreased to 8.66%, but the wear results were more scattered, with an average coefficient of variation of 109.54%. Based on the lowest coefficient of variation, reference materials identified for repeatability and precision in 1000 °C tribology are Alumina on IN 725 for wear and sapphire on GPS silicon nitride for friction. We believe that this will serve as a calibration standard for high temperature tribology and enable the benchmarking of the newer coatings, high entropy alloys and additively manufactured materials being developed by the scientists

Keywords: Coefficient of Variation, 1000 deg C, Friction, Wear.

ITRS250

Effects of Viscosity Variation on Frictional Force of an Elliptic plate using Squeeze Film Technique

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Abstract: Effect of viscosity variation in elliptic plate considering squeeze film technique using couple stress fluid as lubricant is taken up for study. Expression for pressure, friction force, load carrying capacity are derived from the modified Reynolds equation considering viscosity variation effects. The effect are compared with the non viscosity variation problem.

Keywords: Couple Stress Fluid, Elliptic Plate, Frictional Force, Viscosity Variation.

ITRS251

Effects of Viscosity Variation on Frictional force of a Triangular Plates Lubricated with Couple Stress Fluid

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Abstract: A theoretical study is made in this paper to analyse the effect of viscosity variation on frictional force of a porous triangular plates lubricated with couple stress fluid considering squeeze film technique. Modified Reynolds equation is derived. The impact of varying viscosity on pressure, frictional force and load carrying capacity is analysed for various parameters, and the effect on it is discussed.

Key Words: Couple-stress fluid, Frictional force, Triangular plates, Squeeze Film Technique Viscosity variation.

ITRS252
MICROSTRUCTURE AND MECHANICAL PROPERTIES OF DOUBLE-SIDE FRICTION STIR WELDED AA7075-T651

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Abstract: High strength, precipitation hardening 7000 series aluminum alloys such as AA7075 are extensively used in numerous applications and they are regarded to be difficult to weld by traditional fusion welding methods. Friction stir welding, being a solid state joining process, is proved to be a viable technique to successfully join these high strength alloys, in particular AA7075. However, the friction stir welding causes reductions in weld properties and the reduction is more pronounced in thicker welds. Double-side friction stir welding is considered to be one of the possible solutions to address the problem of weld property reductions. In this study, 10 mm thick AA7075-T651 plates were friction stir welded from both sides and the welds were evaluated for mechanical properties using tensile, hardness and impact tests. Optical and scanning electron microscopies were also used to examine the weld microstructures and the nature of tensile fractures. It was found that the double-side friction stir welded joints exhibit higher hardness values across the joint compared to that of normal single-side friction stir welds. It was also observed that double-side friction stir welding results in better tensile properties. The reasons for improvements in the weld properties are discussed, connecting mechanical behavior and weld microstructures.

Key words: Double-side friction stir welding, Aluminum alloy 7075, Optical microscopy, Tensile properties, Impact toughness

ITRS253
Fatigue performance of the Al-Mg/$MgAl_2O_4$ in-situ composites synthesized through MnO_2 and CuO reinforcement

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Abstract: This research work focus on the novel approach for synthesizing in-situ Magnesium Aluminate ($MgAl_2O_4$) particles in the Al-2Mg alloy by addition of MnO_2 and CuO precursor addition (1 wt %, 1.5 wt % and 2 wt %) during the casting process. Al-2Mg alloy was prepared using the pure aluminium and commercial grade pure magnesium in an electric resistance furnace. MnO_2 and CuO precursor with varying wt.% (1, 1.5 and 2 was taken as the oxide source and added into the Al-2Mg melt. The fabricated Al-2Mg/$MgAl_2O_4$ in-situ composite specimens (1, 1.5 and 2 wt %) were subjected to low cycle fatigue testing at two different strain amplitude of 0.3 % and 0.4 % and at the frequency of 0.3 Hz. Among all the composite specimens, the specimens reinforced with 2 wt % MnO_2 and 2 wt % CuO outperformed when tested in strain amplitudes of 0.3 % and 0.4 % respectively.

Keywords: Aluminium, $MgAl_2O_4$, in-situ composites, Fatigue, MnO_2 and CuO

ITRS254
The role of process parameters on laser cladded Stellite 6 geometry: A statistical approach

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Abstract: Laser cladding is an advance surface modification and/or additive manufacturing technique, used for repair/rebuild the damaged surfaces. Stellite 6 (Co based) is a hard alloy used in high wear, corrosion and heat resistance conditions. This paper deals on the effect of process parameters on Stellite 6 clad geometry deposited using laser cladding process. Here, laser power (*P*), scan speed (*V*), and powder feed rate (*F*) are varied at different levels using Response Surface Methodology and investigated for clad geometry. The geometrical characteristics include clad width (w), clad height (h), penetration depth (b), wetting angle (θ) and deposition efficiency (η). Empirical models are developed from the experimentally obtained results and further a correlation is established between the clad geometry and input parameters. The analysis show that scan speed has most significant impact on clad height and wetting angle. The increase in laser power shows greater effect on clad width than scan speed and powder feed rate. With decrease in scan speed, laser power and increase in feed rates, the deposition efficiency increases; showing a linear relationship with powder feed rate. The clad height and wetting angle are linearly varying with the line mass. The study concludes in finding the process parametric range in order to achieve a specified clad geometry or vice-versa.

Keywords: Laser Cladding, Stellite 6, Empirical Model, Clad Geometry, Process Parameters

ITRS255
Nanoindentation Simulation of Gallium Nitride Film Grown in Different Orientations on a Sapphire Substrate using Finite Element Method

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Abstract: Gallium nitride is very popular material for optoelectronic applications such as LED devices, High electron mobility transistors (HEMTs), etc. for its higher bandgap leading to greater performance. It is very expensive to grow freestanding GaN layers, therefore, it is normally grown on substates like sapphire, or silicon. C-plane growth is the most common, but because of higher number of defects due to higher mismatch strain between sapphire, and gallium nitride layer, it is also grown in other orientations, such as a-plane, m-plane, and r-plane. These devices are very sensitive to changes in mechanical strain as small change in strain can cause drastic changes in optoelectronic performances. Therefore, we have conducted nanoindentation based numerical investigations to understand the deformation pattern in various growth orientations of gallium nitride as discussed above. The freestanding gallium nitride material of 10-micron thickness, gallium nitride film layer of 100 nm, 500 nm, and 1 micron thickness grown on 10-micron thick sapphire substrate in c-, a-, and m-plane were modeled using commercial finite element analysis tool, ABAQUS 6.14. Mismatch strain between the film and the substrate was considered appropriately. Two-dimensional axisymmetric models of both indenter, and the film substrate system were modeled in ABAQUS CAE. The indenter was modeled as rigid body while the film substrate system was assigned with transversely isotropic material properties. The displacement control load was applied to evaluate the forces at different indentation depths. Freestanding gallium nitride bulk material load-indentation depth result obtained through this study was compared with the experimental result available in the literature and found to be in complete agreement. The study can be very useful in terms of understanding mechanical integrity of the thin film grown on thick substrates applicable to various application areas such as optoelectronic devices.

Keywords: Optoelectronic devices, Gallium nitride film on sapphire substrate, Mismatch strain, Growth orientations, Nanoindentation modeling, Deformation pattern.

ITRS256
Sustainable Cutting Fluids: A Review

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Abstract: Lubrication technology is continually changing to meet new challenges and open up new possibilities. Decreased emissions, higher durability, longer service intervals, and reduced friction are all being pushed in all applications, all of which lead to lower energy use. The usage of petroleum-based cutting fluid endangers both employees' and the environment's health. As a result, industrialists and researchers are collaborating to find user-friendly and environmentally

favourable alternatives to traditional petroleum-based cutting fluids. Vegetable oils are gaining popularity as a result of their superior lubricating characteristics, ease of supply, biodegradability, low cost, and nontoxicity. In this study, a comprehensive evaluation of studies on the use of vegetable oils as cutting fluids is undertaken. One goal of this evaluation is to highlight the advantages of vegetable oil-based cutting fluids that operate similarly to mineral oil-based cutting fluids and to look at how vegetable oils have evolved as cutting fluids in the manufacturing industry Another topic that was investigated was that of Protic Ionic Liquids (PILs). Ionic Liquids (ILs) were proposed as an alternative for conventional cutting fluids by 2001 due to their excellent lubrication properties, low vapour pressure, non-flammability, thermal stability, and wide liquid range. PILs are the most researched ILs in the last decade because of their excellent biodegradability and their potential to be added in both water-based fluids and hydrocarbon-based fluids and as stand-alone cutting fluids. The tribochemical thin layer with low shear strength on engineering surfaces is produced by the structured structure of formed ions in ILs, which is driven by Coulombic contact and intrinsic polarity and lowers friction and wear. They can be tailored for a distinctive application by keeping in mind that a small change in anion structure, cation structure, or both can change the physical and chemical properties of the liquid. The physicochemical, friction-reducing and anti-wear properties of different PILs have been explored in recent years using methodologies such as FTIR spectroscopy, corrosion tests, EDS analysis and tools such as viscometer, scanning electron microscopes and optical microscopes, and tribometers. The results from these studies compared their properties with commercially available alternatives such as synthetic base oils which showcased their superior qualities.

Keywords: Cutting fluids, Vegetable-based cutting fluids, Sustainability, Green fluids, Protic ionic liquids, Friction, Wear

ITRS257

Tribological performance evaluation and ANN-assisted prediction of halloysite, montmorillonite, and wollastonite filled friction composites

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Abstract: Composite friction materials were fabricated based on natural silicates such as tubular halloysite, platy montmorillonite, and acicular wollastonite using the compression molding technique with and without the presence of MgO. The mechanical, thermo-mechanical, and tribological performance attributes of the natural silicates-based composite friction materials were evaluated. The morphology and hardness of the natural silicates dominated the mechanical and tribological responses of the friction materials. The worn surface morphology revealed the natural silicate assisted interfacial phenomenon during sensitivity analysis under the operating variables i.e., braking load, sliding speed, and temperature. The sliding induced tribo-layers were characterized with elemental mapping and Raman spectroscopy. All the performances of natural silicate-based friction materials were systematically evaluated with respect to the silicate and

silicate-MgO free composites. In this regard, halloysite-based friction materials showed excellent wear resistance, and in presence of soft abrasive MgO wollastonite-based friction composites retained the friction coefficient (□0.43- 0.61) under variable operating parameters. The artificial neural network assisted modeling with optimally tuned network architecture predicted (R^2 □ 97 %) the tribological performance attributes of the natural silicate-filled friction composites more accurately as compared to the conventional Rhee's and Archard's equations.

Keywords: Natural silicates, braking load, sliding speed, temperature, artificial neural network.

ITRS258

Improvement of Wear Resistance for Marine Steel using SiC and TiB_2 Ceramic Coating with HVOF technique

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Abstract: Steel has been a primary material in construction and industrial applications of marine systems. It has been affected by its inherent property of poor wear resistance when subjected to harsh conditions. This has been a major reason leading to reduction in the overall operational life of such steel-based components in service. Surface modifications are noted for being an effective solution to overcome these problems. To limit such damages, a study has been made to check the performance of Silicon Carbide and Titanium Diboride based coatings on marine steel. The ceramic coating is performed on the steel using thermal spray approach by employing High Velocity Oxy Fuel technique. A microstructural and mechanical analysis has been performed on both coated as well as uncoated specimens to analyse the surface modifications by the coating process. A mechanical wear test is performed for the specimens using pin-on-disc tester to understand the wear behaviour of the coated approach. Based on the test results it can be observed that the application of Silicon Carbide and Titanium Diboride coatings has shown an improvement in wear resistance. This improvement is attributed to the improvement in hardness of the surface. Thus, indicating that inert material-based surface modifications can be an effective way to improve the wear resistance in steel.

Keywords: Ceramic Coating, Thermal Spray, Corrosion Resistance, Surface Modification, Marine Steel

ITRS259

Experimental investigation on impact of sio_2, tio_2 and al_2o_3 as nano additives in tribological properties of sn500 base oil and optimization of additives composition by taguchi technique

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Abstract: In the past few decades, the development of nano phased materials has led to extensive research on the use of nanoparticles as lubricant additives. Lubricants play a vital role in the performance of a machine, machine life, wear rate and friction. Several studies have proved that the tribological properties of lubricants with nano additives are far better than that of traditional virgin lubricants. The poor performance of a lubricant cause's significant energy and material losses to the subparts. Hence, to improve the lubricating properties of the oil, nanoparticles can be added as additives to SN-500 base oil. Micro structures, and particle size of the above compounds were investigated using FE-SEM (Field Emission-Scanning Electron Microscope). Nano additives of TiO_2, $Al2O_3$, SiO_2 in the oil were prepared in different weights percentages. Trails of friction and wear was carried out on pin disc tribotester, under different loads, different speeds and pins. The results of the experiment are compared with that of a DOE (Design of Experiments) analysis done on Mini Tab Software, to find the optimum conditions and components for the best possible results.

Keywords : Wear, friction, lubricant, additives, Design of Experiments

ITRS260

Wear characteristics of Hot Dip Aluminized of Mild Steel

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Abstract : Steel remains one of the important engineering material due to its ability to develop wide range of microstructures and mechanical properties and its availability at low cost. However its resistance to environmental degradation and abration are poor and hence the researchers are continuously working towards the improvement of corrosion resistance and wear resistance of steel through surface engineering. The diffuaion of aluminuim into the surface of steel know as aluminizing, found to be better choice for modifying surface of steel and hence improve the corrosion resistance and wear resistance of steel. In the present work, mild steel specimens were dipped into molten aluminium at different dipping time. The samples were then subjected to metollographic study to determine coating thickness and X-ray study to identify the intermetallic phase evolution. The dry sliding wear tests were carried out for hot-dip aluminized mild steel using pin-on disk machine. The results clearly indicates that formation of intermetallic layer of type Al_xFe_y during hot dipping due to diffusion of aluminium into steel. The intermetallic layer thickness increases with diffusion time and has significatnt influence on wear behavior of mild steel.

Key Words: Aluminizing, Hot dipping, Intermetallic layer, Wear, Coating

ITRS261

Effect of post processing on microstructure and mechanical properties of additive manufactured Inconel 718

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Abstract: The laser based additive manufacturing techniques are widely used for refurbishment of worn out components. The post-processing treatments were performed on additive manufactured parts for improving the material properties and to meet the functional requirements. In this study, multi-layered cladding of Inconel 718 (nickel based) alloy is performed using laser-aided direct energy deposition technique. The fabricated samples are subjected to two different stages of heat treatment namely (i) solution treated and (ii) solution treated plus direct aged, aiming to enhance mechanical and microstructural propreties of the deposit. Microstructural observations are carried using scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS) and microhardness measurements were done using Vickers indentation tester. Further, the influence of different stages of heat treatment on microstructure formation is investigated individually for all samples. The heat treatment results show that at different stages, the morphology and hardness differ irrespective of the number of layers. In addition, solution treatment at high temperature with direct aging reveals precipitation of γ′ (Ni_3Ti) and γ′′ (Ni_3Nb) phases in Ni-γ matrix. Further, 50-60% increment in microhardness was obtained in all multi-layered samples, also the two stage heat treatment process has given better results.

Keyword: Laser-aided direct energy deposition, Inconel 718, Heat treatment, Microstructure, Microhardness.

ITRS262

Effect of laser surface texturing on the tribological behaviour of aluminium-silicon (Al-Si / Al2O3) advanced composite under dry and lubricating conditions

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Abstract: In the present work, modification of aluminum-silicon (Al-Si) alloy surfaces is performed using laser texturing (LT). An investigation is carried out to study surface texturing (ST) effects on friction and wear reduction mechanism. LT with different patterns, i.e., dimple (T1), square (T2), triangular (T3), and line hatched (T4) texture are done on the alloy surface.

The tribo tests are carried at 10 N load, Hertzian contact pressure (P_{max}) 708.7 MPa, 1 mm stroke, 50 Hz frequency for sliding distance up to 450 m. The friction and wear behavior of the non-textured surface (NTS) and textured surface (TS) are analyzed under dry sliding conditions (DSC) and lubricating sliding conditions (LSC) [i.e., virgin PAO-4 and PAO-4 + 1 wt. % graphene nanoplatelets (GNP)]. T2 texture reveals a 49.53%, 69.21% and 44.91% decrease in friction coefficient (COF) and 58.1%, 43.74% and 83.86 % decrease in wear volume than the NTS for DSC, virgin PAO-4 and PAO-4 + 1 wt. % GNP, respectively. Results show that ST improved friction efficiency, and shortened the running-in period. The current study results help to provide in-depth interpretation of micro-texturing and its relationship w.r.t. tribological characteristics.

Keywords: laser surface texturing (LST), friction, wear, lubrication, aluminium-silicon, aluminium oxide.

ITRS263

Prediction of abrasion wear properties of eggshell powder filled polymer composite using Taguchi design integrated with quadratic regression modelling and desirability approach

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Abstract: Polymer composites are widely used in load bearing structures and wear related situations in industrial sector. Polymers and their composites form a very important class of tribo-engineering materials and are invariably used in mechanical components, where wear performance in non-lubricated condition is a key parameter for the material selection. The production and worldwide use of chicken eggs on an industrial or domestic level leads to a considerable quantity of shell residue, which is considered as a waste or is used as a complement in agriculture. Use of waste materials in polymer matrix composites is on the rise mainly due to environmental and economic apprehensions. The objective of the present research is to investigate the effect of eggshell powder (ESP) as a filler material on mechanical and sliding wear properties of glass/epoxy composites. The composites are prepared by varying the weight content of ESP with a constant glass fiber loading by hand layup technique. The mechanical characterizations are done as per ASTM standards. Dry sliding wear tests of the composites are conducted as per L_{25} Taguchi design. An optimized parametric combination of control factors is established for minimum wear loss of composites. The results revealed that addition of ESP improved the wear resistance of the composites. Furthermore, a quadratic regression model is developed to predict the specific wear rate of the composites. Confirmation test was conducted showing the acceptability of the predictive model based on desirability approach.

Keywords: Eggshell powder, composite, Taguchi design, quadratic regression model, desirability approach

ITRS264
High temperature dry sliding Wear behaviour of cold sprayed Inconel 738 coating

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Abstract: The present investigation deals with dry sliding wear behaviour of cold sprayed Inconel 738 (IN 738) coating up to 600°C. The coating was deposited by a high-pressure cold spray system using Helium as the propellant on low carbon steel substrate. The dry sliding wear behaviour of uncoated specimens is compared with IN 738 coating using pin-on-disc tribometer (ASTM G99). SEM, EDX and XRD analysis provides better insights on worn surface morphology, changes in oxide scales and phase transformation. At 400°C, the tribo-layer developed at the interface contains NiO, which is a lubricious oxide. Therefore, the wear rate of the coating decreases. Further increase in temperature up to 600°C, forms a protective layer, which results in the enhancement of high-temperature dry sliding wear resistance of the coating. At 600°C, sliding wear resistance offered by the coating is approximately four times higher than T11 low carbon steel. Therefore, the cold sprayed IN 738, promises potential applications where higher dry sliding wear resistance at elevated temperatures is the primary objective.

Keywords: Dry sliding; Cold spray coatings; Inconel 738; high-temperature wear, EDX.

ITRS265
Microstructural and Sliding Wear Investigation of Co-based Microwave Cladding on Stainless Steel

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Abstract: Partial dilution of clad powder and the substrate to form a new protective layer is called cladding. The present work mainly focuses on a novel development in surface engineering techniques in the form of microwave cladding. Microwave clad of CoMoCrSi+Cr3C2 on austenitic stainless steel (SS-316) was developed by exposing the preplaced powder for a duration of 30 minutes to microwave radiation at 2.45 GHz frequency and 900 W power in a domestic microwave system. After the clad was developed, characterization in the form of microstructure and hardness were carried out. Substrate and clad samples were subjected to sliding wear test under room temperature conditions. Investigation of the clad microstructure

shown crack-free interface revealing good metallurgical bond associated with partial dilution of the stainless steel substrate and partial melting of CoMoCrSi+Cr3C2 particles. Reinforcing of Cr3C2 particle improved the hardness and wear performance of clad.

Keywords: Microwave Cladding; SS-316; Chromium Carbide; Partial Dilution; Wear

ITRS266

Influence of Normalized enthalpy on the Morphology of Direct Metal Deposited Inconel 718

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Abstract: Morphology of each layer contributes to the final shape of the component fabricated by direct metal deposition process, since it's layer-on-layer fabrication technique. Hence, it is a requisite to understand the layer morphology evolution and the factors affecting. The present work deposited single tracks of Inconel 718 by systematically varying input parameters, and investigated their effect on the track geometry. The parameters varied in the study are laser power (P), scan speed (V), and powder feed rate (F). Linear heat input, volumetric energy density, line mass, and normalized enthalpy are considered as the combined parametric effect. Cross-sections of the deposits are observed under optical microscope, and the morphology i.e., width (w), height (h), depth of penetration (b), and dilution % (D) are measured. The geometry variation with input parameters either individually or in combination are investigated and correlated. These investigations revealed a good relationship between input parameters and the morphology. Of these, normalized enthalpy is observed to be a valid measure in predicting the track geometry than others; which considers thermo physical properties along with input process parameters. This also found to be suitable to assess the complex melting, solidification, deposition phenomena and thereby clad morphology. The results have shown a linear relationship between width and normalized enthalpy; and height is observed to be increasing with line mass. Henceforth, the study helps in developing a statistical model to predict clad geometry.
Keywords*:* Direct Metal Deposition, Clad Geometry, Parametric Effect, Volumetric Energy Density, Normalized Enthalpy.

ITRS267

Wear characteristics of red brick dust-sisal fiber epoxy composites: A parametric analysis using response surface method and neural networks

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Abstract: Red brick dust (RBD) is one of the biodegradable constructional wastes which can improve the strength of polymer composites. It is the waste or leftover powder, or the powder formed from deformed bricks in the process of their manufacturing. Bricks can be deformed while handling and the deformed bricks cannot be used for construction purposes; hence, they are dumped as waste. The major constituents of RBD (density about 1.837 g/cm^3) used are silicon oxide, aluminum oxide, and calcium oxide. Although a number of ways for its utilization have been suggested in the past, its potential as a filler material in polymeric matrices has not yet been explored so far. This research is focused on the study of the tribological properties of epoxy composites reinforced with red brick dust and sisal fiber. Dry sliding wear trials are conducted under different test conditions following the L_{16} model of response surface method (RSM). A parametric appraisal of the wear process is made using RSM and the significant control factors and their interactions influencing the specific wear rates are identified. Scanning electron microscopy of the worn composite surfaces is done to ascertain the wear mechanism. It is found that the presence of sisal fiber improves the wear resistance of red brick duct composites substantially. Further, prediction of wear rate of the composites for a wide range of filler content and sliding velocities is conducted using RSM and another prediction model based on artificial neural network and the outcomes are compared. This study also reveals that these composites are found appropriate in tribological areas as well.

Keywords: Red Brick Dust, Sisal Fiber, Response Surface Method, Scanning Electron Microscope, Artificial Neural Network.

ITRS268

An Investigation on Tribological Properties of Rail and Wheel under Different Environmental Conditions using Pin-on-Disc Tribometer

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Abstract: Railways are one of the largest networks in the world and play vital role for the socio economic development of any country. In railways, there is always rolling and sliding contact between rail wheel and rail tracks. The wear and friction are the most prominent phenomenon which occur between the rolling and sliding contacts and result in significant changes at macro and micro levels in rail and wheel materials over a period of time. From the past studies, it has been observed that apart from the dynamic loading and speed, several environmental factors like temperature, relative humidity, precipitation, etc. also plays an important role. Furthermore, this will affect the friction and wear mechanism between wheel and rail interfaces. The present paper focuses on the study of these two important factors with the help of the pin on disc tribometer on the different environmental conditions as well as fixed loading condition at different

temperatures. In present investigation the pin and disc are made up of railway track and boggy wheel material, respectively. The tests are conducted for different loads, speeds, ambient temperatures and humidity levels. The experimental results clearly reveal that the wear and friction increases rapidly with increase in loading and speed up to an extent and thereafter becomes constant. Wear and friction decreases with increase in humidity and increases with ambient temperature. Furthermore, it was observed that at higher humidity or precipitation, wear and frictional losses are negligible.

Keywords*:* Rail; Wheel; Friction; Wear; Humidity; Temperature.

ITRS269

Physical, Mechanical and Dry Sliding Wear Characterization of Kota Stone Dust and Fly Ash Filled Hybrid Epoxy Composites

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Abstract: Kota stone dust (KSD) and fly ash (FA) are the wastes generated from the construction industry and thermal power plant respectively. KSD is generated by the Kota stone processing unit in huge quantity. Fly ash is the waste residue created during the combustion of coal. This paper reports on the utilization of these wastes as a filler material for the development of a new class of particulate filled polymer composite. Epoxy-based composites are prepared with different weight proportions of KSD and FA using simple hand lay-up method. The prepared samples are tested for their physical, mechanical and dry sliding wear behaviour. Density and void content increases with increase in the either of the filler content. Water absorption rate also increases with increase in filler content and immersion time. Under mechanical testing, samples are tested to evaluate tensile, compressive, flexural hardness properties of the material. From the mechanical testing, it has been found that compressive strength and hardness of the material increases as a function of filler content but, tensile and flexural strength decreases for high filler content. Wear trials are conducted using a pin-on-disc test apparatus based on the Taguchi's L_{16} orthogonal array. The effects of different parameters on the specific wear rate of the composites are studied and an optimum combination of parameters is obtained for the least wear rate. Based on the experimental data, a prediction model using the artificial neural network is used to predict the specific wear rate of the composites at a wider range of operating parameters, within and beyond the test region. The morphologies of the worn surfaces are studied by a scanning electron microscope to ascertain the wear mechanism of the composites at different conditions. This work thus opens up a new avenue for the value-added utilization of wastes like KSD-FA in light duty structural and tribological applications.

Keywords: Epoxy, Kota Stone Dust, Fly Ash, Physical Properties, Mechanical Properties, Sliding Wear, Scanning Electron Microscope, Artificial Neural Network.

ITRS270

Corrosion and Wear Behavior of Stir Cast, Brick Powder Reinforced, Aluminum based Metal Matrix Composites

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Abstract : Aluminium alloys are widely used in numerous engineering applications due to its good mechanical properties, high strength, sufficient hardness, good weldability and high corrosion resistance. One of the important aluminium alloys is Al 6061 that is used mainly for marine frames, aircraft frames, heat exchangers, heat sinks and fasteners. Although Al 6061 shows superior properties, an enhancement in the properties like corrosion and wear resistance can be done by preparing metal matrix composites (MMCs) with better reinforcement materials. It is a well known fact that the properties of MMCs greatly depend on the quality of reinforcement materials employed in the metal matrix. For present work, four Al 6061 based MMCs have been manufactured with brick powder (reinforcement material) by stir casting. The MMCs have been manufactured by changing concentration (weight percentage) and size of brick powders: MMC1, 2 h ball milled and 1%; MMC2, 2 h ball milled and 7%; MMC3, 4 h ball milled and 1%; and MMC4, 4 h ball milled and 7%. The 0 h, 2 h and 4 h ball milled brick powders are analyzed by camera and field emission scanning electron microscopy (FESEM). The analysis clearly shows that there is a change in the size of brick powder after ball milling and increase in ball milling time. The formations of MMCs are analyzed by FESEM, energy dispersive X-ray spectroscopy (EDAX) and X-ray powder diffraction (XRD). The analysis confirms that the MMCs have been successfully manufactured. After manufacturing, these MMCs are tested for its corrosion and wear resistance. The wear resistances are tested on a pin on disc tribometer and the corrosion resistances are tested in 1 M NaCl by open circuit potential (OCP) curves, Tafel polarization curves (TPC) and electrochemical impedance spectroscopy (EIS). The results favor that increase in the concentration and decrease in size of the reinforcement material (brick powder) improves the corrosion and wear resistance of the manufactured composites.

Key Words: MMC; Al 6061; Brick Powder; EDAX; Corrosion Resistance; Wear Resistance.

ITRS271

Superconducting Magnetic Energy Storage (SMES) Supercapacitor application using Magnetic Graphene Oxide (MGO)

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Abstract: Current scenario, furtherance in Synthesis of hybrid nanocomposites using Magnetic Graphene Oxide [MGO] possesses distinct physical and chemical characterization, including nano scale, large specific area, paramagnetic and compatible make it a promising material for energy storage devices & which stores energy as charge on the electrode surface or sub-surface layer, than in the bulk material as in batteries. Research happenings in the field of Superconducting Magnetic Energy Storage [SMES] have gained great importance. Material advancement points that the mechanical properties of materials can be altered at the fundamental level, i.e. at the atomic-scale modification along with magnetisation. They can provide high power due to their ability to release energy more easily from surface than from the bulk. In supercapacitors charging-discharging occurred on the surface, which does not induce drastic structural changes upon electroactive materials, supercapacitors possess excellent cycling ability. In this, Fe_3O_4/GO is the electrode material synthesized by using Hydrothermal and Co-Precipitaion method, where as GO is synthesized using Hummer's method. Due to these unique features, Ultracapacitors are promising with high capacitance, good conductivity, low cost and ease of fabrication with relatively low mechanical stability and cycle life. Coupling the unique aspects are verified using techniques such as XRD, FTIR, UV-Visible, SEM, TEM, BET and further studies are carried out for the confirmation of electro- chemical properties.

Keywords: Superconducting Magnetic Energy Storage [SMES], Magnetic Graphene Oxide [MGO], hybrid nanocomposites, Hybrid supercapacitors.

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ITRS273
Theoretical Analysis And CFD Simulation On The Ceramic Monolith Heat Exchanger

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Abstract: The main objective of this work is to analyze heat transfer characteristics in the monolithic heat exchanger by ANSYS-Fluent CFD Software. Three different heat exchangers made of alumina, silicon carbide, and $CrCO_3$ are considered. The variables chosen for this study are hot air flow, cold airflow, and variable shape airflow passage (circular, oven, and hexagonal). The heat transfer characteristics revealed that Oval shape and $CrCO_3$ ceramic material are suitable for monolithic heat exchangers.

Key words: Monolithic heat exchanger, Al_2O_3, SiC, $CrCO_3$, CFD, ANSYS

ITRS274

Optimization of influencing parameters on friction and wear behaviour of AZ91D–B4C−Gr hybrid composite under dry sliding conditions

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Abstract: The tribological behaviour of bottom pouring stir cast AZ91D magnesium alloy with boron carbide (B4C) and graphite (Gr) were investigated. AZ91D magnesium alloy, AZ91D-B4C composite and AZ91D-B4C-Gr hybrid composite were fabricated separately to investigate their wear and frictional characteristics under dry sliding conditions. To conduct the experiments L9 orthogonal array method were chosen to study the effect of different sliding distances (0.5, 1 and 2 km) and different applied normal loads (5, 10 and 20N). The results showed that the wear loss and coefficient of friction (COF) were decreased for AZ91D-B4C-Gr hybrid composite when compared with AZ91D magnesium alloy and AZ91D-B4C composite. The hybrid composite hardness values are higher than that of AZ91D magnesium alloy. SEM analysis was carried out to study the predominant abrasive wear mechanism on the worn surfaces of fabricated composite pins. The analysis of variance (ANOVA) and F-test were used to form the rationality model and to govern the important parameters which are influencing the wear loss of the composites.

Key words: AZ91D; B4C; graphite; Wear; Friction; Composite; ANOVA

ITRS275

Influence of boron carbide content on dry sliding wear performances of AZ91D magnesium alloy

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Abstract: The exigency of AZ91D Magnesium alloy in automobile and aircraft industries are mainly due to weight reduction, and low CO2 emission with good mechanical properties. The present study aims to investigate the effect of boron carbide on dry sliding wear performance of AZ91D magnesium alloy. Boron carbide (B4C) reinforced magnesium metal matrix composites with different weight fractions (1.5 wt.%, 3 wt.% and 4.5 wt.%) were fabricated by bottom pouring stir casting process. Hardness test and Ultimate Tensile Strength (UTS) test was performed for all samples. To evaluate wear performance of the samples, three different loads (5N, 10 N, and 20 N) were applied at the room temperature. X-ray diffraction (XRD) analysis was used to find the various compounds present in the developed composites. Worn surfaces of the samples were characterized using Scanning Electron Microscope. Results show that the hardness, UTS and wear resistance of AZ91D magnesium alloy was improved with the addition of boron carbide extensively.

Keywords: Wear; Friction; Composite; AZ91D; B4C

ITRS276

Development of Core-shell Nanomagnetic Zn @ Fe_3O_4 Material for Energy Application

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Abstract: Energy application has gained a lot of importance in view of the fact that global energy crisis is increasing drastically. In current scenario, furtherance of secure and sustainable energy application were followed because of their extensive production and demand. Optimizing the Core-shell Nanomagnetic Zn @ Fe_3O_4 material for Energy Application is crisped, where ZnO was synthesized by Co-Precipitation method and Fe_3O_4 by Hydrothermal method. Due to these unique features, Energy application field are promising by focusing into high capacitance, good conductivity, low cost and ease of fabrication with relatively low mechanical stability and cycle life. The nanomagnetic material were structurally confirmed by the powder X-ray diffraction (XRD), Scanning electron microscope (SEM), Fourier-transform infrared spectroscopy (FTIR), UV-Visible, Transmission Electron Microscopy (TEM), Brunauer-Emmett-Teller (BET) surface area analysis is done and Electro-chemical studies are carried out for energy storage application. This work is accomplished to control the issues of poor

electrochemical stability, low conductivity and high rates of agglomeration. Therefore we believe that, this energy application can pave the way for high stipulation in imminent future.

Keywords: Core-shell, Nanomagnetic materials, Energy application, Co-Precipitaion method, Hydrothermal method.

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ITRS277

Investigation on Surface Roughness and Mechanical Performance with Numerical Analysis of Friction Stir Welded AA6082-T6 Alloys

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Abstract: Friction stir welding (FSW) is gaining popularity due to its Low distortion, void formation, and improved mechanical properties compared to other welding processes. In the current study, friction stir welding of 5mm thickness of AA6082-T6 alloy is executed with a tapered pin. The process parameters employed in this study are tool rotational speed and its traverse speed. The impact of these two factors on tensile strength, microhardness and surface roughness of FSW joints is investigated. The minimum surface roughness value is achieved at 1000 rpm rotational speed and 25 mm/min traverse speed. The maximum value of tensile strength is achieved at rotational speed and 25 mm/min traverse speed. The microhardness value is achieved as 118 HV at the weld stir zone. The numerical simulation of the FSW process has also been carried out with the same tapered pin. In the simulation process, temperature field, Von misses stress distribution, and equivalent plastic strain have been predicted using the Johnson-Cook model. The temperature profile shows that the predicted value is lesser than the melting point of the parent material. The stress profile reveals zero flow stress when the material is in contact with the tool. Hence, maximum tensile strength and minimum surface roughness

attainment during FSW are desirable to improve the service life and suitability of AA6082-T6 alloy. This study enables the welders to control the process parameters precisely.

Keywords: FSW, Surface roughness, Tensile strength, Microhardness, Temperature profile, Von misses stress, JC model

ITRS279
Improvement of Wear Resistance for Marine Steel using SiC and TiB_2 Ceramic Coating with HVOF technique

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Abstract: ASTM A131 AH36 Steel has been a primary material in construction and industrial applications of marine systems due to its versatility, low cost and availability. However, steel is inherently plagued by limited wear resistance when subjected to adverse conditions due to sub-sea terrain, wave impacts and marine ecology. This has been major reasons reducing the overall operational life of steel-based components in service and these problems can be mitigated by improving the hardness, chemical inertness and adhesion to the substrate. Silicon carbide (SiC) and Titanium Diboride (TiB_2) are noted for their hardness and ecologically inert behaviour. Steel surface has been coated with SiC/TiB_2 improve the wear resistance for the marine applications. Surface modifications are noted for being an effective solution to overcome these problems by enhancing the wear resistance of the marine AH36 steel surface In this research work the ceramic coating is performed using thermal spray approach by employing High Velocity Oxy Fuel (HVOF) technique. A microstructural and mechanical analysis has been performed on SiC and TiB_2 coated specimens to analyse the surface modifications by the coating process in terms of material composition, coating porosity and coating quality. A mechanical wear test is performed for the specimens using pin-on-disc tester to understand the wear behaviour of the coated approach. Based on the test results it can be observed that the application of Silicon Carbide and Titanium Diboride coatings has shown an improvement in wear resistance. This improvement is attributed to the improvement in hardness of the surface. Thus, indicating that inert material-based surface modifications can be an effective way to improve the wear resistance in steel.

Keywords: Ceramic Coating, Thermal Spray, Corrosion Resistance, Surface Modification, Marine Steel

ITRS280

Investigation on Tribological behaviour of AA7075 Reinforced with SiC & TiC Composites for Automobile Applications

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Abstract: AA7075 Aluminium alloys were predominantly used in the automobile and Aerospace applications because of their high strength, toughness, ductility, corrosion resistance and fatigue. But for the high stressed structural applications, the available strength is not sufficient and require some improvements. Internal Combustion engines engine produces low frequency vibrations at low operating speeds and these vibrations are transferred to the vehicle structure borne. Such vibrations are found to be dangerous and it reduces the life and reliability of the vehicle. Engine Mounts play important role in the reduction of vibrations and those engine mountings are generally made by elastomers supported by cast iron or steel, which has higher weight and poor corrosion resistance. When the mount supporting plates made by Aluminium metal matrix composites were found to be good solution to mitigate the vibrations. To enhance the required mechanical properties in the alloys for the fabrication of structural applications, carbides / oxides were added commonly with the base metal. In this research work, AA7075 MMC is manufactured through an ex-situ casting process with the Silicon Carbide (2.5 to 7.5 Wt%) and Titanium Carbide (5 Wt%) reinforcement. The dry sliding wear behaviour, tensile strength, and hardness of the MMC has been investigated. The hardness of the tested bar of AA7075 sample was found to be 83 HV which has been increased to 95 HV, 108 HV and 119 HV with the dispersion of 2.5% SiC & 5% TiC, 5% SiC & 5% TiC and 7.5% SiC & 5% TiC respectively. Similarly tensile strength has been increased from 70 MPa to 245 MPa. The pin-on-disc test was carried out to test and analyse sliding wear characteristics of the MMC considering the sliding velocity, load and temperatures as variable. The results of wear rate, coefficient of friction and wear debris were studied and analysed on the MMCs in respect of variation in the input parameters within the range considered. The results of abrasive wear tests on the MMCs showed that the wear loss of MMCs with 7.5% TiC & 5% SiC was decreased by 15% compared to the bare AA7075 samples.

Keywords: MMC, SiC, TiC, Dry sliding wear, Frictional coefficient, wear rate.

ITRS282

Exploration of cottonseed oil as an ecologically sustainable and new generation rust and oxidation inhibited type spindle oil lubricant

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Abstract: India is currently the world's largest cotton producer, with 108 to 115 million tonnes of excess cottonseed ready for processing each year. Seed oils play an essential role in the lubricant industry, and demand is growing steadily. Because of the rising demand for these seed

oils, it is vital to identify oils from non-traditional sources to meet requirements of the specific Applications. Cottonseed oil, employed in some food-based applications and in insecticide formulations, suggests they may be economically advantageous as a component in sustainable industrial fluids. Cottonseed oil includes 70 percent unsaturated fatty acids, including typically around18 percent oleic, 52 percent linoleic, and 26 percent saturated Palmitic and Stearic fatty acids. Interestingly, cottonseed oil also contains between 0.4 and 1 percent Cyclopropanoic fatty acids, notably malvalic and sterculic acids. The superior shelf life of cottonseed oil with respect to oxidative stability as compared to other plant-derived oils has been attributed to its high content of tocopherols, which act as natural antioxidants. There is, however, limited literature on use of cottonseed oil in lubricant base stocks. Against this background, cotton seed oil and polyol synthetic ester were blended in 1:1 to 3:1 ratios to develop biodegradable inhibited type spindle oil bio-lubricants. Based on these preliminary studies, the products have shown a high potential for usage as environmentally acceptable and biodegradable base stocks in formulations such as BIS: 11696, Inhibited Type Spindle Oils. Such oils are suggested for lubricating high-speed textile and woodworking machine spindle bearings, as well as in high-speed machine tool bearings and precision machine tools.

Keywords: Cotton seed oil, tocopherols, natural antioxidants, biodegradable base stocks, inhibited type spindle oils.

ITRS283

A Complete Elastic-Plastic Spherical Asperity Contact Model with the Effect of Linear Kinematic Strain hardening

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Abstract: Contact surfaces of machine parts are rough at microscopic level. Understanding the deformation behavior of rough surface contacts is essential to minimize the tribological consequences of contacts. In general, contact of rough surfaces is modeled and analyzed through statistical, deterministic and fractal approaches. In statistical approach, contacting spots (asperities) of rough surfaces are described in terms of shape, size, spacing and asperity height then theoretical expressions are developed to describe the deformation behavior of the asperities in contact and finally extending it to the whole surface contacts. In some of the main FEM based single asperity contact models like the Kogut-Etsion model (KE model), Jackson-Green model (JG model) Shankar-Mayuram model (SM model) and Megalingam-Mayuram model (MM model), an axisymmetrical hemispherical asperity in contact with a rigid flat surface is modeled and analyzed using finite element concepts and the resultant contact parameters relations are extended to find rough surface contacts based on statistical approach. In the present work, the effect of Poisson's ratio, Young's modulus to yield strength ratio and linear kinematic strain hardening on the FEM based single asperity contact model is analyzed. The results show that the

contact load, contact area and mean contact pressure are significantly influenced by the material properties of Young's modulus, Poisson's ratio, yield strength and kinematic strain hardening rate. Using the single asperity model results, empirical relations are developed to predict the contact parameters (dimensionless contact load and contact area) which can be extended to study the statistical rough surface contacts.

Keywords: single asperity contact, finite element method, elastic-plastic, linear, tangent modulus, kinematic strain hardening

ITRS284
Comparison between tribological performance of nano additive lubricants containing SiO2 and Cu particles

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Abstract: In recent times, Nanoparticles have been extensively studied to act as additives in lubricating oils. The addition of particles with varied morphology and size at nanoscale improves the tribological performance of lubricants by a significant margin. In this work, To understand the effect of the addition of metallic and ceramic nanoparticles to conventional liquid lubricant, Reciprocating sliding wear tests are carried out. Copper (Cu) nanoparticles with particle size ~40 nm and Silica (SiO2) nanoparticles with ~60-100 nm size are dispersed in MAK-65 commercial mineral oil with varying concentrations. An optical profilometer is used to characterize the worn surface after wear tests to analyze the surface roughness pattern and calculate respective wear volumes. Electron dispersive spectroscopy (EDS) was used to study Cu deposition on the worn surface after tribo tests and correlated with variations in the additive concentration. At lower concentrations of 0.2%, Cu displayed a better reduction in COF, whereas, at a higher concentration of 1%, SiO2 showed better tribological performance.

Keywords: Cu, SiO2, Wear, Mineral oil additives, Lubrication

ITRS285
Bio-Tribo-Behaviour of Ti6Al4V: A Review

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Abstract: Advanced materials such as stainless steel (SS316 L), copper chromium (Co–Cr) alloys, titanium (Ti) and its alloys are examples of metallic implants that can be used to repair and transport broken load-bearing structures. The major biomedical applications of these alloys include artificial hip joints, artificial knee joints, bone plates, dental implants, and stents in blood vessels. In the human body, however, osseointegration of a metal with a bone is difficult. Ti and

Ti alloys are better suitable for biomedical applications than biomedical 316 L stainless steel (SS316 L) and Co–Cr alloys due to advantageous features such as lower Young's modulus and mild toxicity. The Ti6Al4V alloy (titanium grade V, ASTM F136) is distinguished by qualities such as a comparatively low elastic modulus close to that of bone (reduced of stress shielding phenomena) and high corrosion resistance to body electrochemical processes due to the creation of a passive layer (TiO_2). It has recently been preferred over stainless steel and cobalt alloy in dental implants and orthopaedic applications due to the physiological environment of the body on its surface, lack of allergenic responses, high strength, low density, and complete neutrality to the body environment, high biocompatibility, low modulus, and high capacity for bonding with bone and other tissues. The structural and chemical resemblance to the human skeletal system, hydroxyapatite (HA, $Ca_{10}(PO_4)_6(OH)_2$), which was used for surface modification, has shown the ability to improve the bioactivity and biocompatibility of Ti alloys.

The major problems faced by the alloy (in biological systems) are the release of aluminium (Al) and vanadium (V) leading to serious illnesses, the low permeability of this alloy, chemical and biological disagreement with the hard tissue, prevents living tissue from penetrating into the implant (necessitating a permanent connection between the tissue and the implant), and tear due to use (demanding repetitive and expensive surgeries). Al and V ions may also be released into the human body which can lead to neurotoxicity in humans and have been linked to Alzheimer's disease, neuropathy, and osteomalacia. Implant surface modification is used to improve the tribological response, corrosion characteristics, hardness, biocompatibility, and bioactivity features of these implants in order to overcome these issues.

Ti alloys being used as biomedical implants have been reported to have poor tribological performance and low surface hardness. Their tribological behaviours are characterised by high coefficients of friction (CoF), strong adhesive wear, and low abrasion resistance. The high reactivity of Ti alloys produces a quick transition in the oxide surface layer in an oxidative environment, which may result in removal of the two contacting surfaces during sliding. While the inclusion of alloying elements improves Ti's corrosion resistance and mechanical qualities to some extent, the release of additional elements from Ti alloys may become the primary source of concern for their harmful biological effects. Due to low wear resistance tissue excised from the area around the Ti-alloy prosthesis had higher metal concentrations. The body fluid environment showed higher wear rates and material losses than the normal air state, which could be attributed to the corrosive character of the body fluid environment.

In this paper, various surface modification techniques for improving the bio-tribo-behaviour of Ti6Al4V are discussed. The various surface modification processes include plasma-assisted chemical vapour deposition (PACVD) method along with HA coating by sol-gel, selective laser melting (SLM), additive manufacturing (AM), laser processing technology, micro-arc oxidation (MAO), etc. are used to improve the biocompatibility. Because of its corrosion resistance and biocompatibility, the HA/TiN nanocomposite coating is a good choice for dental and orthopaedic implants, based on cell survival and proliferation. MAO is able to dramatically promote the osteointegration of implants by its microporous structure and chemical composition of the implant surface. The Ti6Al4V surface can benefit from a porous structure generated by interlaced nanowires, as well as a high crystallinity of HA and adequate surface wettability. By creating micro-textures as lubricant storage on the material surface by surface texturing, frictional and tribological efficiency of materials can be improved. Furthermore, during sliding, the hydrodynamic pressure rises, trapping wear debris in dimples and reducing the contact area, friction coefficient, and wear rate. Even at larger weights, a simulated bodily fluid has better

tribological performance than water. Surface coatings can help medical implants last longer by preventing the formation of wear particles.

Keywords: Ti6Al4V, Biocompatibility, Surface Modification, Coatings, Wear.

ITRS286

Application of the finite element method coupled with hybrid models to predict and optimize unidirectional-rolling parameters for minimizing edge cracks

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Abstract: Metal strips forms crack on work piece edges along any direction during rolling process. Secondary tensile strains on work piece surfaces are deemed as one of the important factors for such tearing. For improved product quality in the context of reduced edge cracks, the following process parameters were considered at various levels, namely, the roller speed (360,500,600 RPM), number of stages (6,9), and constant slip factor were chosen to optimize for minimum roll crack defects. FEM, RSM, Levenberg-Marquardt ANN (LM-ANN), and Bayesian Regularization (BR-ANN) models, each of which coupled with Genetic Algorithm (GA) were used to predict and optimise the input parameters. The quality response variables, namely, crack-angle and crack-length were optimized for higher product quality of lesser defects. FEA simulation was made using ANSYS 2021. Statistical error predictions of various models were compared with R^2, RSME, and MAPE values along with desirability index. All models' outputs were optimized using GA. In terms of model comparison-parameters, it was found that BR-ANN-GA hybrid model produced the most accurate findings with high desirability index, validated by real-time experiments for optimum settings.

Keywords: Unidirectional rolling; Input parameters; Optimization; Edge cracks; RSM; ANN; GA

ITRS287

Digital technologies in tribology and envisage towards future: A contemporary review

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Abstract: Today's world is sustained by the digital technologies. Every part of the world is working towards digital technologies which none of us can rid of it. Enormous growth is achieved only by unexpected acceleration by digital technologies including Machine Learning (ML), Artificial Neural Network (ANN), Deep Learning (DL), Artificial Intelligence (AI), Internet of Things (IoT), Internet of Everything (IoE) and many more. These technologies started occupying all the engineering sectors including manufacturing. This article focuses on tribology analysis related to manufacturing with respect to various digital manufacturing technologies. Article narration is like the way of tribology using the digital technologies wherein they are abetted by the journals and patent landscape analysis. In trend, the way tribology utilizes all these technologies today along with envisaging its growth with the predominant technological invention in the border view. As per the survey of various literature, it reveals the conspicuous outcome that only three digital technologies including AI, ML along with ANN are used in by the tribologists around the globe. Other Technologies like Evolutionary Algorithm (EA), Support Vector Machine (SVM) and Adaptive Neuro-Fuzzy Interference Systems (ANFIS) are not used predominantly.

Key words:
Digital technologies; AI; ML; ANN; Patent landscape analysis

ITRS288

Investigation on the mechanical, wear and corrosion behavior of Titanium-Titanium boride composites for biomedical applications

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Abstract: In this work, an attempt has been made with Titanium-Titanium Boride composites towards understanding the bio response of these composites by evaluating corrosion and wear in simulated bio fluid environment (Ringers solution). Titanium (Ti)–titanium boride (TiB) composites with 20 and 40 (by vol. %) TiB particles were fabricated by three powder metallurgical techniques such as spark plasma sintering (SPS), vacuum sintering (VS) and hot isostatic pressing (HIP). The hardness and indentation fracture resistance was evaluated using nano-indentation technique. The electron probe microanalysis (EPMA) was used to examine the homogeneity of Ti and boride phases in the composites. Corrosion studies were carried out in simulated bio fluid at 35°C to simulate the body temperature. The wear behavior of the

composites was analyzed using wear and friction monitor with the normal loads of 10 N, 20 N and 30 N with a sliding velocity of 1.4 m/s. The surface morphology of the corroded and worn out samples disclose the presence of fine titanium boride needles of high hardness and the existence of strong bonding between Ti matrix and TiB reinforcement, contributing to improving corrosion and wear resistance. The results revealed that that the titanium composite with 40 vol % titanium boride processed by Spark Plasma sintering offer better corrosion resistance and wear resistance in Ringer's solution, which may fulfill its role as a suitable biomaterial in areas where corrosion and wear resistance may be of sole concern.

Keywords: Titanium composites, Wear, Corrosion, Ringer solution, SPS, HIP, VS

ITRS289

Taguchi's DOE and Artificial Neural Network analysis for the prediction of tribological performance of graphene nano-platelets filled glass-fiber-reinforced epoxy composites

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Abstract: In the present work, glass fiber reinforced epoxy (GFRE) composite laminates filled with graphene nano-platelets were fabricated using the hand lay-up followed by press molding. Probe-type ultrasonicator method was used to get well-dispersed graphene nano-platelets (GNPs) in the epoxy resin. Four types of composite laminates were fabricated with incorporation of 0 wt.%, 0.5wt.% GNP, 1wt.% GNP and 1.5 wt.% GNPs, respectively. The tribological performance of GFRE composites and GFRE doped GNPs have been evaluated using a Pin-on-disc Tribometer under different loading conditions in the dry sliding environment. The design of the experiment identified the input parameters of 40 N normal load and 1 wt.% of GNP as the optimal parameters for least specific wear rate and coefficient of friction compared to other test settings. The most significant factor is determined by applying Analysis of variance (ANOVA), which shows that GNP wt.% has a considerable effect on the specific wear rate. An artificial neural network (ANN) model has been developed that predicts the specific wear rate with a coefficient of determination (R^2) equal to 0.965 and coefficient of friction with R^2 equal to 0.986. The overall output of the ANN model has a correlation factor of 0.99774, which shows a strong correlation with the experimental data. Field-emission scanning electron microscope (FESEM) analysis of the worn specimen is conducted to examine surface morphology and wear behaviour.

Keywords: Taguchi's DOE; Graphene; Artificial Neural Network; friction and wear; composites.

ITRS290

Characterization study on the mechanical behavior of composite honeycomb sandwich panels

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Abstract: The use of lightweight sandwich panels, particularly in defence and aviation, is extensive. Due to its superior strength to weight ratio compared to monolithic composite panels, an Aramid honeycomb is widely used as a core in sandwich structures. Numerical analysis is commonly used to reproduce same conditions of the composite structure virtually and validate the experimental results with numerical ones. For finite element modeling, which requires mechanical properties of the aramid honeycomb, limited data is available. This manuscript contains different mechanical tests necessary to identify various mechanical properties of the composite honeycomb structure. In the present study, the composite structure consists of an aramid honeycomb core backed by Aluminum facesheets on both sides. For computing mechanical properties and examining structural behavior, tension, compression, and shear tests were carried on bare aramid honeycomb and composite structures. These mechanical properties of the aramid honeycomb are then used to model and analyse composite honeycomb sandwich structures. After comparing numerical and experimental data, it was observed that they are almost similar. Specifically, numerical simulations were able to predict impact damage and energy absorption by the structure accurately.

Keywords: Sandwich structure, mechanical properties, failure mode, Aramid Honeycomb, Mechanical testing, Impact behavior

ITRS291

Experimental Investigation on Vibrational Properties of Natural Fiber Reinforced Epoxy Composite

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Abstract: In the arena of composites numerous types of manmade and natural fibers used as reinforcement purpose, but the manmade fiber are non-biodegradable and non-recyclable materials. In current days as per ecological worry, recyclable and renewable material used in industrial applications as in the bio composites. Strength of different accepted fiber composites material is focus on categorization as per their use in different applications as per requirement. Variability of bio fibers is obtainable in market, but as per cost alarm, banana fiber is low cost material as related to other natural fiber material. In this study different fiber material is in use for study. The samples are set in layers as the fiber orientation, prepared as per ASTM standard methods. Vibrational characterization at different ply orientations is studied.

Keywords: banana fiber, epoxy resin and epoxy hardener, hand lay-up method, Vibrational properties.

ITRS292
Influence of unidirectional laser texture with different laser frequency and scanning speed on wettability and surface energy of Hastelloy C22, C245 and X

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Abstract: Hastelloy is a nickel-chromium-molybdenum-iron based alloy and it is a member of the 'superalloy' family. Hastelloy has exceptional properties like high strength, wear resistance and high temperature stress-corrosion resistance. Therefore, Hastelloy is used in high temperature applications like gas turbines, power plants, metal injection moulding, etc. There are many applications that are related to the properties of their surface. Wettability is a key surface property that affects applications like lubrication, adhesion, coating, heat conduction, etc. In the present study, unidirectional textures were created on Hastelloy (C22, C245, X) using fibre laser and different sets of textures were formed by changing the laser frequency and laser scanning speed. Further, we studied the effect of the laser parameters (scanning speed and frequency) on the wettability of textured surfaces by measuring the contact angle using DI water and glycerol as test fluids. Surface energy of a given set of samples was also measured in the study.

Keywords - Laser Texturing, Wettability, Surface Energy, Superalloy, Hastelloy, Laser Parameters.

ITRS293
Study and Comparison of Thermal Conductivity, Interfacial Tension, and Wettability of Cutting Fluid on Different Unidirectional Surface Roughness of Ti67

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Abstract: The cutting fluid is an essential part of the machining process. It is used as a coolant as well as a lubricant. The commercial cutting fluid (CCF) available in the market is based on mineral oil, with emulsifiers and additives that are produced chemically. CCF has an adverse effect on the environment that is harmful to the human being, non-biodegradable, toxic, unsustainable that can cause health issues like chronic bronchitis, respiratory diseases, digestive

cancer, etc. To avoid the use of CCF, Green Cutting Fluid (GCF) is a good alternative. The GCF is based on vegetable-based oil that is eco-friendly, non-toxic, biodegradable, and sustainable. In this work, seven different Ti67 samples were prepared with unidirectional surface roughness in the range of 111.38 to 1350nm, and six emulsions were prepared with 5, 10, 15, 20, 25, and 30% concentrations of GCF and CCF in DI water. To understand the effectiveness of the cutting fluid, various properties like wettability, thermal conductivity, and Interfacial tension (IFT) were compared. Also, we studied how surface roughness affects wettability and surface energy. Further, we analysed the optimum concentration of GCF and CCF for the above-given properties on the given roughness range.

Keywords: Wettability, Thermal conductivity, Interfacial tension (IFT), Green cutting fluid (GCF), Commercial cutting fluid (CCF), Unidirectional surface roughness, surface energy.

ITRS294
A study on the friction and wear behavior of PTFE filled with boron carbide nanoparticles

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Abstract: The composite material was made by hot compression molding PTFE and nano boron carbide particles. Prior to compression molding powders were blended by using a jet milling apparatus. The composites were manufactured from 0 to 20 % wt. These composites were tested against polished stainless steel counter face on pin on disc tribometer. The experimental condition were contact pressure 6 MPa sliding speed 1 m/s to 2 m/s. The frictional coefficient of composite increased from μ = 0.1 to μ= 0.2. At filler Concentration of 10% wt the wear resistance improved 600 times. The wear resistance of this composite increased monotonically with increasing filler concentration and no optimum filler friction was found.

Keywords: Friction; PTFE; Boron carbide Nano particles , Sliding wear , Tribological response.

ITRS295
Effect of full and partial texturing on tribological performance of meso scale air journal bearing: an experimental study

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Abstract: The present study deals with the experimental investigation on meso scale air journal bearing with texture effect. The experimental setup is developed to investigate the tribological performance of plane and textured meso scale air journal bearings. Both the plane and textured bearings are fabricated using a novel texturing technique: metal 3D printing (additive

manufacturing). Textures employed in different regions of the bearing. The study is carried out at variable speed operating under different loading conditions. It is found that texturing has a significant influence on the tribological performance of the meso scale air journal bearing. Also, textures distribution plays an important on friction and wear reduction. The textured bearing which offered minimum friction and wear is proposed.

Keywords: Meso scale air bearing, surface texture, partial texturing, friction coefficient, wear

ITRS296
Comparison between tribological performance of nano additive lubricants containing SiO2 and Cu particles

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Abstract: In recent times, Nanoparticles have been extensively studied to act as additives in lubricating oils. The addition of particles with varied morphology and size at nanoscale improves the tribological performance of lubricants by a significant margin. In this work, To understand the effect of the addition of metallic and ceramic nanoparticles to conventional liquid lubricant, Reciprocating sliding wear tests are carried out. Copper (Cu) nanoparticles with particle size ~40 nm and Silica (SiO_2) nanoparticles with ~60-100 nm size are dispersed in MAK-65 commercial mineral oil with varying concentrations. An optical profilometer is used to characterize the worn surface after wear tests to analyze the surface roughness pattern and calculate respective wear volumes. Electron dispersive spectroscopy (EDS) was used to study Cu deposition on the worn surface after tribo tests and correlated with variations in the additive concentration. At lower concentrations of 0.2%, Cu displayed a better reduction in COF, whereas, at a higher concentration of 1%, SiO_2 showed better tribological performance.

Keywords: Cu, SiO_2, Wear, Mineral oil additives, Lubrication

ITRS297
Tribological and Mechanical Properties of Zinc aluminium (ZA-27)/aluminium Zinc alloy (Al-25Zn): a Comparative Review and Research

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Abstract: This paper presents a literature review on Zinc-Aluminium and Aluminium-Zinc

alloys and experimental investigations on tribological and mechanical properties of pure Aluminium, Pure Zinc, ZA-27 alloy, and Al-25Zn alloy. The studied literature shows that Al-25Zn alloy has comparable mechanical and Tribological properties as that of ZA-27 alloy. However, rarely saw the experimental data showing the comparison of properties of this alloy. In the present research, aluminium, Zinc, ZA-27 alloy, and Al-25Zn alloy were fabricated using stir casting and investigated their sliding wear and mechanical properties. The results shown that the Al-25Zn alloy has the maximum hardness, tensile strength, and wear resistance among studied materials.

Keywords: ZA-27, Al-25Zn, Wear, Hardness, Strength, surface morphology

ITRS298
Reinforcement of different Fine Grains particles in Aluminum Alloy by FSP Technique – A Review

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Abstract: With increased demand to develop economical and high strength lightweight ratio, composites, the Friction stir Process (FSP) is the best method carried out from the Friction Stir Welding to fabricate such composites. FSP helps us to Enhance the Mechanical as well as the Tribological properties of the source material by reinforcing fine grains particles into the source material. FSP is well known for its great capability to develop surface composites. FSP helps to homogenize the particle distribution and improves the standard grain refinement in the processed zone for surface improvement. Aluminum Alloys are the most promising alloy used in Aerospace industries and Automotive industries because of their low density, less specific weight, great strength-to-weight ratio, and decent corrosion resistance. In this study, we studied the effects of different types of reinforcement of fine grains particles in Aluminum Alloy [5 series, 6 series, and 7 series] on Mechanical properties (Microhardness and Tensile Strength) as well as Tribological Properties (Wear Resistance and Coefficient of friction). Different types of reinforcements are used in this study which is in the form of Ceramics and metallic alloys derived into fine grains particles of Micro and Nano size. This review mainly focused on the Current Status of FSP Technology in the field of composite fabrication with Aluminum alloys of different types as the base material and different types of Ceramics and metallic alloys, fine grains particles as the reinforcements.

Keywords: Friction Stir Process, Reinforcement, Aluminum Alloys, Coefficient of Friction, Composite.

ITRS299
Nanosecond Laser Surface Texturing for High friction applications

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Abstract: Friction is involved in thousands of applications in our daily lives. In some applications high friction is desirable, as in vehicles' tires on the roadways, brakes, clutches and frictional power transmission systems. In all cases, understanding the mechanism involved in friction and the means to control it are necessary. Various approaches have been employed in order to control friction, some of which are lubrication, coating, and surface modification such as texturing, which is the focus of this study.

Laser Surface Texturing, a surface modification technique utilized for the fabrication of micro features i.e. dimples, grooves, crosshatches, protrusions, on contacting surfaces for modifying the surface tribological properties. These patterned micro surface textures on the surface of the materials offers several benefits for tribological applications, including improved wear resistance, load capacity, reduced friction coefficients and lubrication lifetime. The present aim of this experimental work was to investigate the effect of different dimple coverage performed on polished gray cast iron employing nanosecond pulsed Nd:YLF Laser system. In this work, tribological behavior of gray cast iron is studied with respect to friction and wear behavior under constant Load and constant velocity conditions. The sample with dimples pitch of 40µm and dimple area coverage of 176% (full overlap) showed the highest friction coefficient by a factor of 14.5% as compared to untextured sample. The eventual objective of this experimental investigation deals with the prospect of replacing the current wet clutch, disk brake practices in the automotive sector by nanosecond Laser Surface Texturing to enhance the tribological performance.

Keywords: Laser Surface Texturing, dimples, high friction, wear.

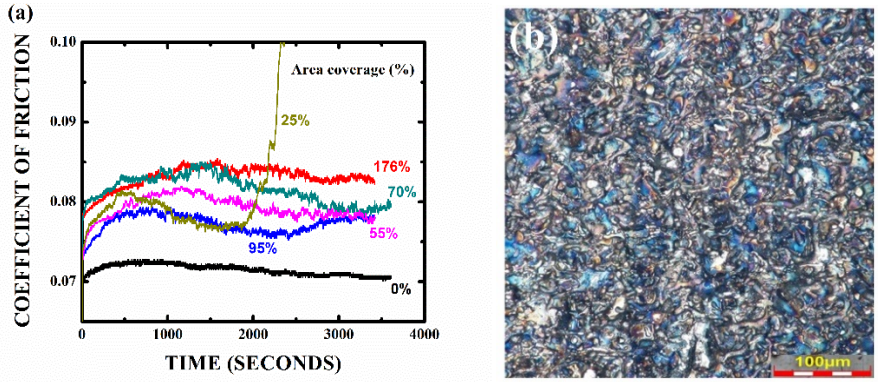

Fig. 1 (a) Ball-on-disk test performed at room temperature: friction coefficient as a function of time (b) Opto-digital Microscope image of 176% area coverage (full overlap) sample

ITRS300

Effects of different Process Parameters on the fabrication of Aluminium Matrix Composite by FSP. A review

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Abstract: Friction Stir Process (FSP), as an innovative processing technology, is a very effective method for the fabrication of Metal Matrix Composites with high performances under

appropriate conditions. Different types of reinforcement can be done to enhance the properties of the base material. Reinforcing particles in base material through FSP is more efficient than the Conventional method because of the low-rate issues related to defects such as porosity, particle clustering, etc. Aluminium Metal Matrix composites are the most promising material for the structural application used in the Aerospace and automotive industries due to their low density, low specific weight, great strength to weight ratio, and decent corrosion resistance. The present study firstly summarizes the different types of reinforcement into the different series of Aluminium Alloy [5 series, 6 series, and 7 series]. In this study, we can carry out the various changes that occur after the reinforcement in Aluminium Alloy. This study mainly focuses on the current status of Aluminium Metal Matrix Composite fabrication through FSP and various effects on the properties of the source material after reinforcing fine grain particles into the source material. The number of passes in FSP also plays a significant role in enhancing the Mechanical, Tribological, and Surface properties. In this study, we concluded that with the increase in the number of passes in FSP, properties of the base material can also increase and become better because of the increase in the grain's refinement with every single pass.

Keywords: Friction Stir Process, Metal Matrix composites, Reinforcement, Mechanical properties, Surface Properties.

ITRS301

Surface Topography Evolution and Pitting under Rolling/ Sliding Motion to Pearlitic Steel

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Abstract: In this study, a Micopitting test is performed to investigate the topography evolution and pitting mechanism in rail/wheel contact. The experiment is performed considering pure roll and some slide-to-roll ratio (SRR) in the Twin-disc set up with the actual contact pressure found in the rail transportation system. Few micro-pits are found on contact surfaces under pure roll conditions due to generated high contact stresses because of sharp asperities contact of rollers under the same experimental conditions. These micro-pits are about to convert into macro-pits if the load is increased to more. In subsequent fatigue tests, these macro-pits connect each other to form surface-initiated spalls under higher load and more SRR. The RMS Roughness (s_q) is found decreased more at higher load indicating more flattening in the Rolling contact fatigue (RCF) test. The skewness is becoming more negative and autocorrelation length (s_{al}) also found increased after this test. These changes in topography parameters indicate the flattening of the contact surfaces under the Rolling/sliding motion.

Keywords: RCF; SRR; Surface Topography; Pitting.

ITRS303

MICROSTRUCTURE AND MECHANICAL PROPERTIES OF IN-PROCESS COOLED ALUMINUM ALLOY THICK PLATE FRICTION STIR WELDS

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Abstract: Heat-treatable aluminum alloys such as AA7075 are widely used in manufacturing of primary aircraft structures due to their satisfactory strength to weight ratios. Production of such structures unavoidably involves joining. However, performing traditional welding by melting aluminum alloys is challenging. Friction stir welding, being a solid-state joining technique, is proved to solve the issues of joining aluminum alloys. However, the friction stir welding causes decrease in joint properties and the decline is more prominent in case of thick section joints. In this study, friction stir welding of 16 mm thick AA7075-T651 plates with forced cooling by a compressed air flow and water immersion was investigated. The defect-free joints were made and evaluated for weld mechanical properties in thickness direction using tensile, hardness and bend tests. The weld microstructures were also examined by optical and transmission electron microscopes. It was observed that the weld hardness across the joint increases from surface to root of the weld along the thickness. Also, strength values were found to increase from the surface in the thickness direction. Forced air cooling was found to exhibit better bend ductility of the joint compared to that of other samples. The weld microstructures and precipitate morphology were also discussed to understand the reasons for mechanical behavior of the welded joints.

Keywords: Aluminum alloy 7075, Friction stir welding, Forced cooling, Tensile properties, Transmission electron microscopy

ITRS305
Erosion Wear Behaviour of Nano-Zirconia Filled Wild-Cane Fiber Reinforced Epoxy Composite: Experimental and Optimisation Approach

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Abstract: Natural fiber composite materials are widely used in various structural fields, interior design, and sports equipment in the present scenario due to their high specific strength, stiffness and biodegradability properties. Various applications in these emerging fields induce the manufacturers to examine its tribological performance. This work deals with the development and erosion wear characteristics of wild-cane fiber-reinforced nano zircon-toughened mullite

(ZTM) filled epoxy composite. The three-layered composite laminate is fabricated by hand lay-up technique using woven cellulosic wild-cane fiber mat (Arundinariagigantea), epoxy resin and ZTM nano-filler. Four different types of specimen are fabricated by varying weight percentages of ZTM filler (i.e., 0, 5, 7.5 and 10). Both angly-ply [+450/-450/+450] and cross-ply [00/900/00] configured specimen are fabricated and tested to study the erosion wear behaviour of composite specimens. The test is carried out by taking various parameters such as impact velocity, impingement angle and filler content by adopting Taguchi philosophy. The erosion wear test revealed that the impact velocity, impingement angle, and contents of filler influence the wear characteristics of wild-cane fiber composites. The wear mechanism failures are also examined microscopically. This research demonstrates that these composites are found suitable in wear-related fields.

Keywords: Wild-cane fiber mat, Zircon toughened mullite, Erosion wear, Taguchi method, Microstructure

ITRS306

Wear, Corrosion and Tribocorrosion Mechanisms of Offshore Mooring Chains

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Abstract: The safety of floating offshore structures has been a hotly debated issue in the last century. Wear and corrosion problems of these structures, especially in mooring chains, can cause severe damage. This paper addresses the wear, corrosion and tribocorrosion mechanisms of offshore mooring chains. The evaluation considers applied load and electrochemical potential, lubricant characteristics, surface properties, oxidation characteristics, abrasion of the counter body, material loss and synergistic interactions between wear and corrosion of the mooring chains in seawater. Besides, boriding, aluminizing and boroaluminizing are suggested to increase the tribocorrosion resistance of the mooring chains of floating wind turbines, which have emerged as a new application area.

Keywords: Offshore mooring chains, wear, corrosion, tribocorrosion, synergism

ITRS307

Design of LQG controller for an active magnetic thrust bearing

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Abstract: Active magnetic bearings (AMB) are used in niche applications where it is not feasible to use oil lubricated bearings. They have inherent advantages such as contact free suspension, high speed operation [Schweitzer 2009], continuous condition monitoring [Knospe 2007] and the ability to tailor the stiffness and damping online through feedback control parameters. Since AMB are unstable in open loop condition, closed loop control system is

employed to stabilize them. Most commonly, PID control scheme is employed. Linear Quadratic Gaussian (LQG) [Franklin 1998] based controllers are also increasingly being used for these applications.

In this work, a 1-Degree of Freedom (DOF) AMB mathematical model is developed from first principles in MATLAB environment. Using classical control system design techniques, a PID controller is developed. Using the AMB mathematical model, LQG controller is also developed and the performances of the controllers are compared with respect to the ability to tolerate artificially injected noise in the sensor signal to feed back controller and with respect to the ability to track the set point given to the controller.

Since only position sensor is available in the AMB setup, the velocity information required by the controller has to be estimated by an estimator. As mentioned in [Ahad 2021], with the introduction of the estimator, gain and phase margins are reduced. The impact of this reduction is studied in this work. The LQR controller, with the state estimator gives the LQG controller for open loop unstable systems. The block diagram of this control scheme is shown in Figure 1 and the simulink controller model is given in Figure 2.

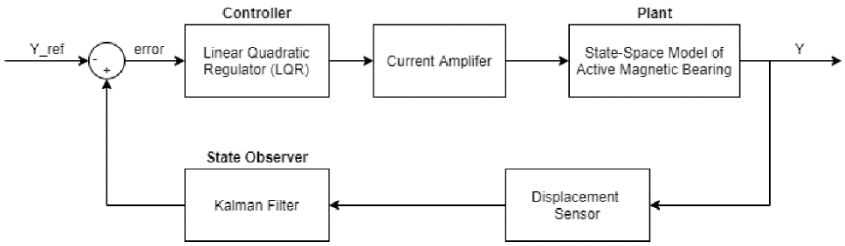

Figure 1 Block Diagram of controller with state estimator

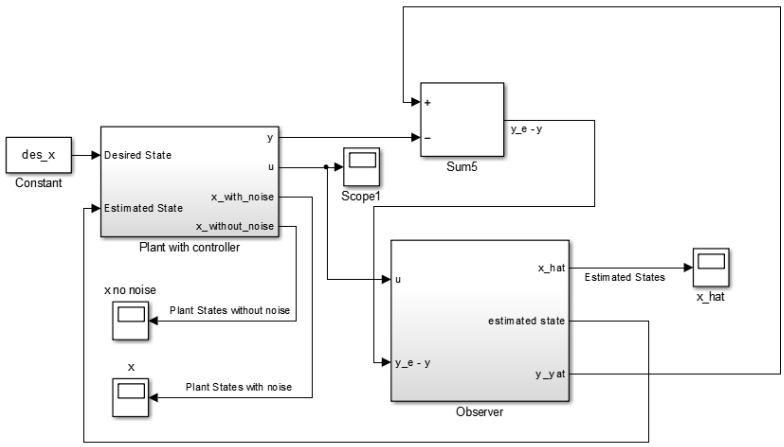

Figure 2 Simulink model of controller with state estimator

After the development of the LQR algorithm with state estimator, its implementation in an embedded controller with timing requirements is presented. This work will enable the implementation of LQR based closed loop feedback controller implementation in thrust AMB.

Keywords: Active magnetic thrust bearing, LQG controller, velocity estimation, Kalman Filter

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ITRS308
Dry Sliding Tribological Behavior of AZ31-B_4C Nano Composites

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Abstract: The current research work deals with the characterization and tribological behavior of AZ31-B_4C nano-composites fabricated through a ultrasonic assisted stir casting route. B_4C with varying weight percentage (0.5-2.0 wt %) is reinforced in magnesium alloy to produce different composites. Optical microscope (OM), scanning electron microscope (SEM) and energy dispersive x-ray analysis (EDX) are utilized to characterize AZ31 alloy and fabricated composites. The microhardness of developed composites is obtained through Vickers's micro hardness tester. Hardness shows increasing trend with increased wt% of B_4C nano particles. Dry sliding tribological behavior is mainly investigated at room temperature on a pin-on-disc tribo-tester. The characterization illustrates the presence of boron carbide and its effect on the grain refinement of composites. AZ31-B_4C composites exhibit better hardness with compared to the base alloy. SEM and EDX analyses are investigated for the worn-out surfaces in order to predict the wear mechanisms based on different sliding parameters. Wear behavior of base alloy and nanocomposites investigated under applied load of 10-40 N and sliding speed of 0.1 m/s to 0.4 m/s. The nano-composites shows better wear and friction behavior. The wear morphology of pin samples reveals abrasion, oxidation, and delamination mechanism on pin surface.

Keywords: AZ31-B_4C nano-composites; Magnesium; Ultrasonic assisted stir casting; wear, friction;

ITRS309
Study of Sinter Return Fines Generation and Their Effective Utilization: A Comprehensive View for Sinter Making in Rourkela Steel Plant

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Abstract: The sintering process of iron ore fines is an essential part of modern iron-making.

Sintering prepares ore for a blast furnace by causing the metal in the ore to agglomerate. The characteristics of the agglomerate greatly affect the operating conditions of the blast furnace. In this process, iron ore fines is mixed with fine particles (-3mm) of flux (limestone and dolomite), (-3mm) coke, and returned sinter; and the heat from the burning coke causes agglomeration. The input raw material for this sinter making is called as base-mix. The sintered ore is then broken up into smaller pieces and fed into the blast furnace. An important parameter of the sintering process is the burn-through point (BTP), which is defined to be the first position on the sinter strand where the ore is completely sintered. The stability of the BTP directly influences the quality and quantity of sintering agglomerate. If the BTP occurs before the optimum position, the area of the sintering machine is not used effectively; so the utilization factor is too low. This directly reduces the quantity of agglomerate. On the other hand, if the BTP occurs after the optimum position, some ore remains unsintered; so the agglomeration rate is too low. This degrades both the quantity and quality of agglomerate, and increases the amount of returned sinter. In addition, frequent changes in the BTP shorten the lifetime of the sintering machine. A key problem in the control of a sintering process is effective tracking of the BTP to keep it at the optimum value. Sintering is a complex, nonlinear process with coupled parameters. Many factors affect the BTP: the sinter strand velocity, the ignition temperature, the chemical composition of the raw material, the flow rates of the fresh-air blowers, etc. Since most of these factors change freuently and unpredictably, it is difficult to establish a practical, precise mathematical model of the sintering process. In this paper, a detail study is carried out to estimate the tribological challenges, predict the burn-through point for better sinter quality and study the return fines generation and their effective utilization in sinter making.

Keyword: Sinter, Basicity, Burn Through Point, Available Lime, Sinter Return Fines

ITRS310

Surface Metallization of Laser Powder Bed Fusion Manufactured Polyamide Parts

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Abstract: Laser Powder Bed Fusion (LPBF) is a kind of additive manufacturing (AM) technology which generates 3D complex geometries, layer-by-layer from its CAD data. Beside rapid prototyping, the technology provides opportunity to generate near net shaped functional parts. Having easy processability, high chemical resistance, high mechanical strength, high impact resistance and cost effectiveness, polyamide 12 (PA12) is most widely used polymer in additive manufacturing applications. However, service environment conditions such as moisture, temperature, UV radiation, friction etc. significantly affect the properties of the PA12. Therefore, surface metallization of the AM manufactured polymer parts would be a solution to enhance the durability of the PA12 parts.

In this study, LPBF manufactured PA12 part surface was coated by Ti film with DC magnetron sputtering deposition technique. Metallized surface was inspected in terms of its surface

roughness, friction properties, chemical composition and wettability properties. 3D surface roughness parameters were recorded by optical profilometer while frictional behavior was tested by ball-on-disc type tribometer. Wettability was inspected by water contact angle measurement. The chemical composition of the metallized surface was defined by SEM-EDS and XRD analysis. It was recorded from the experiments that metal thin film deposition was successfully achieved on to the PA12 surface. Surface metallization decreased surface roughness and friction coefficient while it increased surface wettability. It can be stated that coating of the AM manufactured polymer surface with metal layers is promising way to improve surface properties of the parts.

Keywords*:* Coating, Surface post processing, Laser powder bed fusion, PA12, metallization

ITRS311

Mechanical, Corrosion and Tribological Behaviour of AA 5052/TiB_2 Composites for Marine Applications

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Abstract: The current work is aimed to investigate the effect of varying percentage of Titanium Diboride particles in Aluminium Alloy 5052 on various mechanical, corrosion and tribological properties. Various mechanical properties like hardness, density have been investigated. The corrosion studies are performed in simulated marine environment which is achieved by the preparation of substitute ocean water. Also, the effect of surface roughness on the corrosion behaviour in Aluminium Alloys has also been studied. The wear resistance of the fabricated AA5052/TiB_2 composites enhanced significantly at all loads and speeds. Wear resistance increases by 36% at high sliding speed at high load. Hard ceramic particles of TiB_2 thus impart significant improvement to the composites up to the 5 wt. %. Further increase in the TiB_2 content decreases the wear resistance of composites due to porosity and poor wettability.

Keywords: Metal Matrix Composites, Marine, TiB_2, Wear, Corrosion, Immersion, Artificial Seawater

ITRS312

Friction Behaviour of 3D Printed PLA Parts- Effect of Surface Texturing

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Abstract: Additive Manufacturing or 3D Printing is one of the fastest emerging technology in the manufacturing industry. It is widely being used for the mass customization and fabrication of

any type of geometrical designs. Out of all 3D Printing techniques available, Fused Deposition Modeling is dominating the printing industry with its flexibility in materials for printing. It is widely being used in industries like Aviation, Healthcare, Agriculture and Automotive industry with versatility in materials from thermoplastics to metals. FDM method is used in this study to print the samples with surface texturing in order to study the friction behaviour on 3D printed surface textured samples under dry and lubricated conditions. PLA was used as material. Three different types of textures were printed by means of an FDM based printer. The effect of load, texture diameter and texture spacing on the coefficient of friction was studied under dry and lubricated conditions. The results obtained were compared with non-textured surfaces.

Keywords: Fused Deposition Modelling; 3D Printing; Poly Lactic Acid; Tribology; Friction; Texturing

ITRS313

Corrosion behaviour of engineering materials – a review of methodologies and environments

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Abstract: Corrosion significantly affects the performance and durability of any material and as such is an important determining factor in critical industries like marine, aerospace, aircraft, and construction. The corrosion behaviour of any material depends not only on the material itself but also the interaction of the material with the environment and many other allied factors. The clear understanding of corrosion process is thus of utmost importance for the proper selection of the materials in any given environment and for their successful use in engineering and commercial applications. In this paper, a comprehensive review of various studies carried out to analyse the corrosion behaviour of different metals and other materials in different environments is presented. Also, various inhibitors and reinforcements having varying effects on the corrosion behaviour of different materials are presented. Also a special focus has been laid to discuss the various methods to evaluate corrosion and the various corrosive environments to which the materials are susceptible. The literature revealed that the material-environment interactions and other various factors greatly affect the corrosion behaviour of the materials. The paper apart from presenting fundamentals related to corrosion testing shall also present the literature related to the corrosion behaviour of various critical engineering materials and the paper shall act as a stimulant for future research.

***Keywords*:** Corrosion resistance, Corrosion Inhibhitors;Alumunium; Magnesium ;Copper; Iron

ITRS314

Effect of Alumina and Titanium di oxide nanoparticles on Lubrication behaviour of Rice bran and Sesame Grease

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Abstract: In the current study, nano grease based on Rice bran oil & sesame oil doped with Al_2O_3 and TiO_2 additives have been investigated for tribological properties. Nano additives with concentration of 2 wt% have been initially dispersed in the base oil. The mixture is subjected to sonification followed by the addition of thickener and further heating till grease is formed. The nano grease is finally obtained by cooling the mixture. The nano grease thus obtained is tested for tribological behaviour with varying load and sliding conditions. It was found that pure VRG and VSG have higher COF which is found to be reduced by the addition of Al_2O_3 nanoparticles. The COF was found to be reduced further by the addition of TiO_2 nanoparticles in both the cases. The wear volume was found to be minimum in case of TiO_2 based grease followed by Al_2O_3 based nano grease. Maximum wear volume was found in base oils. SEM micrographs and 3D profilometer were used to examine the wear behaviour. The addition of TiO_2 nanoparticles in Rice bran oil & sesame oil have significantly improved the tribological properties owing to change in wear mechanism from adhesion to abrasion
.

***Keywords*:** Rice bran Grease; Sesame Grease; Lubrication; Nanoparticles; Tribology.

ITRS315
Lubrication behaviour of Rice bran and Sesame Greases using different nanoparticles

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Abstract: The severe environmental effects and resource depletion caused by the overuse of petroleum-based products prompted researchers to consider an alternative biodegradable solution. The key aim of the present work is to investigate the tribological behaviour of rice bran and sesame-based greases with addition of nano h-BN (Hexagonal Boran Nitride) and CuO (Copper Oxide). Rice bran oil (RBO) and sesame oil are used as a base oil for formulating different grease samples while lithium stearate is used as thickening agent. The tribological properties of developed greases with h-BN and CuO particles has been investigated on a ball-on-disc tribometer of reciprocating configuration as per the ASTM G-99 standard. The results

suggests that addition of h-BN and CuO to both rice bran and sesame-based nano grease has a substantial effect on the evaluated properties. The addition of CuO improved the tribological performance more significantly as compared to h-BN.

Keywords: Rice bran Grease; Sesame Grease; Lubrication; Nanoparticles; Tribology.

ITRS316
Volume/shear work ratio dependency on contact pressure in abrasive wear modelling by DEM

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Abstract: Abrasive wear is a very complex phenomenon because there is acting at least two bodies. Mainly, wear losses in abrasive wear are caused by abrasive particles. Its interaction with the surface creates pressure, deforms, and allows to appear material loss. The discrete element method (DEM) helps to simulate the abrasive wear process because abrasive particles are modelled as sphere particles. The Rocky DEM software uses the volume/shear work ratio parameter to describe wear intensity. The three-body abrasion test where rotated rubber rimmed wheel (ASTM G65 test) is pressed to the sample at various load (17, 35, 57, 78, and 100 N) simulation showed that volume/shear work ratio parameter is dependent on the contact pressure with the sample. During the experiment, the contact area between wheel and sample is varied: at the beginning – small, at the end of experiment wear scar is higher. The contact pressure acts in the opposite way: at the beginning is higher compared to the pressure later. The volume/shear work ratio parameter must be assigned inversely proportional to the contact pressure. This dependency should be considered when the simulation of agricultural tools is done via DEM, where tools suffer high abrasive wear loss and contact pressure because of soil resistance.

Keywords: Abrasive wear, Discrete element method, Contact pressure, Rocky DEM

ITRS317
Tribological properties of Hybrid Natural Fiber Reinforced polymer composites under different environmental conditions: A Review

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Abstract: The growing demand for the manufacturing of products that are environment friendly has posed a serious challenge to researchers. There is an increasing demand for the manufacture of quality products that are sustainable. The use of synthetic fibers is limited due to non-biodegradability and harmful effects to the environment. In this regard natural fibres are gaining the attention of many researchers over the synthetic fibers owing to advantages like low cost,

light weight, ease of processing, biodegradability, good mechanical properties. Several studies carried out have shown that by reinforcing the polymers with fibers enhances the mechanical and tribological properties. Some of the researchers also found out that improvement in properties is more when polymers are reinforced with hybrid fibers. Use of Natural fiber reinforced polymer composites is increasing in the areas of Automobiles and construction, ship building parts. However water absorption and durability are the major hurdles that limits their use. Thus a tribological characterization of Hybrid Natural fiber reinforced polymer composites in different environmental conditions will help the researchers in optimising its properties and make their use possible in a wider domain. The aim of this study is the provide an extensive literature review on tribological characterisation (friction and wear) of the Hybrid Natural fiber reinforced polymer composites under different environmental conditions.

Keywords: Natural fibers, Polymer composites, Tribology, sea water, wear

ITRS318

3D Printing of polymers using FDM: A study on their properties.

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Abstract: 3D printing has been one of the breakthrough technologies of the past few decades. It is finding its increasing use in manufacturing industries. Fast fabrication, more variety, less wastage, automated nature and higher customer satisfaction through more customization are some of its key features which encourages the manufacturers to resort to this technology. The most commonly used method of 3D printing is Fused Deposition Modelling (FDM) which is based on solid rapid prototyping. In this method, the material is fused, cooled and solidified. The materials mostly being used in FDM include a variety of thermoplastic polymers. The inferior properties of polymers makes it challenging for industries to adopt 3D printing and in many practical applications. These polymers are continuously being tested and analyzed in order to find ways in which their properties can be enhanced. Sustainability is also a factor which is looked after in the use of these polymers. This study aims at having a deeper and a clearer understanding of the properties of these polymers and highlight the important ones that need to be enhanced which play a key role in their application in practical world.

Key words: 3D printing, FDM, thermoplastic polymers, solid rapid prototyping, sustainability.

ITRS319

Effect of Electrochemical Potential on Tribocorrosion Behaviour of AISI 304 Stainless Steel in Sea Water

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Abstract: There is an increasing concern over simultaneous wear and corrosion (tribocorrosion)

issues that cause stainless steel's material failure in marine environments. The main objective of this study is to understand the effect of electrochemical potential on tribocorrosion behaviour of AISI 304 stainless steel, which is one of the most used stainless steel in seawater. For this purpose, polarisation scans were carried out in seawater under corrosion and tribocorrosion conditions by applying different loads and potentials. Also, tribocorrosion tests were conducted under cathodic and anodic potential and Open Circuit Potential (OCP) to determine the effect of electrochemical potential on tribocorrosion behaviour. The study revealed that electrochemical potential significantly influences tribocorrosion behaviour of AISI 304 stainless steel.

Keywords: AISI 304, wear, corrosion, tribocorrosion, seawater

ITRS320

Tribological Study of Additively Manufactured Polymers for Simple to Complex Features: A critical review

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Abstract: In recent times, additively manufactured (AM) polymers have gained considerable relevance for industrial and non-industrial applications in the field of medical, defense and automotive sectors due to their inherent advantages like self-lubrication, corrosion resistance, vibration damping ability and ease in manufacturing. Polymers can be 3D printed with several AM technologies such as FDM, MJF, FFF, PJP, DLP, MJ, SLS with vast variations in the printing parameters like infill density, built orientation, nozzle temperature, layer thickness, printing speed, pattern and raster angle. Parts processed by AM usually serve as excellent prototypes but are still maladroit to be used as functioning parts due to their tribological properties which labels them as a main contributor to machine failures. Due to the nature of different AM technologies, the tribological properties are greatly affected by the printing parameters, thus, it is imperative to analyse these aspects (in varying lubrication conditions) if the AM parts are to be purposed as functioning parts. Based on these fundamentals, a critical review has been undertaken on analysis done by various researchers for the tribological performance of different AM polymers like ABS, PLA, PC, PA, PEEK, etc based simple to complex features to determine the optimum process parameters, their advantages, disadvantages and future scope. The scope of tested parameters include volumetric wear, mass wear, coefficient of friction, frictional moment torque, wear track analysis, abrasion, adhesion, diffusion on a tribometer by pitching these against varying loads, time duration and frequency.

Keywords: Polymers for AM, Additive manufacturing, Tribology, Printing parameter, Friction coefficient, Wear

ITRS321

Experimental investigation and modelling on the end milling of wire arc additive manufactured feature

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

Keywords: Surface morphology, hardness, machining, end milling, modelling, chip morphology

ITRS322
3D Printed Polymeric Parts: Mechanical and Tribological Behaviour

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Abstract: Additive manufacturing is evolving as an alternative manufacturing process. The current paper presents an overview of various polymeric parts developed through 3D Printing. An overview of various properties such as tensile strength, flexural strength, wear behaviour and friction behaviour is presented. The effect of various process parameters such as infill percentage, pattern, layer thickness, raster angle and other related parameters. The paper shall also focus on the various challenges and drawbacks faced while printing these parts. The paper shall also focus on various application areas of these 3D printed parts. A separate section is dedicated to the tribological properties.

Keywords: Polymers; 3D Printing; Friction; Wear; Mechanical Behaviour

ITRS323

Effect of Surfactants on Dispersion Stability and Tribological Behavior of Olive oil containing Graphene Nanoparticles

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Abstract: With the increasing energy demand at the global level, different solutions have been proposed by taking into consideration the concept of sustainability. Frictional force comes into picture when different engineering equipment come in contact with each other thereby causing the great loss to energy. In order to reduce the energy losses, lubrication of surfaces by means of different oils is an important aspect. With the development of nanotechnology, the surfactants and nanoparticles are being widely used in lubricating oils in order to improve the different properties. This work is related to the improvement in dispersion of graphene nanoparticles in chemically treated olive oil. The graphene nanoparticles were added in a concentration of 0.3 wt. % in 10 ml of olive oil. The oil samples with nanoparticles were mixed with surfactants for improving the dispersion stability of nanoparticles. The surfactants used were Span 80 and Sodium Dodecyl Sulphate (SDS). The surfactants were added in a concentration of 0.3 wt. %, 0.6 wt. % and 0.9 wt. % in modified olive oil. The mixture of surfactants with nanoparticles was sonicated for a time period of 8 hours in order to get uniform dispersions. The samples were analysed through visual inspection over a period of 1 week. It was found that the 0.6 wt. % of Span 80 in olive oil was the optimal concentration which showed maximum stability with low sedimentation. For Sodium Dodecyl Sulphate, 0.9 wt. % showed the maximum dispersion stability of nanoparticles in modified olive oil Also, in this work the effect of surfactants on tribological performance was investigated using ball on disk setup. Each sample of oil was tested for different loads 40 N, 60 N, 80 N and 100 N keeping the sliding distance and sliding velocity fixed equal to 500 meters and 0.5 m/sec, respectively. It was found that Span 80 surfactant when used in modified olive oil showed minimum coefficient of friction at 0.9 wt. % while for Sodium Dodecyl Sulphate, the minimum coefficient of friction obtained was 0.9 wt%. It can therefore be ascertained that the surfactants also improve the tribological performance by decreasing the agglomeration of nanoparticles and also help in the formation of tribofilm on the surfaces

Keywords: Graphene, Tribological performance, Sodium dodecyl sulphate, Span 80

ITRS324
Recent progresses in surface texturing for machining applications: A review

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Abstract: Machining is the process of material removal from the workpiece surface to get the desired shape and geometry. The geometry and geometric accuracy of products made by machining are usually defined by dimensions, surface finish, etc. The geometrical accuracy of a product is strongly influenced by the accuracy of the machine, the machining technique used,

and the skill of the operator. In addition, the surface finish of the product is significantly influenced by the tool wear, heat localization, and machining characteristics in the machining zone. Machining characteristics are greatly influenced by tool geometry and tool surface texture. Improved machining characteristics can increase surface finish, tool life, machining accuracy, productivity, etc.; can also reduce hazardous environments for operators using minimum quantity lubrication (MQL) or dry machining operations. In this article, a thorough literature survey represents the aspects of texturing of tool surface, which is an effective strategy to enhance tribological properties of the tool. Texturing is also a promising surface modification technique. The article represents different texture patterns like groove, dimple, hybrid, etc. the texture patterns has been created on to the tool rake surface, using various conventional and non-conventional methods of texturing. The study includes research work for the last ten years (2009-2019) and some earlier studies. In which the textures made by the authors like thermal, chemical, direct contact, etc., are mentioned with precision. Through these articles, an attempt has been made to understand significant impact of the texture pattern on machining parameters and improve the machining process.

Keywords: Texturing, texturing technology, tool force, texturing effect, texture pattern, friction and wear of tool, Tool life, effect of coolant.

ITRS325
Metallic Titanium Nanoparticles as Potential Anti-wear additive

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Abstract: The energy efficiency of various tribo-systems in both automotive and industrial equipment's operations are primarily essential for various regulatory compliance. Lubricants are an integral part of industrial machinery. However strict environmental legislation has capped the use of exiting P & S based compounds additives. The lubricants OEM are looking for novel energy efficient environmentally friendly lubricants. Various Nanoparticles (NPs) of have been explored in the past of different families. The nanoparticles (NPs) of Titanium (Ti) were explored for the first time to enhance the tribo-performance of group III base oil. Its Hexagonal Close Packed (HCP) crystal structure indicates the likelihood to show solid lubricity, although nothing is reported on this. The Titanium nano-oils were prepared by homogeneously dispersing NPs ultrasonically using two step methods. The tribo-performance of formulated oils was evaluated on Four ball tester for EP (weld load as per IP-239) and anti-wear performance (ASTM D 4172-B). Formulations were also characterized for density, viscosity, and viscosity index as various ASTM test standards. Worn surfaces of ball were studied to understand the plausible wear mechanism using a various spectroscopic technique such as SEM, EDX, 3D profilometer and XPS. Results revealed the significant reduction in wear (~ 45%) and friction (64%) was exhibited by 0.5 wt.% of NPs. The elemental mapping showed contribution of Ti NPs in forming protective tribofilm formed by tribosintered Ti NPs. XPS characterization revealed formation of chemical tribofilm that Ti nano-oils was due to the tribofilm composed of embedded Ti particles in the form of FeTiO3.

Keywords: Titanium Nanoparticles, Antiwear additive, Nano-lubricants, Tribosintering

ITRS326
LABORATORY WEAR TEST USING JAW CRUSHER

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Abstract: Mineral fragmentation often produces high rates of wear due to impact and abrasion. In this process, the intense contact between the ore and the crusher components produces premature wear on this part. In order to improve lifetime prediction, it becomes necessary to evaluate wear through laboratory tests. The tests are cost-effective alternatives for quantifying wear and investigating the application of new materials. While several tests for impact and abrasion exist, investigating and discussing approaches employing laboratory crushers becomes useful for methodology selection. This paper aimed to review the methodology of wear testing using jaw crushers. A literature review was conducted based on the standardized methodology, proposed adaptations, and the respective wear responses observed. From this, it was possible to present the main characteristics of the test considering its execution parameters.

Keywords: wear, jaw crushers, methodology.

ITRS327
On the influence of axial distortions on lubricant film and friction force of top piston ring conjunction near to TDC

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Abstract: The purpose of this paper was to understand how axial distortions could affect on the tribological performance of ring-liner conjunction. If piston rings and cylinder bore wear out, it might be a potential threat to the engine. A detailed investigation of the worn area will help to diagnose and to correct the symptoms, assisting to mitigate the harmful effects such as Hydrocarbon (HC) and Nitrogen Oxide (NOx) emissions. The current model contains the effects of mixed-hydrodynamic regime of lubrication, axial distortions, and asperity contacts through computational fluid dynamics (CFD) predictions. The axial profiles were modeled using series of sinusoidal waves. The influence of different distortions on ring wear rate is determined, using the Archard's model. The ring friction and minimum lubricant film at maximum combustion pressure near to TDC are predicted for various worn ring and liner profiles. The study shows

that, when the maximum pressure rises, the different wear identities affect the operation of the ring friction much more limited, while the number of sine waves are more pronounced. Finally, it is proved that, even the increase of oil film thickness, it does not presuppose the reduction of friction when it comes to shaping the surface of the cylinder.

Keywords: top piston ring, axial distortions, Archard model, friction, lubricant film

ITRS328

A Review on Condition monitoring of defects in Rolling element Bearings

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Abstract: Rolling element bearings are used to support the rotating parts in almost all the machinery for power transmission purpose. Any defect in the bearing parts may cause severe damage to machines, which may even cause catastrophic failure if left unnoticed. Hence, it is essential to identify the bearing damages and its severity at an early stage to avoid sudden damage of machinery. Defects in any parts of the bearing elements generate vibrations and it increases when the defect size increases. The vibration can be measured using signal analysis techniques for the fault identification in the bearing elements. Many researchers have developed various signal analyzing approaches for the bearing condition monitoring purpose at different conditions using mathematical models. In this review paper, various approaches used by the researchers for the detection of defects in bearings and their mathematical models are discussed. This review will give the researchers a general understanding about the recent developments in the identification of faults of the bearings using various techniques.
Keywords – Signal analysis technique – Defect models – Fault identification - Raceway defects – Rolling element defects

ITRS329

Wear analysis of carbide cutting insert in MQL turning of AISI 304 steel.

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Abstract: Turning is one of the most widely used machining operation in any mechanical industry in which the wear of cutting tool is an important aspect while machining, especially in case of hardened steel. Moreover, the tool wear significantly affects the quality of surface generated on the machined workpiece. In this paper minimum quantity lubrication, using graphene and alumina based nanofluid is performed on AISI 304 workpiece, using tungsten

carbide insert. The graphene and alumina nanofluid is used in three different concentrations (0.5, 1 and 1.5%). The wettability characteristic and the tribological behavior of nanofluid were studied using goniometer and pin on disc tribometer. The input parameter for turning experiment are cutting speed, feed rate, depth of cut and nanoparticle concentration respectively and their effect are analyzed on tool wear. The tool wear of carbide insert is evaluated using optical microscope. The design of experiment is performed using Response surface methodology. The turning operation performed using graphene nanofluid provided better result in minimizing tool flank wear in comparison to alumina nanofluid.
Keywords: wear, nanofluid, steel, turning, tribology.

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