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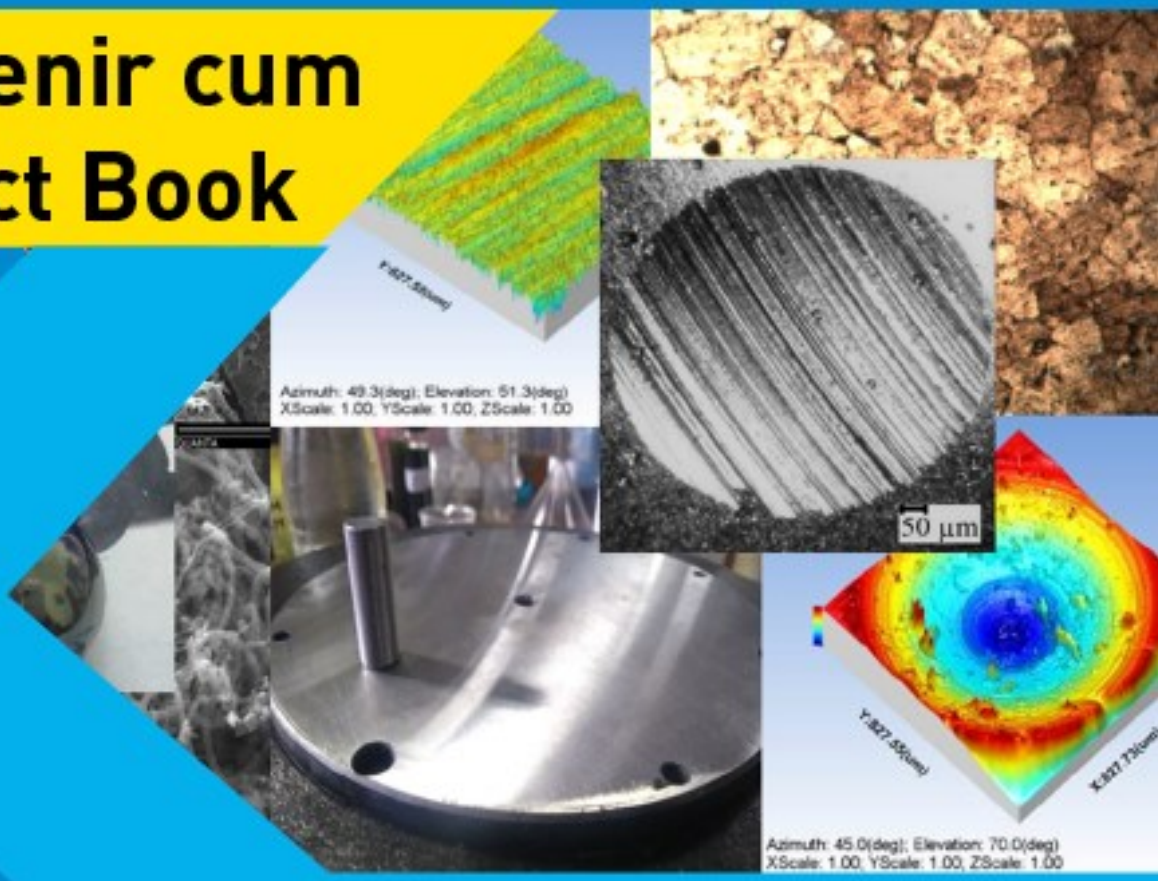
Tribology Society of India
(Affiliated to the International Tribology Council, UK)
TSI

TRIBOINDIA 2020

An International Virtual Conference on Tribology

10th to 12th December 2020

A Souvenir cum Abstract Book



Organized by

Department of Mechanical Engineering

SRM Institute of Science and Technology

Kattankulathur Tamil Nadu 603203, India

Under the Aegis of

Tribology Society of India

Souvenir cum Abstract book

TRIBOINDIA 2020

An International Virtual Conference on Tribology

10th - 12th December 2020

held at the Department of Mechanical Engineering,
SRM Institute of Science and Technology, Kattankulathur, India,

Compiled by

Kumaran D • Arokya Agustin S • Dhanasekaran M

Organized by

Department of Mechanical Engineering
SRM Institute of Science and Technology
Kattankulathur Tamil Nadu 603203

Under the aegis of

Tribology Society of India

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Surface Engineering & Tribology

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TRIBOINDIA 2020

Tribology is a multi-disciplinary subject dealing with the study of interacting surfaces in relative motion. The term, derived from the Greek word "Tribos" (meaning "Rubbing"), in general it denotes the subject of Friction, Lubrication & Wear technology. Over the years, the subject of Tribology came to be recognized as a very important aspect in all industrial operations. The application of correct Tribological practices can protect and enhance the life of plants and machineries, improve efficiency of operations, reduce energy consumption and prevent expensive breakdowns.

To provide a common umbrella to work further in this area, Tribology Society of India (TSI) has been set up as a professional, not-for-profit body bringing together academicians, and industry as well as research organizations as its members. The Society is affiliated to the International Tribology Council (ITC) based in London, UK. The activities related to Tribology in the country started way back in 1972, when first World Conference on Industrial Tribology (WCIT) was organized by Indian Institute of Technology at New Delhi. Continuing with this, a series of National and International Conferences have been organized during the last 48 years including successful recent events ASIATRIB 2014, TRIBOINDIA 2018 at VJTI Mumbai (4th in the series of National Tribology Conferences) and IndiaTrib 2019 (the 10th International Conference on Industrial Tribology at IISc, Bangalore). TSI also organizes its annual event of Summer Schools in Tribology, the recent one being the 12th Summer School in Tribology, in webinar mode having been organised successfully in July 2020.

Currently the Society operates from its registered office at Indian Oil R&D Centre, Faridabad. Tribology society of India invites academic institutions to organize a conference once in every two years with the sole objective of providing a platform to academicians, researchers and practicing engineers to discuss the current trends in tribology practices.

TRIBOINDIA-2020 is the fifth in the series of National Tribology Conferences (NTC), however, the first ever through online mode, The first edition of NTC was organized by IIT Roorkee in 2011 , the second one at PES University at Bengaluru in the year 2014 and third one at IIT BHU during 2016. In 2018 the NTC was renamed as TRIBOINDIA 2018 and was organized at VJTI Mumbai. This year SRM Institute of Science and Technology, Kattankulathur Campus will be organizing the TRIBOINDIA-2020 via online mode.

ABOUT SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

SRM Institute of Science and Technology (SRMIST) formerly known as 'SRM University, is located in an extensive sylvan campus of 380 acres skirting the National Highways (NH145), in the outskirts of Chennai. SRMIST is one of the top ranking Universities and most premier engineering destinations in India, which is established in 1985 by the Founder Chancellor, Dr. T.R. Paarivendhar. Now it is functioning in campuses located at Kattankulathur (KTR), Ramapuram Part (Vadapalani) and Ramapuram in Chennai and one in Modi Nagar, Ghaziabad with over 52000 students and 3200 faculty members, offering wide range of undergraduate, postgraduate and doctoral programs in Engineering, Management, Medicine & Health Sciences, Agriculture, Law and Science & Humanities. The Institution has moved up through international alliances and collaborative initiatives to achieve global excellence. SRMIST also collaborates with various foreign Universities. Now the Institute enjoys an unsurpassed reputation in academic and corporate circles being the preferred manpower source for vision to be recognized as a world-class learning institution. SRMIST has been accorded Category I status by MHRD-UGC of Government of India and also accredited by NAAC with 'A++' Grade in the year 2018.

ABOUT DEPARTMENT OF MECHANICAL ENGINEERING, SRM IST.

The Department of Mechanical Engineering is one of the pioneering departments of SRMIST. The department is functionally divided into three broad areas of specialization: namely, Design, Manufacturing, and Thermal Engineering. B.Tech Mechanical Engineering program at Kattankulathur campus is accredited by Engineering Accreditation Commission (EAC) of ABET, USA. The department also offers M.Tech. and Doctoral programs in various specializations. The present faculty strength is 135. About 800+ research papers and 850+ conference papers have been published in national and international levels. More than 30 patents have been filed in national and international levels.

The following salient workshops and conferences was conducted by the Department of Mechanical Engineering, KTR: International Conference on Advances in Mechanical Engineering 2006, Short Course on Mechanics of Composite Materials and Structures: 2015, Workshop on Development, Manufacturing and Analysis of Advanced Composites, 2015 and short course on FEM, 2015, National Conference on Advances in Mechanical Engineering (NCAME 2016), Brain Wave Robotics, 2017, International Conference on Advances in Mechanical Engineering (ICAME 2018) and 2nd international Conference on Advances in Mechanical Engineering ICAME 2020 (26th February to 29th February 2020).

ABOUT TRIBOLOGY LABORATORY AT SRM IST

The Department of Mechanical Engineering has a dedicated team of faculties who work in the area of tribology in a well-equipped laboratory. This fully functional research laboratory is handling funded projects from several industries and government agencies. Students of this laboratory are sent to reputed institutes for internship in the area of tribology. The laboratory initiated two MoUs with foreign universities and the outcome was seen in joint publications and internship for students. The laboratory also works closely with premier institutes in India in the area of tribology. The laboratory news was published in the Newsletter of Tribology Society of India.

Preface

The Department of Mechanical Engineering, SRMIST, along with the Tribology Society of India is extremely happy to bring out this Souvenir cum Abstract Book proceedings of the virtual conference TRIBOINDIA 2020 in PDF form. TRIBOINDIA-2020 is the fifth in the series of National Tribology Conferences (NTC), (however the first ever through online mode), The first edition of NTC was organized by IIT Roorkee in 2011, the second one at PES University at Bengaluru in the year 2014 and third one at IIT BHU during 2016. In 2018 the NTC was renamed as TRIBOINDIA 2018 and was organized at VJTI Mumbai. This year SRM Institute of Science and Technology, Kattankulathur Campus organized the TRIBOINDIA-2020, 10th -12th December, via online mode. Several researchers, scientists and practicing engineers participated in this online event. 7 Plenary Lectures, 13 Keynote Lectures and 102 Contributory Lectures in various domains of tribology which graced the occasion are presented in this Souvenir. It was an honour for all of us to hear the inaugural lecture by Professor Ali Erdimir, Texas A&M, the President of International Tribology Council.

The organizers are grateful to the Tribology Society of India for providing the opportunity to organize the conference at SRMIST and also for providing all support and advices during the organization of the program.

The Department of Mechanical is thankful to Dr. T.R. Paarivendhar, Chancellor, Mr. Ravi Pachamoothoo, Pro-chancellor (Admin), Dr. P. Sathyanarayanan, Pro-chancellor (Academics), and Dr. R. Shivakumar, Vice President, SRMIST for their encouragement and full support for the success of the conference. The organizing committee thanks the authorities, the Vice Chancellor, Pro-Vice Chancellor (E&T), Dean (CET), Dean (Research) and Chairperson (SME), SRMIST for their supports which motivated the organizing team. It is to be noted that the success of any event lies on the shoulders of every member of the organizing committee. A special thanks to every member of the organizing committee who worked tirelessly in this tough situation and made TRIBOINDIA 2020 a grand success. The organizing secretaries would like to thank all the reviewers who helped in reviewing the abstracts within the deadline. Heartfelt thanks to the participants for their active participation without whom the event would have never been successful.

On a special note of thanks to all our sponsors who have supported the event in this pandemic situation. We hope you all have enjoyed the sessions and have gathered the rich knowledge of tribology during these three days.

With a ray of hope to meet with all of you we remain grateful for making TRIBOINDIA 2020 a great success.

Shubhabrata Datta
Shubrajit Bhaumik

Dated: 10.12.2020

TRIBOLOGY SOCIETY OF INDIA

(Affiliated to International Tribology Council, U. K.)
Registration No. 197 Year 2010-11, Faridabad (Haryana)

Registered Office: R&D Centre, Indian Oil Corporation Ltd, Sector – 13, Faridabad – 121007, Haryana
Telephone: +91 0129 2294264/322/680 Fax: +91 129 2286221
Website: www.tribologyindia.org Email: info@tribologyindia.org

Message

President, Tribology Society of India & Director (R&D), Indian Oil

Dear TSI members and TRIBOINDIA-2020 delegates,

SRM Institute of Science and Technology, Chennai is organizing the TRIBOINDIA 2020 a virtual conference on Tribology from 10th-12th December 2020.

This virtual conference being a part of the new normal in view of the current Covid 19 pandemic is part of the continuing effort on part of Tribology Society of India to sensitize researchers and industry about the benefits possible in improvement of productivity and profitability of all sectors of industry through innovative tribological design and services.

Tribology Society of India has been leading the way in organizing international conferences hosted by an academic and research institution every two years with the sole objective of providing a platform to academicians, researchers and practicing engineers to showcase their work in form of technical papers and discuss the current trends and research in Tribology. TRIBOINDIA 2020 is the fifth in this series of international conferences which started with the inaugural edition in IIT Roorkee in the year 2011.

I am enthused by the good response in terms of plenary and keynote speakers from India and abroad during the conference and hope that these three days of the conference will provide a great opportunity to continue the discussion on Tribology using the virtual platforms in this new normal.

While conveying my greetings and best wishes for a successful organization of TRIBOINDIA 2020 to the organisers, I am sure that ideation through discussions and deliberations during the conference will play a vital role in furthering the body of knowledge of this multi disciplinary science of Tribology.

With warm regards,

Dr S S V Ramakumar
President, TSI
& Director R&D, Indian Oil Corporation Ltd

Prof. SANDEEP SANCHETI Ph.D (UK), FIETE, FIE(I), MIEEE
Vice Chancellor
&
EX- President - Association of Indian Universities, New Delhi

Message

I am happy to know that Department of Mechanical Engineering. SRM Institute of Technology, Kattankulathur campus in association with the Tribology Society of India is organizing the Virtual Conference on Tribology, TRIBOINDIA 2020 during December 10-12, 2020. Tribology is an area that is highly interdisciplinary in nature as it is very important to understand the interacting surfaces that are in relative motion especially in terms of safety, reliability, flexibility and efficiency. The phenomenon of Tribology affects our lives in a multitude of ways every day. And for this, a thorough understanding about the recent advances in the field of Tribology will be important.

1 am sure TRIBOINDIA 2020 will bring together a multidisciplinary community of engineers, scientists and academicians to discuss the recent advancements in the area of Tribology. It will also definitely serve as a great platform for the participants to know- in detail about the practices developed in industries, the needed research that keeps machines working without any wear and tear and will also throw more light in the field of advanced technologies.

I wish TRIBOINDIA 2020 a grand success.

Dr. Sandeep Sancheti

Prof. C. Muthamizhchelvan, Ph. D.
Pro Vice chancellor (E &T)

Message

Wisdom consists of Ideas and Doctrine whose meanings change with the mind that entertain them. The more we collaborate the more we improvise the knowledge.

Engineering Sciences and Technology are always an enthusiastic areas for the researchers and it is a right mix for conferencing among the academic community and industry experts.

It gives immense pleasure in welcoming the participants to the prestigious event TR1BOINDIA 2020, organized by the Department of Mechanical Engineering. SRM Institute of Science and Technology, Kattankulathur, in association with the Tribology Society of India.

TIRIBOIND1A 2020 will set a platform for academicians, scientists, practicing engineers and scholars together to exchange and share their experiences in different areas of tribology and discuss the practical challenges encountered to solve critical problems.

My heartfelt appreciation to the organizing committee and the Tribology Society of India for their sincere efforts in bringing this event to light.

7/12/20

(Prof.C.Muthamizhchelvan)

Prof. C. Muthamizhchelvan
Pro Vice Chancellor
Faculty of Engineering and Technology
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur - 603 203
Tamilnadu, India.

Prof. T. V. Gopal
Professor & Dean (College of Engineering and Technology)

Message

I am delighted to note that the Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, in association with Tribology Society of India is organizing the virtual International Conference TRIBOINDIA 2020 during 10th – 12th December 2020. Certainly, this type of conference not only brings all researchers, students at one platform, but also inculcates the research culture among the entire fraternity of education in the country, thereby, contributing to the development of nation Mutual participation and high quality deliberations create inspiring learning environment resulting into innovative ideas. I am sure the participants of TRIBOINDIA 2020 will be highly motivated alter listening to the esteemed Plenary and Keynote speakers from reputed institutes and industries.

I hope that this conference would certainly induce innovative ideas among the participants paving way for new inventions and technologies in the area of tribology.

I congratulate the organizers and wish the conference a great success.

Dr T V Gopal
DEAN
College of Engineering and Technology
SRM Institute of Science & Technology (SRMIST)
SRM Nagar, Kattankulathur-603 203,
Chengalpattu Dist, Tamilnadu, India.

Prof. D. Kingsly Jeba Singh
Chairperson
School of Mechanical Engineering

Message

I am very happy to note that the Department of Mechanical Engineering is organizing the 3 day **International Conference TRIBOINDIA 2020** in association with Tribology Society of India during 10th - 12th December 2020.

TRIBOINDIA 2020 will give a platform for our academicians, scholars and researchers together to understand the basic fundamentals of tribology, its importance in terms of safety, reliability and efficiency. They will also understand the new areas and development in the field of tribology. I hope this conference also help to build strong inter-institutional networks and pave synergy among the research community and bridge the gaps between industry and academia.

I would like to express my sincere appreciation to the organizing committee of TRIBOINDIA 2020 for their dedicated efforts to materialize the conference in this tough pandemic situation.

I welcome all the eminent speakers and participants to TRIBOINDIA 2020.

1 wish TRIBOINDIA 2020 a grand success.

Dr. D. Kingsly Jeba Singh

Prof. M. Cheralathan
The Head
Department of Mechanical Engineering

Message

The Department of Mechanical Engineering is organizing a virtual International Conference, TRIBOINDIA 2020, **fifth in the series of National Tribology Conferences (NTC)**, during, December 10th – 12th 2020 at SRM Institute of Science and Technology, Kattankulathur in association with the Tribology Society of India. The main focus of TRIBOINDIA 2020 is the research platform to solve the tribological issues in various field of materials and manufacturing.

TRIBOINDIA 2020 will enable participants to interact with the experts in the areas of tribology. I sincerely express my gratitude to the Plenary and Keynote speakers from prestigious institutes and industries for their immediate acceptance to our invitation and obliged to deliver the lectures on various topics on tribology.

I am grateful to the advisory committee members for their valuable inputs towards the conductance of this program.

I take this opportunity to place on record my sincere gratitude to our Chancellor, Pro-Chancellor (Admin), Pro-Chancellor (Academics), Vice Chancellor, Pro-Vice Chancellor (E&T), Dean (College of Engineering & Technology) and Chairperson (School of Mechanical Engineering) for their continuous encouragement and support to this conference TRIBOINDIA 2020.

I also thank the organizing secretaries and all the teams of the Department of Mechanical Engineering for their extended cooperation to conduct this conference successfully. A special heartfelt thanks to Tribology Society of India who have helped us in conducting the conference. A constant support from the members of Tribology Society of India has helped in several ways in making this conference come to light in this pandemic situation.

I express my heartily congratulations to one and all who have directly or indirectly lend their hand in making this conference a great success.

Dr.M.Cheralathan

Prof. Shubhabrata Datta
Department of Mechanical Engineering

From the desk of the Organizing Secretary

It has been a wonderful experience during past few months to be a part of a highly motivated team of faculty members of the Mechanical Engineering department of SRM Institute of Science and Technology, Kattankulathur, who were busy with the organization of TRIBOINDIA 2020. I also had lot of enriching interactions with the senior members of Tribology Society of India. As a result, the virtual conference on tribology, TRIBOINDIA 2020, became a reality. I express my heartfelt gratitude to the Tribology Society of India for giving the opportunity of organizing TRIBOINDIA 2020, and to the management of SRMIST for providing all kinds of support.

I am grateful to the eminent Plenary and Keynote Speakers who have agreed to grace the sessions by sharing their rich experience in the area of tribology. I thank Prof. Ali Erdemir, Texax A&M and the President of International Tribology Council, who accepted our invitation and agreed to deliver the inaugural speech.

I thank all our sponsors. A conference is never successful with the participants; hence I extend heartfelt and sincere gratitude to all the contributory authors who shared their research results in the conference. The organizing secretaries extend their special regards to their colleagues of mechanical engineering without whom the conference would not come to light.

I feel delighted to experience that even during these tough days of the pandemic, the tribologists from various countries have contributed enthusiastically to make TRIBOINDIA 2020 a great success.

(Shubhabrata Datta)

Program Schedule- TRIBOINDIA 2020

TRIBOINDIA 2020

Program Schedule

DAY 1: DECEMBER 10, 2020

TIME	DAY 1 PROGRAM
09:30 – 10:45	**Inaugural Session (Room 1)**
Welcome Address	Prof. M. Cheralathan, Head, Mechanical Engineering, SRMIST
About the Conference	Dr. Shubrajit Bhaumik, Jt. Organizing Secretary, TRIBOINDIA 2020
About TSI	Dr. Barun Chakrabarti, Vice President, TSI
Presidential Address	Prof. C. Muthamizhchelvan, Pro Vice Chancellor, SRMIST
Felicitation	Prof. T.V. Gopal, Dean CET, SRMIST
Felicitation	Prof. D. Kingsly Jeba Singh, Chairperson, Mechanical Engineering, SRMIST
Inaugural Address	Prof. Ali Erdemir, Texas A&M, USA, President, International Tribology Council (Frontiers research on super lubricity: A historical perspective)
Vote of thanks	Dr. P. Nandakumar, Head, Design Division, Dept. of Mechanical Engineering, SRMIST
10:45 – 12:30	**Plenary Session I (Room 1)**
Plenary Lecture 1	The process of wear; A synergistic process Prof. S.V. Kailas, IISc Bengaluru, India
Plenary Lecture 2	Tribology of traction motor bearings of electric vehicles Prof. R. Gnanamoorthy, IIT Madras, India
12:30 – 13:00	**Break**
13:00 – 16:00	**Technical Session 1A (Room 1): Surface Engineering and Tribology I**
Keynote Lecture	Malaysian agricultural waste as new sustainable tribological materials – Prof. Md. Fadzli Bin Abdollah, Universiti Teknikal, Malaysia
Contributory Papers	T003: Ecofriendly and facile fabrication of superhydrophobic aluminum alloy
	T009: Medico-tribological investigation of pulsed plasma nitrided austenitic stainless steel
	T011: Influence of mechanical properties of coating and substrate on wear performance of h-DLC or tin- coated AISI 5140 steel
	T018: Correlating the stress state with morphological and tribological properties of thin coatings
Keynote Lecture	EHL of Non-conformal contacts and isotropic surface textures – Dr. G. Rajaram, Thejo Engineering Limited, India
Contributory Papers	T019: Tribological characteristics of thermomechanically processed 7075 Al alloy through nano-scratch characterization
	T027: Influence of powder feed rate on the slurry abrasive wear behavior of Co-Cr alloys deposited on SS-316l material.
	T030: Molykote – anti friction lubrication coating process establishment on solenoid armature and its tribo performance
13:00 – 16:00	**Technical Session 1B (Room 2): Wear Behavior of Alloys & Composites I**
Keynote Lecture	On the correlation of wear behaviour with subsurface characteristics of die steel – Dr. Debdulal Das, IIEST Shibpur, India

TIME	DAY 1 PROGRAM
Contributory Papers	T002: Review on optimization of process parameters for hybrid metal matrix composites (HMMC)
	T005: Tribological characterization of iron based self-lubricating composite under dry sliding conditions
	T026: Tribo-mechanical behaviour assessment of magnesium based fibre metal laminates
	T039: Fabrication and optimization of wear parameters of B_4C reinforced Al2024 nano metal matrix composites
Keynote Lecture	Research advances and development trend on magnesium alloys and composites - Prof. A. Elaya Perumal, Anna University, India
Contributory Papers	T044: Wear behaviour of magnesium hybrid composite reinforced with Al_2O_3 and MoS_2 particles through PM route
	T045: Cavitation erosion behavior of MoNbTiZr medium entropy alloy
	T053: Erosion wear behaviour of A357/fly ash composites
	T57: Tribological characterization of aluminium metal matrix composites
13:00 – 16:00	**Technical Session 1C (Room 3): Lubrication I**
Keynote Lecture	Graphene: Next generation lubricant additive - Dr. Md. Khalid, Sunway University, Malaysia
Contributory Papers	T006: Investigating graphite added glycerol as metalworking fluid in turning of steel
	T008: Tribological properties of h-BN additivated lubricants
	T040: Comparative study of thermo-physical and tribological properties of coconut oil based nano lubricant using CuO nanoparticle and MoS_2 nanoparticle
	T041: Addition of surfactant in CeO_2 nanoparticles and its synergistic effect on diesel fuel
Keynote Lecture	Oil vs. grease behaviour in rolling/sliding contacts – on the beneficial thickener effects: with a focus on wind turbine application - Dr. Balasubramaniam Vengudusamy, Klueber Lubrication, Germany
Contributory Papers	T042: Friction and wear behaviour of non-edible oil based lubricant
	T043: The enhanced tribological performance of hexagonal boron nitride (hBN) nanoparticle additives in various type of engine oil
	T047: Flash temperature of sliding contacts - a comparative study

DAY 2: DECEMBER 11, 2020

TIME	DAY 2 PROGRAM
9:30 – 11:30	**Technical Session 2A (Room 1): Surface Engineering and Tribology II**
Contributory Papers	T046: Wear behaviour of AA6061 processed by equal channel angular pressing
	T055: Wear, scratch and corrosion resistance of aluminide coating prepared on ferritic martensitic steel
	T067: Reciprocating sliding behaviour of solid lubricant coating over modified titanium alloy surfaces
	T080: Wettability of hydrophobic micro-dimpled HSS surfaces
	T081: Wear behaviour of friction stir welded AA7075 and AA6063 aluminium alloys
	T082: The effect of deep cryogenic treatments on the microstructure and wear behaviour of 3.6C-2.8Si ductile cast iron subjected to austempering
	T083: Prediction of suitable heat treatment for H13 tool steels by application of thermal shock fatigue cycle
9:30 – 11:30	**Technical Session 2B (Room 2): Wear Behavior of Alloys & Composites II**
Keynote Lecture	Tribological investigation of white etching area (WEA) formation under severe sliding condition in bearing steel - Dr. P. Ramkumar, IIT Madras, India
Contributory Papers	T63: Effect of ball milling duration on tribological properties of CNT reinforced Al matrix composites
	T064: Machine learning approaches for analyzing tribological behavior of aluminium matrix composites
	T075: Assessment of mechanical and tribological characteristics of A356 reinforced with x wt% CaB_6 composites
	T076: Assessing the tribological behaviour of stir casted AA6063 with x wt% $ZrSiO_4$ and 6wt% TiB_2 hybrid composites
	T079: Dry and wet tribology of carbon nanotubes in Al/steel and AMMC/steel sliding contacts
	T090: Wear performance analysis using worn surfaces of different aluminium alloy composites - A comparative study
9:30 – 11:30	**Technical Session 2C (Room 3): Lubrication II**
Keynote Lecture	Nanolubricants dispersed with graphene and its derivatives: an assessment and review of the tribological performance – Dr. N.C. Murmu, CSIR-CMERI, India
Contributory Papers	T048: Surface morphology studies in end milling of AA7075 under MQL environment using tri-hybridized carbonaceous nano cutting fluids
	T054: The role of surface roughness frequencies in controlling lubricant wettability in hierarchical engineering surfaces
	T62: Evaluation of tribological performance of coconut oil-based grease with hybrid MoS_2/SiO_2 additives under boundary lubrication regime
	T069: Viscous and molecular effects of fatty acid concentrations in thin film lubrication flow
	T072: Formulation and tribological evaluation of vegetable oil based grease

TIME	DAY 2 PROGRAM
11:30 – 12:30	**Business Talks (Room 1)**
	Optimol Instruments
	Ducom Instruments
	RTec Instruments
12:30 – 13:00	**Break**
13:00 – 16:00	**Technical Session 3A (Room 1): Surface Engineering and Tribology III**
Keynote Lecture	Lubrication performance of hydrostatic / hybrid textured fluid film bearings - Prof. Satish C Sharma, IIT Roorkee, India
Contributory Papers	T084: Understanding the wear behavior of nylon coated steel surfaces in presence of commercial greases
	T086: Evaluation of PEEK to PEEK friction welded joint properties
	T087: Diamond like carbon coating on Y-TZP for dental implant.
	T096: Study of tribological properties of multilayer gradient Ti/tin coating.
	T101: Influence of countersurface roughness on two-body abrasive wear of hastelloy C-276 in dry sliding conditions
	T102: Transitions in two-body microscale abrasive wear of hastelloy C-22 superalloy
	T104: Micro tribological properties of Ti-6Al-4V in comparison to Ti-6Al-4V shot-blasted
13:00 – 14:30	**Technical Session 3B (Room 2): Wear Behavior of Alloys & Composites III**
Keynote Lecture	Three-body abrasive wear property of a quenched and non-isothermally partitioned steel - Dr. Chiradeep Ghosh, Tata Steel Limited, India
Contributory Papers	T091: Effect of reinforcements on graphite/TiO_2/Al nanohybrid composites
	T097: Assessment of mechanical properties for aluminium composites using rice husk ash as a reinforcement.
	T098: Evolution of mechanical and tribological behaviour of hybrid composites under dry and wet conditions
	T100: The effect of sliding speed on dry sliding wear behavior of A356 alloy with minor additions of magnesium
14:30 – 16:00	**Technical Session 3C (Room 2): Tribo-measurement**
Keynote Lecture	Importance of the study in fundamental wear mechanism and data analysis – Spatiotemporal mapping analysis - Prof. Kanao Fukuda, Malaysia-Japan IIT, Malaysia
Contributory Papers	T60: New multi-sensing nanotribology test with electrical contact resistance and friction measurement
	T085: Optimization of parameters of single point cutting tool for turning operation
	T092: Development of test method to detect gear failure using vibration and ferrography analysis
	T093: Development of test method for evaluation of engine oils in horizontal and inclined planes with oil recirculation system in SRY- 5

TIME	DAY 2 PROGRAM
13:00 – 14:00	**Technical Session 3D (Room 3): Lubrication III**
Contributory Papers	T073: Transesterification of blended vegetable oils as cutting fluids and prediction of cutting forces using machine learning techniques
	T074: A comparative study on the tribological performance of solid lubricants over PEEK polymer
	T088: Anti-wear behaviour of polyalphaolefins with oleic acid treated LaF_3 nanoparticles as an additive under extreme pressure conditions
	T099: Tribological characterization of simarouba glauca biodiesel (SGME) with copper oxide nanoparticles
14:00 – 16:00	**Technical Session 3E (Room 3): Condition Monitoring**
Keynote Lecture	Sustainable efforts through lubrication: Balanced approach to performance and environmental acceptability - Dr. T.C.S.M Gupta, Apar Industries Ltd., India
Contributory Papers	SP001: Combination of analytical sciences with tribological quantities for an advanced condition monitoring
	T015: Ferrography – Specialized oil analysis for protection and diagnose gear and bearing detoriation
	T017: Vibration damping analysis using MR fluid assisted worktable for drilling
	T070: Friction analysis of aircraft landing gears due to landing impact
	T089: Experimental study to compare the performance of engine fueled with diesel and biodiesel blend on the basis of vibration signature analysis
16:00 – 18:00	**Plenary Session II (Room 1)**
Plenary Lecture 3	Application of topological optimization methodology in hydrodynamic lubrication – Prof. A. Almqvist, Lulea University of Technology, Sweden
Plenary Lecture 4	Experimental analysis and modelling for reciprocating wear behavior of nanocomposite coatings – Prof. Z. Khan, Bournemouth University, UK
Plenary Lecture 5	Surface design against third body fretting-corrosion of electrical connectors – Prof. T. Liskiewicz, The Manchester Metropolitan University, UK

DAY 3: DECEMBER 12, 2020

TIME	DAY 3 PROGRAM
9:30 – 11:00	**Plenary Session III (Room 1)**
Plenary Lecture 6	Roles of Nanoparticles in formation of tribofilm - Prof. Hong Liang, Texas A&M, USA
Plenary Lecture 7	The influence of double cardan joints kinematics and quasi-static effects on rolling bearings life in railway traction motors - Prof. Viorel Paleu, TUIASI, Romania
11:00 – 12:30	**Technical Session 4A (Room 1): Tribological Performance of Bearings I**
Contributory Papers	T004: Effect of eccentricity ratio on damping and stiffness coefficients for journal bearing with flexible liner taking micropolar lubrication
	T013: Limiting load capacity analysis of FGM texture bump foil journal bearing

TIME	DAY 3 PROGRAM
	T021: Performance behaviors of micro-pocketed/textured tilting pad thrust bearings
	T025: Influence of span angle on the performance of hole-entry hybrid spherical journal bearing
	T031: Influence of textured shapes in hybrid slot entry journal bearing
	T032: Study of a hybrid spherical capillary compensated thrust bearing
11:00 – 12:30	**Technical Session 4B (Room 2): Polymer Composites & Friction Materials I**
Contributory Papers	T001: Indentation behaviour of cellulosic fibres/fly ash incorporated polymer composites at sub-micron scale
	T012: Tribological /mechnical investigations of additive manufactured polymer composites
	T014: Effect of zirconium silicate and mullite with three different particle sizes on tribological behavior of non-asbestos organic (NAO) brake pad
	T020: Synergic effect of metallic fillers as heat dissipaters in tribological performance of a non-asbestos disc brake pad
	T022: Tribological and mechanical performance report of epoxy-resin composites reinforced with multi-walled carbon nanotubes
	T023: Influence of Alkali treatment in Areva Javanica fiber and its effect in mechanical, physical and tribological behaviour in NAO brake friction composites
11:00 – 12:30	**Technical Session 4C (Room 3): Bio-tribology I**
Keynote Lecture	Role of biomaterials for hip joint replacement applications - Dr. Amar Patnaik, MNIT Jaipur, India
Contributory Papers	T007: Tribological investigations of biological interfaces: from cartilages to catheters
	T016: Investigating the tribological properties of HAp/Cu-HAp-POM composites.
	T028: Mechanical behaviour of hydroxyapatite dispersed sulphonated polyetheretherketone based composite membrane at microstructural length scale
	T033: Study and optimization of wear characteristics of PLA/PMMA biopolymer composites
12:30 – 13:00	**Break**
13:00 – 15:00	**Technical Session 5A (Room 1): Tribological Performance of Bearings II**
Contributory Papers	T034: On the behaviour of asymmetric conical hole-entry hybrid journal bearing system
	T035: FEM analysis of a porous hybrid journal bearing under the turbulent regime
	T036: Effect of semi-cone angle on the performance of hybrid slot-entry conical journal bearing
	T037: Effect of non-Newtonian lubricant on the linear and non-linear stability analysis of the double-layered porous journal bearing
	T050: Tribological performance analysis of multi-lobe hydrodynamic journal bearing with nano-additives in lubricants
	T61: Housing light-weighting and its impact on bearing performance
	T078: Analysis of thermoelastohydrodynamic lubrication of journal bearing including the effect of surface roughness and cavitation
13:00 – 15:00	**Technical Session 5B (Room 2): Polymer Composites & Friction Materials II**

TIME	DAY 3 PROGRAM
Contributory Papers	T024: Tribo-mechanical behavior of basalt fiber reinforced polylactic acid and polypropylene hybrid polymer composites
	T029: Tribological behavior of cera –metallic clutch friction material in agriculture tractor applications.
	T038: A review on tribological behavior of silicon nitride based ceramics
	T051: Influence of aluminium foam on dry sliding wear behaviour of glass fiber reinforced epoxy composites
	T058: Tribological characterisation of banana/ sisal composites and hybrid composites: A review
	T066: Newly developed multiscale composites for tribological applications under water-based lubrication
	T094: Wear and morphological analysis on basalt/sisal hybrid fiber reinforced polylactic acid composites
	T095: Thermo-mechanical analysis of ventilated and solid disc brake pad model
13:00 – 15:00	**Technical Session 5C (Room 3): Bio-tribology II**
Contributory Papers	T056: Wear evaluation of polycarbonate urethane core for artificial disc in lumbar region
	T59: AI based design of hybrid UHMWPE composites with enhanced tribo-mechanical behavior
	T065: Bio-tribological performance of medical grade UHMW polyethylene based hybrid composite for cartilage replacement
	T068: New polycaprolactone polymer coated magnesium biodegradable alloy for cardiac stent application.
	T071: Temperature and load influence on adhesion wear in dry sliding contact in vacuum condition
	T077: Electrochemical and biological behaviour of near β titanium alloy for biomedical implant applications
	T103: Wear performance of UHMWPE and PCU artificial disc materials
15:00 – 16:00	**Valedictory Session (Room 1)**
Welcome address	Prof. D. Kingsly Jeba Singh Chairperson, School of Mechanical Engineering, SRMIST
Report of the conference	Dr. Shubhabrata Datta Organizing Secretary, TRIBOINDIA 2020
On behalf of TSI	Mr. Ajay Harinarain Secretary, Tribology Society of India
Special Addresses	Mr. Uttam Kr Roy President, Maihar Integrated Cement Unit, MP BIRLA Group
	Mr. Walter Wagner Managing Director, Wagner German Oils, Germany
Valedictory Speech	Prof Nilesh J. Vasa Dean of Students (DOST) & Professor, Department of Engineering Design, NT Madras
Vote of Thanks	Dr. TVVLN Rao & Dr. Jitendra Katiyar Mechanical Engineering, SRMIST

Inaugural Lecture

Frontiers research on superlubricity: A historical perspective

Ali Erdemir
Texas A&M University
Department of Mechanical Engineering
College Station, TX
USA

Abstract: Friction and wear between moving mechanical assemblies (MMA) collectively consumes nearly a quarter of world's energy output and causes more than 8 Gigatons of CO_2 emissions [1]. With increasing mobility and industrial activity, there is no doubt that adverse impacts of friction and wear of such MMAs on energy, environment, global economy and ultimately sustainability will continue to intensify. Accordingly, as tribologists, if we can lead the way toward far more efficient, green, and long-lasting MMAs, we can reverse this unsustainable trend and hopefully save our planet from major ecological and environmental disasters. In recent years, great strides have been made in the design of new materials and coatings affording friction coefficients below 0.001 level [2]. Such a remarkable progress in vanishing friction is largely due to many concerted efforts and worldwide collaborations centered around the creation of novel materials, surfaces, and interfaces causing little or no friction as well as rapid increases in computational capabilities (including artificial intelligence, machine/deep learning, and data analytics) for more reliable modeling and simulation. In this presentation, a comprehensive overview of what makes and breaks superlubricity will be provided in relation to the many intrinsic and extrinsic factors that are in play starting from the onset of sliding to running-in and well into steady-state. In light of the recent analytical, experimental and computational findings, an attempt will also be made to recap those underlying mechanisms that are most responsible for such superlubric sliding behaviors. In particular, recent mechanistic studies on highly ordered 2D materials (like graphene, MoS_2, HBN, MXene, etc.) and disordered DLCs are highlighted in relation to their structural peculiarities and operating environments. Recent developments in liquid superlubricity will also be covered and their promise for the development of more efficient mechanical systems will be discussed. Overall, these and other novel studies are leading the way for the design and production of next generation materials and coatings that can potentially vanish friction in future MMAs and hence save energy, improve durability, and thus protect the environment for a sustainable future.

[1] Holmberg, K., Erdemir, A. Influence of tribology on global energy consumption, costs and emissions. Friction, 5(2017)263–284.
[2] Erdemir, A., Martin J. M., Luo, J., Eds., Superlubricity (2nd Edition), Elsevier, Amsterdam, 2020.

Profile of **Prof. Ali Erdemir**

Dr. ALI ERDEMIR is a Professor and Halliburton Chair in Engineering in the J. Mike Walker '66 Mechanical Engineering Department of Texas A&M University, College Station, Texas, USA. In recognition of his research accomplishments, Dr. Erdemir has received numerous coveted awards (including STLE's International Award, ASME's Mayo D. Hersey Award, the University of Chicago's Medal of Distinguished Performance, six R&D 100 Awards, two Al Sonntag Awards and an Edmond E. Bisson Award from STLE) and such honors as being elected to the US National Academy of Engineering, the presidency of the International Tribology Council and STLE. He is also a Fellow of AAAS, ASME, STLE, AVS, and ASM-International. He has authored/co-authored more than 300 research articles and 18 book/handbook chapters, co-edited four books, presented more than 180 invited/keynote/plenary talks, and holds 29 U.S. patents. His current research focuses on bridging scientific principles with engineering innovations towards the development of super-hard and -low-friction materials, coatings, and lubricants for a broad range of cross-cutting applications in manufacturing, transportation and other energy conversion and utilization systems.

Plenary Speakers

The Process of Wear; A Synergistic Process

Prof. Satish V. Kailas
Department of Mechanical Engineering
Indian Institute of Science, Bangalore 560 012

Abstract: The process of wear is as complicated as one can imagine. There would be more than a dozen parameters that would influence the wear mechanism and wear rate. In this presentation, it is argued that the process of wear can be reduced to three major processes; 1) Plastic deformation mechanism, 2) Tribo-oxidation/Tribo-chemical, and 3) Mechanically mixed layers. When two surfaces come in contact, the real area of contact is much less than the apparent area of contact. This lower real area of contact leads to a significantly higher level of stress in the asperities in contact. The higher level of stress would lead to plastic deformation in these asperities during sliding. The strain rates experienced by these asperities are high and would lead to a temperature rise in the surface regions. The microstructural response or plastic deformation mechanism of a material depends on the imposed strain rate and temperature of deformation. The concomitant effect of the temperature rise is oxidation taking place in the near-surface regions. If there are specific environments, other chemical reactions could take place. The process of plastic deformation and tribo-oxidation products lead to the formation of debris. This debris can be either be expelled from the tribo-contact or remain in the tribo-system. When it remains in the tribo-system, two things could happen 1) Three-body abrasion occurs or 2) the wear debris mixes back into the surface to form a mechanically mixed layer. Here the tribo-system plays a crucial role in the formation of a mechanically mixed layer. Thus, wear can be considered to be a process that is a synergy of three mechanisms. The talk will also cover an experimental process that will enhance one process and show that the process of wear is indeed a synergistic mechanism.

Profile of **Prof. Satish V.Kailas**

Professor Kailas obtained his B.Tech. from the Government Engineering College, Thrissur in 1987, M.E., and Ph.D. from the Indian Institute of Science in 1989 and 1994, respectively. He then carried out postdoctoral research at IISc till 1996 and was a Guest Researcher at the National Institute of Standards and Technology, USA, during 1996-97. He is at IISc since 1997 and is today a Senior Professor at the Indian Institute of Science, Bangalore, India. Sustainability and how to reach Sustainable Development have been his passion, and his research has always kept these goals in mind. His approach has been to develop a "closed-loop cycle" of the use of materials. His research in tribology, friction stir welding/processing, metal forming, and development of eco-friendly lubricants is geared towards reaching sustainable development. He has published over 170 peer-reviewed Journal articles and chapters in books and 130 Conference Presentations and Papers. He also authored the course on Materials Science for the NPTEL program. He is on the editorial board of STLE Tribology Transactions, Friction (Springer), and Tribology Online of JAST. He was on the editorial board of Wear and ASME Journal of Tribology. He has also published the book "Liberation Through Education."

Tribology of traction motor bearings of electric - vehicles

R Gnanamoorthy, Krishanu Modal, P Karthik
Department of Mechanical Engineering
Indian Institute of Technology Madras
Chennai 600036, INDIA
Corresponding author: Prof R Gnanamoorthy, Email id: gmoorty@iitm.ac.in

Abstract: The main source of noise and vibration in the electric vehicle traction motor is the bearings. The design methodology followed, and materials used for bearings are based on the decades of research work carried out worldwide under normal operating conditions. The extensive research work carried out indicated the failures in rolling element bearings are due to excessive mechanical loads and/or poor lubrication. Pitting, spalling, scuffing, peeling, and uniform wear are commonly observed failures in rolling element bearing parts, and research outcomes helped the industry to design, select bearing materials and lubricants to avoid these failures. In the case of bearings used in electric traction motors, different types of current flow into the driveshaft and bearings depending upon the type of motor and controls used. The flow of electric current in addition to the mechanical loads influences the bearing performance and results in early failures compared to the expected life. The research in this direction is in the early stages and the limited understanding of the influencing parameters on bearing performance is a major concern. Our group is carrying out active research, both numerical and experimental based, to understand the various factors that influence the performance of the bearing parts under combined electrical and mechanical loads. Various contact situations are modeled using simplified models to predict the heat generated due to the flow of current in the contacting surfaces using numerical tools. A novel simulator (patent pending) to study the performance under simulated conditions is designed and developed in the laboratory and experimental research work performed will be discussed. The ongoing research work indicates the accelerated damage in the contact zones due to the combined loading and remedial measures are suggested.

Profile of **Prof. R.Gnanamoorthy**

Prof Gnanamoorthy received his Doctor of Engineering (Dr Engg) degree from Nagaoka University of Technology, Japan. He served at Institute for Materials Research, Tohoku University Japan, as a regular employee before joining as Faculty at IIT Madras in 1997. His teaching and research interests include on Advanced Materials & Product Design, Design with Polymer and Nanocomposities, Machine Element and Special Purpose Test Machine Design, Damage Tolerant & Tribo Design, Behavior of implant materials, and Surface Engineering. Prof Gnanamoorthy has published more than 250 original research publications in reputed International Journals and Conferences. His research publications were cited in more than 1200 research publications worldwide. He has guided 7 Doctoral scholars and holds a patent on innovative surface modification process for surface nanocrystallization and fatigue life improvement. He has successfully completed many sponsored research projects for Government organizations such as NRB, ISRO, DST, IGCAR and offered consultancy services to reputed Industries in India and Abroad. He is on the International Advisory Board of Japanese Society of Mechanical Engineers, and serves on a number of Government, Academic, and Industry committees and advisory bodies associated with the development of new Institutes, curriculum improvement and new product development. He has also served as an Expert Member of Engineering Education for Next Generation Global Engineers, Japan. Prof Gnanamoorthy, served as the Founder Director of IIITDM Kancheepuram, and established a state of the art of green campus at the outskirts of Chennai and is an architect of Design Centric Engineering and Smart (Industry 4.0) Academic Programs in India. He has also served as the Mentor Director for IIITDM Kurnool, AP and Director i/c for the Central Institute for Classical Tamil, Chennai.

Application of topological optimisation: methodology in hydrodynamic lubrication

Andreas Almqvist & Kalle Kalliorinne
Division of Machine Elements, Luleå University of Technology,
Luleå, SE-971 87, Sweden

Abstract: Research devoted to the optimisation of bearing performance is an important branch within hydrodynamic lubrication. It is also a field of research that has attracted a lot of attention and, accompanied by the ever-increasing computing power, it has recently seen a substantial intensification. Still, the most outstanding and ground-breaking result, is the more than 100-year old discovery by Lord Rayleigh. Indeed, already 1918 Rayleigh found the step-bearing geometry, which presents the global optimum, in terms of load carrying capacity, of among all possible geometries under conditions when the lubricant's density and viscosity can be assumed to be constant. This paper follows in Rayleigh's footsteps and it presents a sequence of contributions employing numerical topology optimisation methodology based on the globally convergent method of moving asymptotes GCMMA. With the film thickness as control variable and either the efficiency or load carrying capacity (LCC) as objective function, the GCMMA routine is used optimise the geometry of hydrodynamically lubricated bearings, modelled by the Reynolds equation.

Keywords: Topological optimisation, MMA, load carrying capacity, Reynolds equation

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Profile of **Prof. Andreas Almqvist**

In my role as professor at the Division of Machine Elements, Luleå University of Technology (LTU), I lead the branch of research devoted to Computational Tribology, which have been my obligation for the last eight years. I'm currently the principal investigator of the 4-year project; Multiscale topological optimisation for lower friction, less wear and leakage, financed by the Swedish Research Council. I also lead two other 4-year projects on modelling and simulation of tribological processes and various short-term projects devoted to the same. I am proud to say that I am currently the Editor-in-Chief for Proceedings of the IMechE, Part J: Journal of Engineering Tribology. Quite recently I also had the opportunity to guest edit an SI, entitled Multiphysics and multiscale models of tribology, in the open access journal Lubricants, which I am also very proud of. For more information about me and my research please visit my homepage: http://www.ltu.se/staff/a/almqvist

Experimental analysis and modelling for reciprocating wear behaviour of nanocomposite coatings

Professor Zulfiqar A Khan
Department of Design, Engineering & Computing
NanoCorr, Energy & Modelling (NCEM) Research Group
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Abstract: Research in this paper provides experimental study, results, numerical modelling and simulation to fully understand and enable predictive modelling for wear failures within nanocomposite coating subject to sliding contact. During this research a range of nanocomposite coatings have been developed and have been reported. This presentation is focused on four types of nanocomposite coatings; (i) Nickel-Alumina (Ni/Al_2O_3), (ii) Nickel-Zirconia (Ni/ZrO_2), (ii) Nickel Ni/Graphene, and (iv) Nickel-Silicon Carbide (Ni/SiC) which have been developed by state-of-the-art electroless coating techniques. Among other benefits this methodology allows to optimise homogenous dispersion of nano constituents within thin layer, control porosity, uniform thickness over a surface area from 0.5 µm and above, enhance substrate-coating interfacial adhesion and post processed roughness. These coatings have been experimentally examined by using a modified micro-friction sliding contact tribo bench test. It has been found that Ni/Graphene demonstrated better tribo performance within the context of wear failure, this trend was followed by Ni/Al_2O_3, Ni/SiC and Ni/ZrO_2 respectively. Based on experimental results, numerical modelling has been developed to simulate and predict wear performance in the above mentioned newly developed nanocomposite coating and generalise the model to include a wide range of nanocoating by including nano-mechanics, grain and mechanical characteristics and incorporating energy balance and distribution phenomena. This numerical modelling can be utilised as a holistic design solution which is based on a wide range of attributes such as intrinsic mechanical properties, surface induced stresses, coating porosity, grainsize, interfacial characteristics and nano/ micro hardness. These models are in full agreement with the experimental findings.

Keywords: Numerical modelling, Simulation, Tribo testing, Nanocoating, Sliding wear, Graphene

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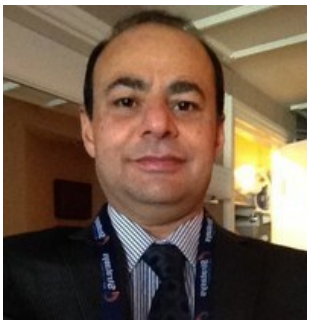
Profile of **Prof. Zulfiqar A Khan**



Professor Zulfiqar A Khan has been leading NanoCorr, Energy & Modelling (NCEM) research group within the University Design & Engineering department. He has developed multidisciplinary research in wear-corrosion synergy, nano-coating incorporating tribo-corrosion issues, thermodynamics and numerical modelling in collaboration with major industrial and academic partners.

He has previously lead Research and Enterprise activity in the then School of Design, Engineering and Computing, as Associate Dean between Nov 2008 'til Aug 2010 and the University's Sustainable Design Research Centre as Director since July 2007.

Surface design against third body fretting-corrosion of electrical connectors

Prof. Dr. T.Liskiewicz
The Manchester Metropolitan
University,UK

Abstract: Over the last few decades complex electronic systems have become an integral part of all types of vehicles. New user features, safety equipment, and increased reliability expectations of electronics require hundreds of meters of wires, connecting individual devices and assuring integrity of the system. This results in a large number of electrical connections with some high specification vehicles having more than 400 connectors with 3000 electrical contacts on board. Comfort and safety of vehicle users rely on reliability of electronics and durability of electrical contacts. Failures do, however, take place and it has been estimated that up to 60% of all car electrical problems relate to degradation of electrical contacts by fretting-corrosion. This type of surface damage is observed between two mated surfaces subjected to vibrations and thermal cycling. Such conditions occur during normal vehicle operation causing two parts of an electrical contact to move in relation to each other with high a frequency and small displacement amplitude - typically tens or hundreds of microns. This generates damage of both surfaces, wear particles are produced and subsequently oxidised in air atmosphere. As a result, an oxide film is formed at the interface, which isolates both surfaces and increases electrical resistivity leading to the contact failure.

In this paper, we are looking at the impact of intentional surface texturing on fretting-corrosion performance of electrical contact components. We have shown, how electrical contact durability can be extended by a surface design approach, which controls the metallic interface and assures low contact resistance. The approach links imposed surface geometry to the progressive process of interface oxidation. A relationship between surface roughness and electrical contact durability has been observed. This relationship has been found to be non-linear, indicating a critical value of surface roughness associated with the maximum electrical contact durability.

Profile of **Prof. T.Liskiewicz**

Tomasz Liskiewicz is a Professor of Tribology and Surface Engineering at Manchester Metropolitan University. He has 20 years of international academic and engineering experience from leading research institutions in the UK, France, Canada and Poland. Currently, Tomasz is the Head of Department of Engineering at Manchester Metropolitan University. His research interests focus on surface engineering and tribology of functional surfaces, with a particular interest in understanding the engineering coatings, its architectures and optimization for enhanced functions. His work has been published in such journals as Surface & Coatings Technology, Wear, Tribology International, and Industrial & Engineering Chemistry Research. It has been presented at international conferences that include the World Tribology Congress, International Conference on Metallurgical Coatings and Thin Films, and Plasma Surface Engineering.Tomasz holds a doctorate in Tribology from École Centrale de Lyon, France, and MSc degree in Materials Science from Lodz University of Technology, Poland. He spent two years in Alberta, Canada, working as a Senior Scientist in Charter Coating leading material testing projects for oil and gas industry. Tomasz has taught BSc, MSc and PhD-level courses on tribology, surface engineering and thermofluids. He was elected Fellow of the Institution of Mechanical Engineers in London in 2014. He is a Fellow of the Institute of Physics in London, where he acts as a Chair of the Tribology Group Committee. Tomasz has an editorial position at Taylor & Francis Tribology journal and contributed invited book chapters on surface engineering and micro-mechanical characterisation methods.

Roles of Nanoparticles in formation of tribofilms

Hong Liang
Texas A&M University
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Abstract: Tribofilms play vital roles in protecting lubricated surfaces in mechanical systems, such as vehicles, manufacturing machines, and artificial joints. Those films are formed through tribochemical reactions under mechanical contact in processes like mechanical mixing, sliding, pressurized loading, and at elevated temperature. Recent research has reported that using nanoparticles as lubricant additives is an effective approach to enhance the formation of tribofilms. To date, the understanding in physical-chemical principles behind the relationship between nanoparticle-enhanced formation of tribofilms and tribological performance remains to be limited. In this presentation, we will start with a brief review of nanoparticles as lubricant additives. The mechanisms of their roles in friction reduction will be summarized. Followed by a case study of our recent investigation of the kinetics of the formation of a tribofilm on a pair of rubbing bearing steels. In that study, strategically-selected-illuminative nanoparticles were used to track the tribochemical reactions resulting the change of properties of the tribofilm. Finally, the effects of nanoparticle additives on the formation of tribofilms are found to display in three stages: running in, reactive, and growth of the film.

Keywords: tribofilms, nanoparticles, in situ characterization, kinetics

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Profile of **Prof. Hong Liang**

Dr. Hong Liang is Oscar S. Wyatt Jr. Professor at J. Mike Walker ’66 Department of Mechanical Engineering, Texas A&M University. Her interests in tribological research include areas of chemical-mechanical polishing (CMP), nanoparticles and tribomaterials and their surface and interface properties. Professor Liang is a co-editor-in-chief for Tribology International and has been on board of a few other journals. She is a fellow of the American Society of Mechanical Engineers (ASME) and a Fellow of the Society of Tribologists and Lubrication Engineers (STLE). She is currently the treasure of STLE. In 2018-2019, she was the ASME Swanson Fellow and served as assistant director for research partnerships for the Office of Advanced Manufacturing at National Institute of Standards and Technology.

The influence of double cardan joints kinematics and quasi-static effects on rolling bearings life in railway traction motors

Viorel Paleu[1], Shubrajit Bhaumik[2], and Daniel Nelias[3]

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[2] Tribology and Surface Interaction Research Laboratory, Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu 603203, India; shubrajb@srmist.edu.in

[3] Univ. Lyon, INSA-Lyon, CNRS UMR5259, LaMCoS, F-69621, France; daniel.nelias@insa-lyon.fr

Abstract: In order to estimate the service life of rolling bearings supporting the shaft of a railway traction motor, it is necessary to know the loads on these bearings, which is only possible by modeling the entire transmission from the bogie to the engine (via the axle/gearbox and cardan shaft). The proposed method for calculating the loads acting on the motor shaft bearings and the method used to predict the life of the bearings take into account the extreme conditions under which electric motors operate: variable loads due to double cardan joint transmissions linking the drive shaft to the gearbox/bridge assembly, imbalance of rotating parts, and vibrations and shocks.

Keywords: cardan joint; rolling bearing, railway; TGV; high speed train; traction motor; imbalance.

Profile of **Dr. Viorel Paleu**

VIORE PALEU, Ph. D., joined "Gheorghe Asachi" Technical University of Iasi from Romania in September 1996. He received the Doctor of Philosophy degree in Mechanical Engineering with Magna Cum Laudae distinction from the same university in 2002. In the period 2000 - 2009 he accomplished all the stages from assistant professor to associate professor at Mechanical Engineering Faculty of "Gheorghe Asachi" Technical University of Iasi.

During his Ph.D. and after, as a post-doctorate, he passed about 2 years at INSA de Lyon in France, working on research projects with industry partners (ALSTOM France, SNR France, SNECMA Parris, Microturbo etc.) and Ministry of Education from France. He is the beneficiary of four international research grants, all of them at INSA Lyon – France: Tempus –IMG, Socrates, Egide, and AUF grants. In addition, he is director of five national research grants and member of the research team for over 20 research national and international grants.

He has published papers in the area of rolling bearings, lubrication and lubricants, tribology, materials, machine parts, data acquisition, diagnosis and signal processing, between the most representative papers being those published in Smart Materials and Structures (2018), Tribology Transactions, Lubrication Science, Tribology International, Journal of Cleaner production, Metals, Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, IOP Science, Matech Web of Conferences, Key Engineering Materials, Applied Mechanics and Materials, Materiaux et Techniques etc.

He has served on peer review panels for Elsevier journals (Tribology International, Mechanical Systems and Signal Processing, Applied surface science) and MDPI journals (Materials, Sensors, Coatings, Entropy, Lubricants etc.). He was chairman and member in scientific committees of many international conferences on mechanical engineering (COMEFIM, ROTRIB, IMANE and ACME).

He was elected vice-president of Romanian Tribology Association (ART) of Iasi, and vice president and president of Romanian Transmissions Association (ROAMET) of Iasi from 2008 up to present.

Keynote Speakers

EHL of non-conformal contacts and isotropic surface textures

Dr. G. Rajaram
Thejo Engineering Limited
India

Abstract: Elastohydrodynamic lubrication (EHL) is the typical regime for friction pairs with elastic contact such as ball bearings and gears. The geometry of contact, oil quantity, and viscosity of lubricant play a vital role to characterize the behaviour of friction coefficient and wear. Machining the grind lines are a problem in critical working surfaces on gears, splines, journals, crankshafts, bearings, camshafts and couplings. The surface irregularities are causing the lubricant flow and the oil film thickness, which results in metal-to-metal contacts of rolling elements and subsequent adhesive wears. The breaking of surface irregularity peak points in the high-pressure contact region causes pressure ripples which induce fatigue failure.

The surface roughness parameter defines the wear life the non-conformal contacts. A strong interaction exists between surface roughness and lubricant viscosity on the coefficient of friction in rolling contact.

The Super-finishing is a process that creates a surface smoother than conventional machining. The honing, tape polishing and super grinding are the few super-finishing processes to achieve low surface roughness contact surfaces.

The word 'isotropic' means uniform in all directions. The isotropic term refers to the non-periodic or randomized surface texture. The existing super finishing techniques create a repeating periodic texture with directional scratch marks or grinding lines. The advantages of the isotropic finishing process are as follows.

- Improved the wear fatigue life of the rolling contacts
- Reduced downtime, less noise, higher energy efficiency
- lower overall costs, improved lubrication

This lecture session also covers the following details.

- Effect of load, speed and temperature on COF with varying lubrication viscosity for conformal and non-conformal contacts.
- Effect of COF on Specific film thickness parameter (λ) and Oil film thickness for smooth and rough surfaces
- Bearing Fatigue life Vs oil film thickness
- Chemically Assisted Surface Enhancement-Isotropic Super finishing Surfaces
- Conventional Vs Isotropic Super finishing Surfaces comparison

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Profile of **Dr. G. Rajaram**

Dr. Rajaram Ganesan - Head R&D Department is a highly qualified and well experienced research scholar. He is having 20+ years of experience in industrial and academic research. He has graduated from the University of Madras with a degree in Mechanical Engineering and done his master's degree with a specialization of Product Design and Development from the College of Engineering Guindy (CEG), Anna university. He has obtained his doctoral degree from NIT Trichy. He has also done the post-doctoral research work in aluminium foam material modelling at U.T.F.S.M, Chile. He served as R&D Manager at National Engineering Industries Ltd, a CK Birla group. He has more research experience in Tribology, surface modifications, surface coatings, CAE-Material modelling, and castings. He has 12 research publications and 7 patents to his credit. His Ph.D research work got a best research poster award by Material Research Society of India (MRSI). He has developed a polymer-based lubricant for rolling element bearings, which has won ACMA GOLDEN Award-Excellence in Technology in 2018. The products developed from his research laboratory fetches the top innovative company in CII Industrial Innovation Awards -2017.

Malaysian agricultural waste as new sustainable tribological materials

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Abstract: Nowadays, many alternative technologies include thin film coatings, green lubricants, and bio/eco-materials, which have been introduced for the sustainability of global need to conserve energy by reducing friction and wear of components or parts. In Malaysia, oil palm and kenaf are two primary commodity plants. Malaysia is one of the largest producers and exporters of palm oil worldwide, accounting for 11% of the world's oil and fat production, and 27% of the world's oil and fat export trade. The palm oil industry produces a tremendous amount of waste, consisting of about 90% of biomass waste and just around 10% of palm oil. Meanwhile, the Malaysian government has taken the initiative to develop kenaf-based products by incorporating the upstream to downstream processing research and development into economic and marketing activities. The use of agricultural waste as a new composite or coating materials has also been found to be sustainable and comparatively less expensive. It ultimately could utilize the waste effectively into wealth. Therefore, this has inspired us to investigate the potential of oil palm- and kenaf-based waste to be new tribological materials, which have potential uses in sliding bearings or friction materials in a variety of applications.

Profile of **Dr.Md. Fadzli Bin Abdollah**

Dr. Mohd Fadzli Bin Abdollah received his Bachelor of Engineering (Honors) in Mechanical Engineering and Master of Engineering (Mechanical) from Universiti Kebangsaan Malaysia (UKM) in 2004 and 2005, respectively. Later in 2011, he completed his Doctor of Engineering (Dr.Eng.) from Nagoya University, Japan.He is currently an Associate Professor at the Faculty of Mechanical Engineering (FKM), Universiti Teknikal Malaysia Melaka (UTeM). Previously, he held various positions, including Deputy Dean (Research and Postgraduate Studies) at FKM, UTeM; Manager and Co-ordinator of Centre of Excellence (CoE) at the Centre for Advanced Research on Energy (CARe); Head of Department (Diploma Studies) at FKM, UTeM; and Executive Member of Society of Engineering Education Malaysia (SEEM). Recently, he has been appointed as the Vice President of the Malaysian Tribology Society (MYTRIBOS), Deputy President of the Asian Tribology Council (ATC), and Vice President of International Tribology Council (ITC). He has received the 'Outstanding Paper Award 2017' by Emerald Publishing UK. Besides, he was recognized as the 'Outstanding Reviewer' for Tribology International (2017) and Energy (2018) by Elsevier. In conjecture, he is one of the key pioneers in developing the Green Tribology and Engine Performance (G-TriboE) group at UTeM. He is a member CEng, Institution of Mechanical Engineers, UK; member of Society of Automotive Engineers of Japan, Inc.; member of graduate member of Institute of Engineers Malaysia and Board of Engineers MalaysiaHe has authored or co-authored more than 100 journal and conference papers and obtained 3 Intellectual Properties. His current interests involve the Tribology of eco-materials and surface engineering. Fadzli has served the Tribology community in various capacities including, Editor-in-Chief for Jurnal Tribologi and appointed as Editor for Journal of Tribology and Lubricants.

On the correlation of wear behaviour with subsurface characteristics of die steel

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Abstract: The wear resistance of a material is largely dependent on the dynamic changes that occur in the surface and subsurface of a specimen during the course of wear; therefore, correlation of wear behaviour with subsurface characteristics of worn specimens is of fundamental importance which has been treated in this article considering a die steel. Dry sliding wear tests of hardened and tempered AISI D2 steel specimens have been carried out using pin-on-disc tribometer under varying normal loads (F_N) at a constant sliding velocity. Subsurface of worn specimens have been characterized by optical and SEM examinations, XRD and EDX analyses, and measurements of microhardness versus depth profiles. These are supplemented by the characterization of microstructure and evaluation of mechanical properties of unworn specimens, measurements of wear rates and morphological analyses of worn surfaces as well as generated wear debris. The obtained results assist to infer that (i) under the investigated wear test conditions, the wear rate (W_R) increases linearly with F_N, while the mode and mechanism of wear has been identified as severe delamination, (ii) wear particles generated by fracturing of featureless white (non) etching layer (*WEL*) which is found to form on the contact surface of the pin specimens during wear under the combined actions of severe plastic deformation and high flash temperature with associated phase transformation at higher F_N, (iii) apart from the *WEL*, the subsurfaces of worn specimens also exhibit a work hardened layer and a softened over-tempered layer; existence of these layers and their thicknesses are dependent on the employed F_N, and (vi) thickness of both wear affected zone (t_{WAZ}) and *WEL* (t_{WEL}) are found to increase linearly with F_N. The obtained results unambiguously establish that wear rates of die steel exhibit linear correlation with the t_{WAZ} and t_{WEL} in the severe wear regime.

Keywords: Adhesive wear; Wear transition; Delamination; Worn surface; Subsurface; White etching layer.

Profile of **Dr. Debdulal Das**

Dr. Debdulal Das graduated in Metallurgy from B. E. College (Calcutta University), received his M.Tech. (Metallurgy and Materials Engineering) degree from IIT Kharapur, and obtained Ph.D. from BESU Shibpur, India. He is currently an Associate Professor in the Department of Metallurgy and Materials Engineering, Indian Institute of Engineering Science and Technology, Shibpur, India. His research interest includes structure-property correlations, tribology, fatigue, hot deformation of advanced high strength steels, composite materials, modelling and simulation, ZnO-based varistor and non-traditional machining. He has authored over hundred research papers in international journals and edited conference proceedings. His present h-index is twenty-one. He received the Young Faculty Research Award 2012, Bengal Engineering College Alumni Association, Washington Metropolitan Area, USA, and G. S. TENDULKAR AWARD 2009, IIM-ATM. He is a reviewer of over fifty international journals. He is a Life Member of IIM, MRSI and IE(I).

Research advances and development trend on magnesium alloys and composites

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Abstract: Magnesium and its alloys have excellent physical and chemical properties such as low density below 1.8 g/cm^3, high strength, good shock absorption, large modulus of elasticity, good heat dissipation, high impact resistance, bio-inert, and recyclability, to have widespread applications in the fields of aerospace, transportation, electronic, biomedical and energy storage.

However, it is limited in many applications because of its poor plasticity and corrosion resistance. In the past decades, lot of research has been carried out on magnesium and its alloys to improve its suitable behavior for the wider applications. The research on magnesium and its alloys includes composition optimization, processing technology improvement, and microstructural enhancement.

A comprehensive review about magnesium and its alloys has been presented under the following areas,

(i). Global presence and trends in magnesium research:

This topic highlights the important advances of magnesium and its alloys worldwide. This review also analyses all the academic articles published by Journal of Magnesium alloys alone from 2013-18. From the web of science core collections: database, it can be concluded that the total amount of literature containing magnesium alloy in the topic is 39,422 papers from 2000-2018. The number of documents published annually ranged between 760 in 2000 to 3735 in 2018, representing a growth rate of 491%. This growth rate reflects the fact that magnesium alloys have become the most common metallic structural materials in the world.

(ii). Techniques to improve performance of magnesium:

Magnesium as a unique performance on various fields of application. The efficiency of the Mg could be improved by alloying, and material processing. Material processing produce refined grain size in the submicron range and even nanometer range, which improves the mechanical and structural properties. Some of the secondary treatments especially severe plastic deformation techniques are ECAP, ARB and HPT, which are reviewed for AZ31 Mg alloy on the aspect of mechanical and tribological property.

(iii). Functional magnesium:

This topic focuses the Mg based composite materials with biodegradable, biocompatibility and mechanical properties. Magnesium alloys are bio compatible and biodegradable with suitable alloyed elements, which are promising to be used as implantable medical devices and implants. Therefore, several investigators designed on in-vitro and in-vivo studies of magnesium alloys and aiming to find the better performing biodegradable magnesium alloy. On other hand, functional magnesium is used for hydrogen storage, batteries and electrical transmission. These topics are also discussed in detail. Hence, it can be concluded that the Mg material is the promising future material and it confirms that Mg is the 21st century material.

Profile of **Dr. A. Elayaperumal**

Dr. A.Elaya Perumal is currently Professor and Head, Engineering Design Division, CEG, Anna University He has completed Bachelors from CEG, Anna University, M.Tech in Machine Dynamics from IIT Madras, he completed Ph.D from Anna University Chennai. His area of interest are Nano science and Engineering, Composite Materials and Nano composites, Surface Engineering & surface coatings. He has supervised more than 10 Ph.D students. He has vast teaching and research experience. Completed many consultancy projects worth around more than 80 lakhs.

Graphene: next generation lubricant additive

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Abstract: Friction and wear-related failures are the major concerns faced by the transportation sector. Additionally, about 30% of the energy is wasted globally in overcoming the friction. Therefore, developing new additives with reliable tribological properties, efficiency and durability are of paramount importance to the transportation industry. Recently, graphene has attracted considerable attention from many fields due to its unique lamellar structure, superior mechanical strength and excellent thermal conductivity. In this paper, we present graphene as a novel additive for lubricating oils and discuss the tribological behaviour of graphene with various functionalizations schemes. The lubrication behaviour was investigated using a four-ball tester under different operating conditions. The graphene additives were characterized using field emission scanning (FESEM), X-ray diffraction (XRD), UV-Vis spectroscopy and Raman spectroscopy prior to tribological testing. Friction test results demonstrate that the graphene concentration in oils varies at different tribological contact conditions to reach the optimum lubrication behaviour. The lubrication mechanism during the shearing process was proposed based on the results from tribological testing and worn scar morphology analysis.

Keywords: Graphene; Wear; Friction; Superlubricity

Profile of **Dr. Mohammad Khalid**

Dr. Mohammad Khalid is a research professor and head of Graphene and Advanced 2D Materials Research Group at Sunway University, Malaysia. He has completed his bachelor's degree in Chemical Engineering from Visvesvaraya Technological University, India and MSc in Chemical and Environmental Engineering from University Putra Malaysia. Later, he did his PhD in Nanotechnology Engineering from International Islamic University, Malaysia. His research focuses on nanomaterial synthesis, heat transfer fluids, phase change materials, energy harvesting and storage. More specifically, he is currently working on solar energy harvesting using deep eutectic salts (DES) and carbon nanoparticles based nanolubricants to improve engine performance. He has published more than 200 papers in international journals and refereed international conferences, edited three book titles and published several book chapters. He has 2 granted patents and holds several local and international grants. Professor Khalid has 15 years of research and teaching experience and he has supervised more than 30 postgraduate students. He is also a Fellow of the Higher Education Academy (FHEA), UK.

Oil vs. grease behaviour in rolling/sliding contacts – On the beneficial thickener effects: with a focus on wind turbine application

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Abstract: Several different types of greases exist in the market and they generally vary by thickener type, base oil viscosity and type, NLGI grade, oil separation and rheological properties. Greases are widely used in rolling element bearings and their selection is generally made based on many factors including the type of application (e.g. wind turbine bearings, automotive wheel bearings), operating condition (speed, load, mounting type, temperature), environment (extreme low or high temperature, humid, dust), etc. Although greases have been in use since many years, unlike oils they are much less researched and reported. As greases generally hold a two phase thickener/base oil structure, they generally should possess properties of both of these components. However, due to their complex composition and nature, grease selection has generally been made based mainly on its base oil properties. Such an approach considerably ignores the potential benefits of thickener in greases.

Unlike oils, greases are reported to form a very thick film at low speeds, which has commonly been attributed to their thickeners. This could potentially influence lambda ratio, although not many have considered investigating this in detail until recently. Another less explored area is the friction properties of greases. For instance, friction curves (Stribeck curves) of oils are well known whereas those of greases are not reported much. The thick film formation at low speeds could potentially influence the shape of friction curves and lubrication condition of greases might differ from those widely reported for oils.

This talk will highlight some key benefits of thickeners and influences of base oil viscosity and NLGI grade on film thickness and friction properties.

Profile of **Dr. Balasubramaniam Vengudusamy**

Dr. Balasubramaniam Vengudusamy graduated in Mechanical Engineering in India, obtained his Masters in Tribology from ISM Dhanbad and PhD in Tribology from Imperial College London, UK. He has been working in the field of tribology for over 18+ years. He is currently a Senior Research Tribologist at Klüber Lubrication, Munich (Germany).

Tribological investigation of White Etching Area (WEA) formation under severe sliding condition in bearing steel

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Abstract: Wind energy is one of the promising renewable energy sources to run on par with the emerging needs of the future. To accomplish this ambitious goal, critical issues such as longest downtime and maintenance due to wind turbine gearbox (WTG) premature bearing due to white etching area (WEAs) and cracks need to be addressed. Gusty nature of wind causes wind shear, acceleration and deceleration, torque reversal, breaking, grid fault and impact event all together imposes severe transient mechanical dynamic loading on WTG. Moreover, the water and salt contaminations, electricity and bearing slip makes the lubrication of contact more vulnerable to premature bearing failure due to hydrogen embrittlement. Extensive root cause assessment of failed bearings identified two predominant driving forces 1) Mechanical stress induced and 2) Hydrogen enhanced premature bearing failure. Despite decades of research, several theories were proposed, but the universal consensus of the underlying mechanism is yet to be arrived. Hence, it is decided to investigate the complete sequential evolution of WEAs formation using a novel developed dynamic load Pin-on-Disc (PoD) tribometer rig. Study of subsurface microstructural changes tested samples has established the sequential microstructural changes such as clustering, agglutination and deformation followed by dissolution of cementites to form WEA in the bearing steel. A complete WEAs formation mechanism is proposed with the help of corroborative microstructure analysis. Besides that an interesting synergic interaction between hydrogen enhanced and mechanical stress induced WEAs drivers were also established during this analysis. Subsequently, quantitative insights on the catalysing behaviour of the individual and concurrent actions of drivers were elucidated. In addition to that the sequential evolution of butterfly around the non-metallic inclusion from the primitive stage was revealed in pure sliding through metallographic investigation.
Keywords: Bearing steel, Dynamic load, Pin-on-Disc, Premature fatigue, White etching

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Profile of **Dr. Ramkumar P**

Dr. Ramkumar P is currently working as an Associate Professor in the Department of Mechanical Engineering in IIT Madras. Prior to coming to IIT Madras, he was an Associate Professor at SSN College of Engineering, Chennai. Dr. Ramkumar received his B.E in Mechanical Engineering from College of Engineering, Guindy, Anna University and his M.Tech (Industrial Tribology) from IIT Madras. He obtained his Ph.D. (2003-07) from University of Southampton with specialisation of Engine Tribology, UK and did his post-doctoral fellowship in University of Leicester (2009-10), UK for developing high speed Cam-Tappet tribometer Rig. He has 14 years research experience in the field of tribology and engine tribology. His primary research interests are in the field of tribology, engine tribology, gearbox design, wind turbine gearbox bearing failures, biotribology, multilayer coatings, ionic fluids, wear modelling and developing new composite materials for brake applications. He has published more than 25 papers in peer reviewed journals and 40 international conference proceedings including 1 patent as well. In his supervision 1 PhD, 4 MS scholars and 15 M. Tech students were graduated and currently supervising 7 PhD, 4 MS research scholars, 2 Project Associates, 1 JRF and 2 M.Tech degrees students. As sole PI, he has received two research grants with total worth of US $1.4M, while as Co-PI US $ 14M from DST. Currently he is handling a lots of consultancy projects from GE, Caterpillar, Rane, Ford, Kone Elevator and L&T. He is a member in IMechE, IoP, STLE, and life time member in TSI. He is reviewer to various top journals including Applied Surface Science, Mechanism and Machine Theory, Part J : Journal of Engineering Tribology, Surface Coatings and Technology, Tribology International, Tribology Letters, Wear, etc.

Nanolubricants dispersed with graphene and its derivatives: An assessment and review of the tribological performance

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Abstract: Graphene is a pioneering discovery of this century and has recently become one of the most studied materials. Recently, researchers have been exploring the possibility of using graphene as a dispersion of nano-lubricants (a stable colloidal suspension of nanoparticles in conventional lubricants). Recent studies showed the latest developments in the tribological properties of different types of nano-lubricants dispersed in graphene and its derivatives. Graphene derivatives include surface-functionalized graphene, graphene decorated with nanoparticles, and composites of graphene and other nanomaterials. The tribological performance of graphene nanolubricants were thoroughly investigated and exhibited improved performances as compared to the existing lubricants. For the preparation of graphene-based aqueous lubricant, Graphene oxide (GO) was prepared from natural flake graphite by modified Hummers method. The friction co-efficient of GO dispersion and the graphite-based imported lubricant were measured with four ball tester according to ASTM D4172 and compared. The aqueous dispersion containing 0.1 wt% of GO showed best friction co-efficient of 0.04 as compared to the graphite lubricant obtained from Henkel and AQNET Netherland. The friction co-efficient of the 0.1 wt% of GO dispersion was also measured at various speed to predict the lubrication regime. It was found that the lubricant showed best anti wear characteristic at 1000 rpm. Extreme pressure (EP) tests were carried out following the ASTM D2783. The rotating speed was 1760 rpm and test duration of 10 sec. In EP test, last non-seizure load (LNSL) and weld point (WP) was determined. LNSL provide the extreme load carrying capacity of the WP is the point at which the rotating ball was weld with the three stationary balls and the corresponding load is called weld point load.

Profile of **Dr. Naresh Chandra Murmu**

Dr. Naresh Chandra Murmu is currently senior principal scientist, Head, Surface Engineering & Tribology Group - Head, Project Monitoring and Evaluation Group CSIR-Central Mechanical Engineering Research Institute, Durgapur. He is also Professor at Academy of Scientific and Innovative Research, New Delhi. His research interest are Micro/Nano-Manufacturing, Nano-Composites, Coating & Aqueous Lubrication. Completed his B.E. (Mechanical Engineering) from Indian Institute of Engineering Science and Technology, Shibpur. M.E. (Mechanical Engineering) (1994) Indian Institute of Science, Bangalore. PhD (Mechanical Engineering) (2010) Indian Institute of Technology-BHU. To his credit he has 90 SCI Journal publications, 4 book Chapters, over 30 Conference Publications; 7 patents filed. Received many awards and recognitions such as Fellow of Indian National Academy of Engineering, VASVIK Award, CSIR-Raman Research Fellowship, DAAD fellowship. Associate Editor - Journal of the Institute of Engineers (India) Series –C, Co-Guest Edited the Special Theme (2017): India's Reusable Launch Vehicle Technology Demonstrator: The Future of Space Transportation System with Shri Sivan, K., Chairman, ISRO. Member- Expert Advisory Committee (EAC-AMT), DST, New Delhi. Member- Lubricating Equipment Sectional Committee, PGD19, Bureau of Indian Standard, Govt. of India.

Lubrication performance of hydrostatic / hybrid textured fluid film bearings

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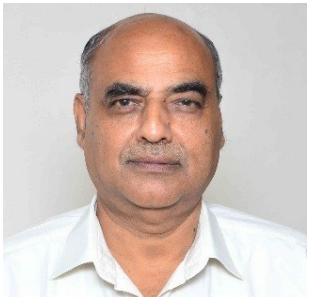
Abstract: In recent times, use of textured surface bearings has emerged as an effective way to enhance the lubrication performance of the fluid film bearings. The concept of applying texture features over the bearing surfaces are in fact taken after observing the existence of the special surface texture (scales) on the skins of marine animals and plants. Use of textured surfaces have been reported to enhance the efficiency of fluid film bearings, by improving the load carrying capacity and reducing the friction between sliding surfaces. Majority of studies in the field of textured fluid film bearings are limited to mainly hydrodynamic bearings therefore, this presentation is basically aimed to outline the research efforts undertaken so far in the area of hydrostatic / hybrid bearings and to present some salient findings of studies related to textured surfaces concerning these class of bearings. To get the numerical solution of textured bearings, solution of modified Reynolds equation is obtained using Finite Element Method by taking into account the flow of lubricant through restrictor as constraint along with JFO/Reynolds boundary condition. Newton-Raphson method is used to solve the non-linear system of equation resulted due to restrictor equation and different non-Newtonian lubricants. Published studies indicate that use of textured surfaces enhance the efficiency of fluid film bearings by improving the load carrying capacity and reducing the friction between the sliding surfaces. Additionally, partial texturing is found to be an effective way of enhancing the performance of fluid film bearings from view point of friction and load carrying capacity. The optimum bearing performance can be obtained by selecting an optimum values of texture attributes.

Keywords: Surface Texture; Hydrostatic/ Hybrid bearings; FEM; Journal bearing.

Profile of **Prof. Satish C Sharma**



Prof. Satish C Sharma is associated with Mechanical Department at IIT Roorkee for the past 15 years. He also a Chair Professor in Railway Vehicle dynamics and Coordinator, Centre for Railway Research. He has completed B.E –Mechanical, M.E(Hons) – Machine Design, Ph.D in Tribology from University of Roorkee. Under his guidance more than 26 Ph.D has been awarded. To his credit he has more than 150 international publications. He has successfully completed many consultancy and sponsored projects from Indian railways and other private agencies for a worth of 10 crores.

Three-body abrasive wear property of a quenched and non-isothermally partitioned steel

Chiradeep Ghosh
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Abstract: Ever since the pioneering work on conventional quenching and isothermal partitioning in steel by Speer and his research group, the Q&P process has been receiving increasing attention. The resultant microstructure of this process is essentially the martensite and retained austenite, where the latter occupies the martensitic lath regions. This provides an exceptional combination of strength and ductility in lean alloyed steel. Without altering the final microstructure and therefore, the properties, a possible alternative of the above approach is quenching and non-isothermal partitioning process, where the steel is cooled very slowly after quenching. In the current work, an attempt has been made to process a low alloyed steel through quenching and non-isothermal partitioning process. The wear property in this steel was measured using a dry three-body abrasive wear tester. There were no significant differences in the wear loss was observed with the change in quench temperature for the samples without hot rolling. However, an improvement of about 27% was detected when the same steel has undergone hot rolling. The scanning electron micrographs illustrated that the worn surface of the hot-rolled sample is relatively smoother when compared with the samples without hot rolling. The possible reason for this smooth surface is the result of the grain refinement and thus increased phase boundaries in the hot-rolled condition. The plastic flow of the deformed material gets hindered because of these boundaries and subsequently delays the debris formation, thereby, reducing the wear loss.

Profile of **Dr. Chiradeeep Ghosh**

Dr. Chiradeeep Ghosh graduated from IIEST, Shibpur (Formerly known as B.E. College, Shibpur) in the year 2001 and subsequently obtained his M.Tech from IIT, Kanpur in 2003. Then he joined the R&D Division of Tata Steel, India and worked there for 7 years. In 2010, he went to McGill University, Montreal, Canada for pursuing his Ph.D. degree. In 2013 after completing his Ph.D. he came back and joined the same department of Tata Steel. In all these years, his areas of research broadly include thermomechanical controlled processes, phase transformation and related phenomenon. Till date he has published more than 40 scientific papers in international peer reviewed journals which include Progress in Materials Science, International Materials Review, Metallurgical and Materials Transactions A, Acta Materialia, Scripta Materialia, ISIJ International etc. According to 'Google Scholar' his current h-index is 17 and his total citations are more than 1100. He has also 9 granted patents to his credit. He was the recipient of '*Leon and Suzanne Fattal*' Graduate Fellowships in McGill University for carrying out Ph.D. research. This is awarded annually by the Faculty of Engineering to recruit outstanding students into the Faculty's graduate degree programs. He is also the first recipient of the *'2018 ASM-IIM Visiting Lecturer'* from an industrial R&D in India. Till date, he has been the reviewer for 8 different international peer reviewed journals.

Importance of the study in fundamental wear mechanism and data analysis-spatiotemporal mapping analysis

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Abstract: Tribology is an key technology in many innovative fields and countless researchers are struggling to develop new valuable technologies all over the world. In these days, many technical approaches in the tribology are made from the viewpoint of contiguous technical fields such as computational science, nano/micro technologies, material science, bio/medical-technology, physics, surface science, etc. because of being interdisciplinary. These approaches are based on the latest knowledge in the each technical field and advance the researches powerfully. Although the new trend of the research, which is introduced above, is about to provide invaluable benefits to human society, there are some concerns that young researchers in this tide tend to have not enough experience and knowledge in tribology itself. Consequently, experimental results of tribology tests in such tide tend to be discussed using tribological terms such as mild wear, delamination, etc. as the vague concept without their historical background.
This talk starts with the research history of adhesive wear mechanisms from the primitive Archard's model until Sasada's mutual transfer and growth model of wear particle, and then introduces resent researches on adhesive wear analysis by the author. One of the difficult events in the adhesive wear mechanism to explain is deciding when and how a wear particle is generated. Although the understanding of this event is indispensable for the quantitative prediction of wear amount, it is left unknown until today. A spatiotemporal mapping analysis method for the tribo-data is demonstrated to show how it works to clarify the mechanism quantitatively and even visualizes the phenomena.

Keywords: spatiotemporal mapping analysis, tribo-data, friction, visualization

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Profile of **Prof. Dr. Kanao Fukuda**

Prof. Dr. Kanao Fukuda is currently Professor, Head of Tribology and Precision Machining I-KOHZA Mechanical Precision Engineering, Universiti Teknologi Malaysia, Malaysia. He is also a Guest Professor, WPI Invited Professor and Academic Advisor, Kyushu University, Japan. He completed B. Sc. Mechanical Engineering from Tokyo Institute of Technology, Master of Mechanical Engineering from Tokyo Institute of Technology, PhD in Mechanical Engineering from Kyushu University. Research Interests are Tribology and Precision Machining, Hydrogen Energy. He has more than 25 research articles published in reputed journals, Granted patents are 2 and filed patents is 1. Active Member of many reputed professional societies like Malaysian Tribology Society, Society of Tribologists and Lubrication Engineers, Japanese Society of Tribologists.

Sustainable efforts through lubrication: balanced approach to performance and environmental acceptability

Dr. T.C.S.M.Gupta
Senior Vice President, Apar Industries Limited, Mumbai

Abstract: Tribology plays a major role in conserving energy in transportation and industrial sector and also bringing in the sustainability concepts based on co-dependent triangle consisting of machines/ materials/ lubricants lubrication practices and environmental protection as the core.

The trends in transportation, urban mobility, manufacturing activity to meet the various sustainability developmental goals needs innovation in product development, sustainable practices to improve the quality and performance of lubricants. While the transportation lubricants are governed by various performance standards which are driven by stringent emission norms and corporate average fuel efficiency, most of the industrial and metal working lubricants are highly specific to requirements of customers and OEM's.

Industrial and power segment applications are witnessing great shift from the type of materials used, compact designs and high operating loads which require lubricants with improved performance under demanding conditions.

Challenges of developing the lubricants suitable for intended applications must include the knowledge on compatibility with advanced material, minimal toxicity/impact to environment.

Sustainable lubrication efforts have been directed largely in developing novel type of fluids such as nano fluids, ionic liquids, MQL, using variety of raw materials from renewable base stocks and additives etc. However, to bring the measurable effect, Sustainable lubrication programmes should include sustainable lubricants and practices of lubrication programs by understanding the entire life cycle of lubricants in terms of formulation, selection, storage, handling, contamination control, lubricant analysis and safe disposal by understanding the trends and industry best practices.

Profile of **Dr. T.C.S.M.Gupta**

Dr. T.C.S.M.Gupta, Ph.D in Refining Chemistry from Indian Institute of Petroleum, Dehradun India. Working as Senior Vice President- Quality, R&D and Technical with Apar Industries Limited, Mumbai, India. has over 28 years of experience in the areas of Specialty Chemicals, Lubricants and additives

Dr. Gupta has co-authored 48 papers, filed two Indian Patents and published 6 Technical reports. Research Interests include sustainable lubricants, additives, Nano fluids, transformer oils and specialty oils.

He is member of BIS, India committees in ETD 3/PCD 25 , Working Group lead and member of Cigre/IEC Europe,Vice Chairman and Honorary Secretary of Association of Lubricants Manufactures Union (ALMU), Singapore, Secretary NLGI India Chapter. He is Examiner/ co-supervisor/Industrial Panel Member for Masters & Ph.D. Thesis at the University of Nottingham, Taylors University, Malaysia, Dharmsinh Desai University, Nadiad Gujrat and the Institute of Chemical Technology, Mumbai, India and PDPU, Gandhinagar etc.

Role of biomaterials for hip joint replacement applications

Amar Patnaik
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Abstract: The field of biomaterials has turned into an electrifying area because these materials improve the quality and longevity of human life. These biomaterials are used to make devices to replace a part or a function of the body in safe, reliably economically, and physiologically acceptable manner. But, the first and foremost necessity for the selection of the biomaterial is the acceptability by human body. The most common classes of metal materials used as biomedical materials are stainless steel, Cobalt chromium alloy, Titanium and Ti-6Al-4V. Cobalt based alloys have been used for biomedical implants for a number of years. Biomaterials in the form of implants (joint replacements) are also widely used to restore the function of traumatized or degenerated tissues or organs, and thus improve the quality of life of the patients. The electrochemical corrosion behaviors of fabricated implant alloy composites under NaCl solution by using potentiodynamic scan method. The corrosion characteristic properties of the fabricated implant alloy composites are investigated in terms of corrosion potential (E_{corr}) and corrosion current density (i_{corr}). All these tests have been carried out as per ASTM standard. The fabricated alloy composites used as implant are expected to be highly nontoxic and should not cause any inflammatory or allergic reactions in the human tissues and cells. Wear characteristics of these alloy composites have been successfully analyzed using Taguchi experimental design scheme. Significant control factors affecting the wear rate have been identified through successful implementation of analysis of variance. This study will give an idea for femoral head material of hip implant application but not direct replacement of human joints.

Profile of **Dr. Amar Patnaik**

Dr. Amar Patnaik is currently serving as Associate Professor in Department of Mechanical Engineering at MNIT Jaipur. He has completed B.E – Mechanical from REC Karnataka, M.Tech – Prodction Engineering and Ph.D – Mechanical from NIT Rourkela. He has vast Teaching and Research experience. He has published more than 300 research articles in international journals and conferences. Received many awards and recognitions from DST and Institution of Engineers. He has been sponsored by DST, CSIR, DRDO, ISRO, for many technical projects. He been acting as a guest editor for many prestigious journal like Advanced Materials and Manufacturing Processes, IOP Conference Series: Materials Science and Engineering, Lecture Notes In Mechanical Engineering, Materials Today: Proceedings. In his supervision, 22 PhD, 26 M.Tech Thesis were submitted. Total number of patents filed is 7.

Tribological performance of Bearings

Influence of span angle on the performance of hole-entry hybrid spherical journal bearing (ID:T025)

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Abstract: This paper deals with the finite element analysis of a hole-entry hybrid spherical journal bearing system. The effect of different values of span angle on the bearing performance characteristics has been studied. The modified Reynolds equation for the hybrid spherical journal bearing and the flow equation of the orifice restrictor have been solved using Finite element technique by incorporating suitable boundary conditions. A source code in MATLAB software has been developed in order to numerically simulate the performance characteristics of the hybrid spherical journal bearing system. The numerical simulation indicates the bearing performance is greatly influenced by the variation in the bearing span angle. The numerically simulated results reveal that the value of minimum fluid film thickness and frictional torque is increased for larger value of bearing span angle. The present work may be useful for bearing designer and academic community.

Keywords: Finite element method; Reynolds equation; Spherical journal bearing; Span angle

1. INTRODUCTION

Due to rapid technological advancements in last few decades, necessities the precise and accurate design of fluid film bearings. These bearings have specific advantages as compared to circular bearings, such as self-aligning property and also have capability to support radial and axial load [1-3].

1.2 Methodology

Fig. 1 shows the schematic diagram of bearing system using orifice restrictors. The Reynolds equation for hybrid spherical journal bearing is given as [2-4]

$$\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\frac{\bar{h}^3}{12\bar{\mu}}\sin\theta\frac{\partial\bar{p}}{\partial\theta}\right)+\frac{1}{\sin^2\theta}\frac{\partial}{\partial\phi}\left(\frac{\bar{h}^3}{12\bar{\mu}}\frac{\partial\bar{p}}{\partial\phi}\right)=\frac{\Omega}{2}\frac{\partial\bar{h}}{\partial\phi}+\frac{\partial\bar{h}}{\partial\bar{t}} \quad (2)$$

The solution of the Reynolds equation is obtained by Gauss-Seidel method. Newton-Raphson method is used for handling the non-linearity occurs in the system. A source code is developed in Matlab software to study the bearing performance.

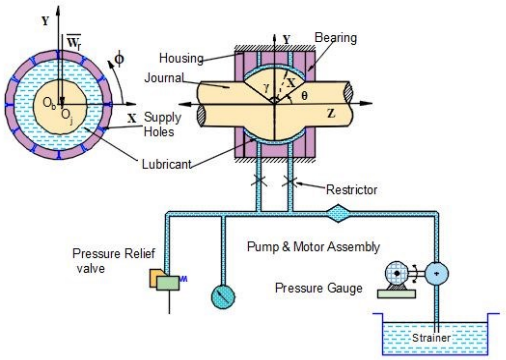

Fig. 1 Schematic diagram of bearing system

2 RESULTS AND DISCUSSION

From the Fig. 2, it is seen that the value of $\bar{h}_{min}$ reduced as the external load increases. Further, the higher value of span angle provides enhanced value of the $\bar{h}_{min}$. Fig. 4 depicts that value of $\bar{T}_f$ increases, as radial load increases. Further, it may also be seen that the higher value of span angle results in the increment in value of $\bar{T}_f$.

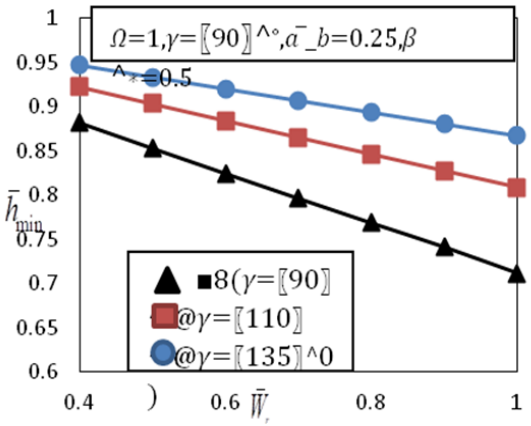

Fig. 2 Minimum fluid film thickness$(\bar{h}_{min})$ with radial load$(\bar{W}_r)$

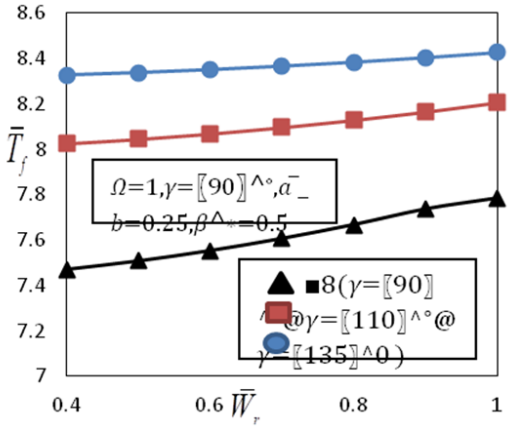

Fig. 3 Frictional torque with radial load

3. CONCLUSION

Larger value of the bearing span angle results in increase in $\bar{h}_{min}$. The $\bar{T}_f$ value increases for larger value of the span angle. The bearing having span angle $\gamma = 90^{\circ}$ appears to be suitable from frictional torque $(\bar{T}_f)$ point of view.

4. DECLARATION:

The work has not presented elsewhere or not being consideration for presentation in any journal.

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Influence of textured shapes in hybrid slot entry journal bearing (ID:T031)

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Abstract: The textured surfaces on the bearing significantly influence the performance of journal bearings. In this study the influence of various geometric shapes of texture surface (rectangular, triangular, spherical, conical and circular) is used to numerically simulate the performance of slot entry bearing. Finite element method is used to solve the Reynolds equation. To compute the bearing performance characteristic parameters, a MATLAB source code based on Gauss-Seidel iteration method has been developed. A comparative numerical analysis has been carried out for bearing with different texture shapes and bearing with smooth surface. The numerically simulated results indicate that textured shapes affects the bearing performance significantly. The rectangular textured surface enhances the value of fluid film damping coefficient, frictional torque, minimum fluid film thickness as compared to the other textured shapes.

Keywords: Textured surfaces, Slot entry, texture shapes, Reynolds equation

1 INTRODUCTION

The bearing designers were interested to fabricate ordered patterns of micro-dimples (surface texturing) on bearing surface, as a results, remarkable improvements in the tribological performance of bearings is obtained. The performance of bearings depends on the geometric features (shape, size, orientation, density) of micro-textures and operating parameters (speed, lubricant) of the bearing systems [1, 2]. Hamilton et al. [3] was the first one to investigate the idea of surface texturing in the form of micro-irregularities in journal bearings. It was noticed that these asperities offer an extra hydrodynamic lift and led to an enhancement of the load capacity of bearings. This idea was investigated on the surface of various tribo-pairs such as, mechanical seals, slider bearings, cylinder lines, journal bearings etc. Qiu and his co-workers [4, 5] examined the impact of various textured shape like spherical, ellipsoidal, circular, elliptical, triangular and chevron on the performance of gas-lubricated slider bearing systems and optimized each textured shape by changing its geometry and density. They concluded that the ellipsoidal texture shape provides larger value of load carrying capacity, lowest friction coefficient and improvement in the bearing stiffness. They recommended that the use of spherical dimple shape may be more cost-effective in terms of manufacturing due to easier manufacture than ellipsoidal dimples. Brizmer and Kligerman [6] examined the effect of partial and full laser surface texturing on the values of load carrying capacity and attitude angle of the journal bearing.

2 METHODOLOGY

The dimensionless form of Reynolds equation for slot entry hybrid journal bearing operating in laminar and incompressible flow regime has been expressed as [7].

$$\frac{\partial}{\partial\alpha}\left[\frac{\bar{h}^3}{12\bar{\mu}}\left(\frac{\partial\bar{p}}{\partial\alpha}\right)\right]+\frac{\partial}{\partial\beta}\left[\frac{\bar{h}^3}{12\bar{\mu}}\left(\frac{\partial\bar{p}}{\partial\beta}\right)\right]=\frac{\Omega}{2}\left[\frac{\partial\bar{h}}{\partial\alpha}\right]+\frac{\partial\bar{h}}{\partial\bar{t}}$$

The mathematical expression of nominal fluid film thickness for smooth slot entry hybrid journal bearing is written as $\bar{h}=1-\bar{X}_j\cos\alpha-\bar{Z}_j\sin\alpha$

The non-dimensional fluid film thickness of slot entry hybrid journal bearing, with considering the textured surface is expressed as $\overline{h}=1-\bar{X}_j\cos\alpha-\bar{Z}_j\sin\alpha+\bar{h}_{hg}$

3. RESULTS AND DISCUSSION

To verify the numerical simulation methodology used in the present investigation, the developed MATLAB

program has been validated for the slot entry bearing with the available literature.

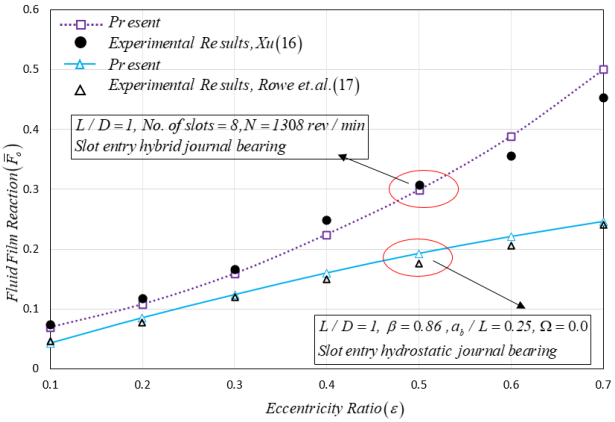

Figure. Validation of slot entry journal bearing

The main objective of this study is to provide an unbiased comparison of commonly used dimple shapes for the general case of fluid film journal bearings and obtain the optimum dimple shape for non-recessed hybrid journal bearings. In this study, five different types of textured shapes have been used i.e. spherical, circular, conical, triangular and rectangular.

4. CONCLUSION

Based on the computed results, it has been concluded that the use of rectangular textured shape in slot entry journal bearing system provides significantly higher enhancement in the values of coefficient of friction, bearing lubricant flow, fluid film damping coefficients than that of other textured surfaces like circular, triangular spherical and conical shaped surfaces.

5. ACKNOWLEDGEMENT

The authors are grateful to the Indian Institute of Technology Roorkee for providing the necessary funding to present this work.

6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Study of a Hybrid Spherical Capillary Compensated Thrust Bearing (ID:T032)

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Abstract: This work describes a theoretical study concerning the static performance of a hybrid spherical thrust bearing compensated by capillary restrictor. The modified Reynolds equation governing the lubricant flow in the bearing clearance space together with the restrictor flow equation and appropriate boundary conditions have been solved by the Finite Element Method using Galerkin's technique. The study describes the influence of the axial eccentricity ratio and restrictor design parameter $\bar{C}_{s2}$ on the static characteristics such as load carrying capacity, friction power loss, lubricant flow rate. The computed results indicate that to get an improved performance from a hybrid spherical thrust bearing, a proper selection of the value of the restrictor design parameter $\bar{C}_{s2}$ is essential.

Keywords: Spherical thrust bearing, Reynolds equation, Finite element method, Restrictor design parameter

1. INTRODUCTION

Hydrostatic/hybrid spherical thrust bearing offers excellent characteristics such as self-aligning properties and ability to support both radial and axial load together with untextured relative motion. Pioneering investigation of hydrostatic spherical thrust bearing can be found in the work of Dowson [1], who analyzed the bearing performance by considering the inertia effects due to rotation of shaft in his analysis. Hydrostatic/hybrid spherical thrust bearing offers a high potential for improving the performance of machine elements. In recent times Yacout et al. [2] theoretically analyzed the effect of surface roughness coupled with centripetal inertia effects on the behaviour of fitted and clearance type hydrostatic spherical thrust bearing. In the present paper the influence of the axial eccentricity ratio and restrictor design parameter $\bar{C}_{s2}$ on the static performance of a hybrid spherical thrust bearing compensated with capillary restrictor is analysed using FEM.

2. METHODOLOGY

The Reynolds equation for the spherical thrust bearing in the clearance is solved by using FEM and applying Galerkin's technique.

Reynolds Equation:

$$\frac{1}{sin\phi}\left\{\frac{\partial}{\partial\phi}\left(sin\phi\,\frac{\bar{h}^3}{12}\frac{\partial\bar{p}}{\partial\phi}\right)\right\}+\frac{1}{sin^2\phi}\frac{\partial}{\partial\theta}\left[\frac{\bar{h}^3}{12}\frac{\partial\bar{p}}{\partial\theta}\right]$$

$$=\frac{\Omega}{2}\frac{\partial\bar{h}}{\partial\theta}+\frac{\partial\bar{h}}{\partial\bar{t}} \qquad (1)$$

Film thickness expression:

$$\bar{h}=\ 1-\varepsilon_y\,cos\,\phi \qquad (2)$$

Flow of fluid through a capillary restrictor is given as:

$$\bar{Q}_R=\bar{C}_{s2}(1-\bar{p}_r) \qquad (3)$$

3. RESULTS AND DISCUSSION

Static characteristics such as load carrying capacity, friction power loss, lubricant flow rate are numerically

computed for spherical hybrid thrust bearings. Here for the conciseness of the paper only load carrying capacity is discussed. Fig. 1 shows the variation of load carrying capacity F_y versus restrictor design parameter for different value of positive axial eccentricity ratio (ε_y). It is noticed that for lower value of operating eccentricity ratio (i.e. $\varepsilon_y = 0$) , the load carrying capacity is higher as compared to higher eccentricity ratio (i.e. $\varepsilon_y = 0.6$). This is due to the fact that there is formation of convergence to divergence zone from pocket boundary to ambient boundary resulting in negative pressure gradient and thus reduces load carrying capacity.

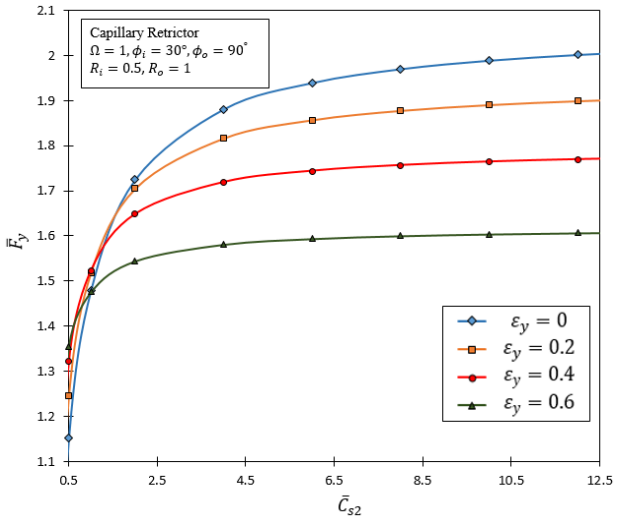

Fig 1: Load Capacity (F_y) Vs Restrictor design parameter ($\bar{C}_{s2}$)

This behaviour is predominant for higher eccentricity ratio. Further, it has been observed that the load carrying capacity increases with increase in the value of restrictor design parameter and shows negligible variation after certain value of restrictor design parameter.

4. CONCLUSION

It has been observed that load carrying capacity is significantly affected by eccentricity ratio and restrictor design parameter.

5. AKNOWLEDGEMENT

The authors are grateful to the IIT Roorkee for providing the necessary funding to present this work.

6. DECLERATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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On the behaviour of asymmetric conical hole-entry hybrid journal bearing system (ID:T034)

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Abstract: The present study deals with theoretical investigation on performance characteristics of hybrid conical asymmetric hole-entry journal bearing compensated with capillary restrictor. Finite element approach using Galerkin technique and orthogonality condition has been used in order to tackle the solution complexity of developed mathematical model. The obtained non-linear system of equation has been solved using Newton-Raphson method and a suitable iterative scheme. The numerically computed results show that bearing performance characteristics gets significantly affected at different semi-cone angle. The study indicates that $\overline{W}_A$, $\overline{Q}$ and $\overline{C}_{yy}$ results in better performance at higher value of semi-cone angle while $\overline{p}_{fric}$ and $\overline{S}_{yy}$ tends towards better performance at lower value of semi-cone angle.

Keywords: Hole-entry, Conical bearing, FEM, Asymmetric configuration, Capillary restrictor

1. INTRODUCTION

In technologically advancing era, the conical bearings are widely used so as to have compactness of rotating elements. The design of conical bearing has the flexibility to take up some amount of lateral load in addition to transverse radial load. Due to the remarkable performance behaviour, these type of bearings can be used wherever there is demand of reliable and predictable performance in both axial and radial direction. Yoshimoto et al. [1] studied the behaviour of hydrostatic conical bearing lubricated with water and reported that the optimum value of spiral groove attributes provides much better bearing performance. Further, the hydrodynamic conical bearing has been analysed with multiple wedge for evaluating the static performance characteristics of bearing, which was reported by Korneev [2]. The present work deals with static and dynamic characteristics of asymmetric configuration of hole-entry conical hybrid journal bearing system.

2. METHODOLOGY

The dimensionless modified Reynolds equation for the lubricating film can be expressed as:

$$\frac{1}{\beta^2 \sin^2\gamma}\frac{\partial}{\partial\alpha}[\overline{h}^3\overline{F}_2\frac{\partial\overline{p}}{\partial\alpha}]+\frac{1}{\beta}\frac{\partial}{\partial\beta}[\beta\overline{h}^3\overline{F}_2\frac{\partial\overline{p}}{\partial\beta}]=\Omega\frac{\partial}{\partial\alpha}\{(1-\frac{\overline{F}_1}{\overline{F}_0})\overline{h}\}+\frac{\partial\overline{h}}{\partial\overline{t}} \quad (1)$$

The non-dimensional lubricant film thickness for conical hybrid journal bearing is expressed as:

$$\overline{h}=(1-\overline{X}_j\cos\alpha-\overline{Y}_j\sin\alpha)\cos\gamma+\overline{Z}_j\sin\gamma \quad (2)$$

The solution field domain is solved using FEM (Galerkin's) technique to obtain the following global system of equation:

$$[F_{ij}]\{\overline{p}_j\}=\{\overline{Q}_j\}+\Omega\{\overline{R}_{H_j}\}+\dot{\overline{X}}_j\{\overline{R}_{X_j}\}+\dot{\overline{Y}}_j\{\overline{R}_{Y_j}\}+\dot{\overline{Z}}_j\{\overline{R}_{Z_j}\} \quad (3)$$

3. RESULTS AND DISCUSSION

In this study, the theoretical simulation of conical hybrid journal bearing has been performed by considering

Asymmetric configuration of restrictor i.e. 6 supply holes have been provided - one at the top and other five at the bottom of loading direction. The influence of axial load capacity, lubricant flow rate, frictional power loss and stiffness and damping coefficient has been analysed by varying the radial load capacity at different semi-cone angle. For brevity and conciseness, only variation of axial load capacity has been provided which is shown in Fig. 1. It can be observed from this figure that axial load increases with increase in radial load. Also, with increment in the values of semi-cone angle, the value of axial load capacity increases.

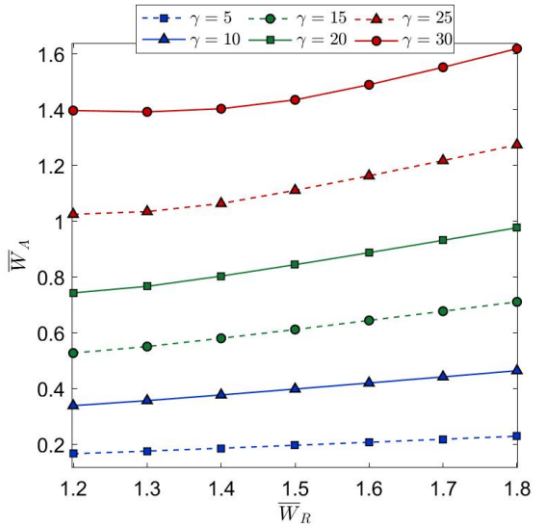

Fig. 1: Axial load ($\overline{W}_A$) versus Radial load ($\overline{W}_R$)

4. CONCLUSION

The semi-cone angle has significant influence on performance characteristics of conical hybrid journal bearing under asymmetric configuration of bearing.

5. ACKNOWLEDGEMENT

The authors are grateful to the Indian Institute of Technology Roorkee for providing the necessary funding to present this work.

6. DECLERATION:

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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FEM Analysis of a Porous Hybrid Journal Bearing Under the Turbulent Regime (ID:T035)

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Abstract: The objective of the present paper is to numerically study the performance of a porous hybrid journal bearing system ($PHJB_S$) operating under turbulent flow condition. The Reynolds equation governing the flow of Newtonian lubricant in the clearance space of porous journal bearing is solved by finite element method. The turbulent lubrication theory proposed by Constantinescu's has been used to numerically simulate the performance. The Numerically simulated results indicates that the bearing operating with turbulent flow condition provides the larger value of minimum fluid film thickness. The present study is expected to be useful for academic community and bearing designers.

Keywords: Reynolds equation; Finite element method; Porous hybrid journal bearing system; Turbulent Regime

1. INTRODUCTION

The porous circular journal bearings find use in various industrial applications because they are less noisy, lower friction, good precision, and are relatively maintenance free. Howarth [1] carried out numerical and experimental study of porous journal bearing for circular thrust bearing. Majumdar et al. [2] theoretically studied the stability of rigid rotor in porous hydrostatic bearing system.

The turbulent flow of lubricant occurs under the conditions of high journal speed, small kinetic lubricant viscosity (liquid metals, water, synthetic lubricants) and large bearing clearance. Hashimoto et al. [3] investigated the wear behavior of the hydrodynamic journal bearings operating in turbulent and laminar flow condition.

The current work is therefore attempts to study the influence of turbulence flow condition on the behavior of the $PHJB_S$.

2. METHODOLOGY

The modified Reynolds equation governing the turbulent flow of Newtonian lubricant in the clearance space of a $PHJB_S$ in the non – dimensional form is expressed by the following equation [2,3]:

$$\frac{\partial}{\partial \alpha}\left[\left(\frac{\bar{h}^3}{G_\alpha \bar{\mu}}+\frac{\Psi}{\bar{\mu}}\right)\frac{\partial \bar{p}}{\partial \alpha}\right]+\frac{\partial}{\partial \beta}\left[\left(\frac{\bar{h}^3}{G_\beta \bar{\mu}}+\frac{\Psi}{\bar{\mu}}\right)\frac{\partial \bar{p}}{\partial \beta}\right]=\frac{\Omega}{2}\frac{\partial \bar{h}}{\partial \alpha}+\frac{\partial \bar{h}}{\partial \bar{t}} \qquad (1)$$

Fluid film thickness

The expression for fluid film thickness in non-dimensional form is expressed as:

$$\bar{h}=1-\bar{X}_j\cos\alpha-\bar{Z}_j\sin\alpha \qquad (2)$$

Finite element formulation

The modified Reynolds equation (1), has been solved by finite element analysis using Galerkin's technique. The fluid flow field domain has been represented by using four-noded quadrilateral isoparametric elements. The fluid film pressure variation is assumed as linearly vary over an element as follows:

$$\bar{p}=\sum_{j=1}^{n^e} N_j \bar{P}_j$$

Applying the Galerkin's orthogonality condition on equation (1), the following global system equation is obtained:

$$\left[\bar{F}_{ij}\right]^e\{\bar{P}_j\}^e=\{\bar{Q}_j\}^e+\Omega\{\bar{R}_{Hj}\}^e+\dot{\bar{X}}_j\{\bar{R}_{Xj}\}^e+\dot{\bar{Z}}_j\{\bar{R}_{Zj}\}^e \qquad (3)$$

3. RESULTS AND DISCUSSION

In this work, the performance behavior of PHJBs has been obtained considering the turbulent flow conditions. A MATLAB based source code has been developed on the FEM solution technique to compute the performance characteristics of bearings system.

Minimum fluid film thickness $(\bar{h}_{min})$

Fig. 1 depicts the variation of $\bar{h}_{min}$ with S_o for the influence of laminar and turbulent flow condition. It may be observed that the porous hybrid journal bearing operating under turbulent flow condition offers the higher value of $\bar{h}_{min}$ than that laminar flow condition.

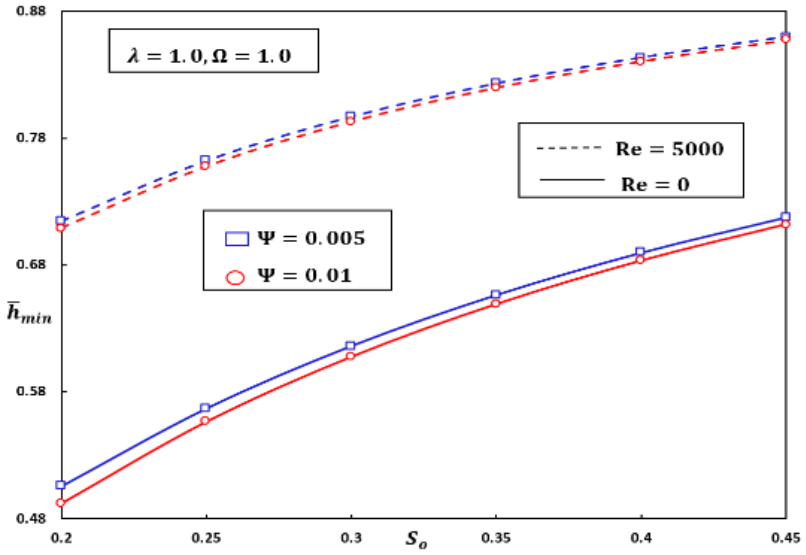

Fig. 1: $\bar{h}_{min}$ vs. S_0

4. CONCLUSION

It has been observed that the bearing operating under the turbulent flow condition operates at higher value of $\bar{h}_{min}$ than that of correspondingly similar bearing operating under laminar flow condition.

5. ACKNOWLEDGEMENT

The authors are grateful to the Indian Institute of Technology Roorkee for providing the necessary funding to present this work.

6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Effect of semi-cone angle on the performance of hybrid slot-entry conical journal bearing (ID:T036)

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Abstract: This work examines the performance of hybrid slot-entry conical journal bearing system using finite element analysis. This paper studies the influence of variation in the value of semi-cone angle on the bearing performance. Finite element method has been used to solve the modified Reynolds equation for hybrid slot-entry conical journal bearing system. A MATLAB source code has been developed in order to numerically simulate the performance characteristics of the hybrid slot-entry conical journal bearing. The numerical simulation shows that the bearing performance is altered by the variation in the semi-cone angle. It has been found that the axial load carrying capacity and frictional torque is increased for larger value of semi- cone angle. The numerically simulated results presented in this paper are expected to be beneficial to the academia and bearing designer.

Keywords: Conical journal bearing, Semi-cone angle, slot-entry, FEM.

1. INTRODUCTION

Conical hybrid journal bearing has been widely used in engineering applications. Apart from that, precision machining and self-guiding nature of the conical bearing offers various applications that are high-speed rotating machinery, lathes, grinding

machines, etc [1,2]. These bearing are capable of supporting simultaneously both load such as axial as well as a radial load.

2. METHODOLOGY

Fig.1 shows the slot entry conical journal bearing along with the coordinate system of bearing. The bearing is mathematically modeled for the slot to investigate the behavior of different performance characteristics of bearing.

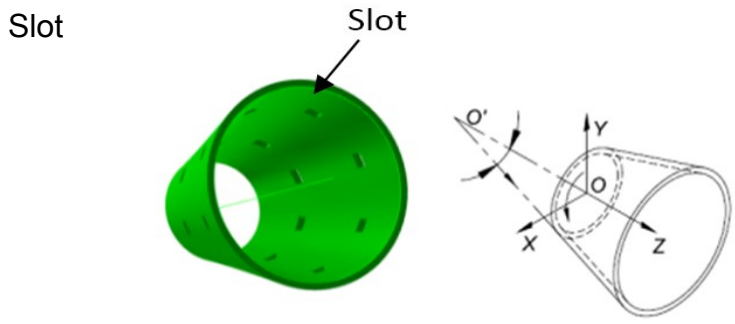

Fig.1 Conical journal bearing

The modified Reynolds equation governing the lubricant flow through the conical bearing clearance is defined as [3]

$$\frac{1}{r^2 sinx^2\gamma}\frac{\partial}{\partial\varphi}\left[\frac{h^3}{12\mu}\frac{\partial p}{\partial\varphi}\right]+\frac{1}{r}\frac{\partial}{\partial r}\left[r\frac{h^3}{12\mu}\frac{\partial p}{\partial r}\right]=\frac{\omega_j}{2}\frac{\partial h}{\varphi x}+\frac{\partial h}{\partial t}$$

3. RESULT AND DISCUSSION

Fig. 2 shows the variation of $\bar{h}_{min}$ with respect to radial load from Fig. 2 it may be observed that the value of film thickness is decreased with increase in the value of radial load .The value of $\bar{h}_{min}$ is reduced for larger value of semi-cone angle and The Fig. 3 show the value friction torque is increase with radial load for larger value of cone angles.

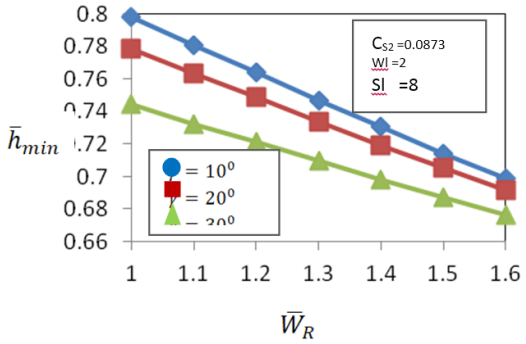

Fig. 2 Variation of Fluid Film Thickness ($\bar{h}_{min}$) with Radial Load ($\bar{W}_R$)

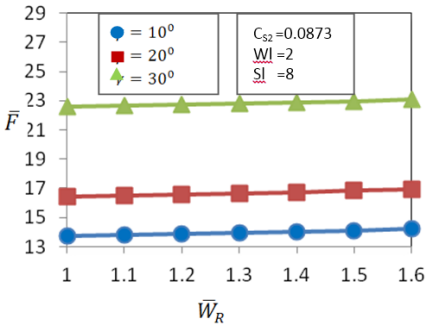

Fig. 3 Variation of Frictional Torque ($\bar{F}$) With Radial Load ($\bar{W}_R$)

4. CONCLUSION

The enhanced value of fluid film thickness is observed for smaller value of semi-cone angles, and the value friction torque is increase with radial load for larger value of cone angles.

5. ACKNOWLEDGEMENT

The authors are grateful to the IIT Roorkee for providing the necessary funding to present this work.

6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Analysis of thermoelastohydrodynamic lubrication of journal bearing including the effect of surface roughness and cavitation (ID:T078)

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Abstract: A numerical approach is presented to simulate combined effect of pressure, temperature, roughness and cavitation in hydrodynamic plain journal bearing. Due to shearing action the temperature of the oil film increases in hydrodynamic journal bearing. Because of rise in temperature, viscosity of the lubricant is reduced which in turn leads to decrease in load carrying capacity of the film. Hence, for better estimation of bearing performance, thermoelastohydrodynamic (TEHD) analysis of journal bearing is essential. Finite difference method is used to discretise the governing equation and obtain oil film pressure and deformation of bearing is obtained by influence coefficient method (ICM). The Reynolds equation and energy equation within the lubricant film and heat transfer within the bush body is solved simultaneously. Effect of hydrodynamic roughness parameter (λ) and surface pattern parameter (γ) on pressure, temperature, friction and oil flow are studied. Model program includes a numerical solution technique for obtaining pressure and temperature of the lubricant fluid, the bush temperature. Results obtained have been compared with the references and are in good agreement with it. There is marginal increase in deformation value with increase in eccentricity ratio till 0.8 eccentricity ratio after that there is sharp rise in deformation for further eccentricity ratios.

Keywords: Thermoelastohydrodynamic (TEHD), Influence coefficient method (ICM), hydrodynamic lubrication.

1. INTRODUCTION

Hydrodynamic type journal bearings are considered to be very important component of all rotating machinery. It consists of a stationary cylindrical body and rotating shaft separated by a layer of lubricant that supports radial loads. The present study analyzes the TEHD behaviour of a bearing operating under condition that tends to be severe. The deformation of bush due to pressure, temperature, cavitation condition and effect of surface roughness are taken into consideration.

2. METHODOLOGY

Non-dimensional form of modified generalized Reynolds equation which incorporates both mass-conserving cavitation condition and surface roughness effect under steady-state condition is given as,

$$\frac{\partial}{\partial\bar{x}}\left(\phi_x\bar{\beta}g(\theta)\bar{F}_2\frac{\partial(\theta-1)}{\partial\bar{x}}\right)+\frac{1}{4}\left(\frac{1}{\lambda}\right)^2\frac{\partial}{\partial\bar{z}}\left(\phi_z\bar{\beta}g(\theta)\bar{F}_2\frac{\partial(\theta-1)}{\partial\bar{z}}\right)$$
$$=\left(\frac{1+erf\left(\frac{\Lambda\bar{h}}{\sqrt{2}}\right)}{2}\right)\frac{\partial}{\partial\bar{x}}\left(\theta\bar{h}\left[1-\frac{\bar{F}_1}{\bar{F}_0}\right]\right)-\frac{1}{2\Lambda}\frac{\partial(\theta\phi_s)}{\partial\bar{x}} \quad (1)$$

Hydrodynamic pressure field can be calculated as,

$$\bar{P}=\bar{P}_c+g\bar{\beta}(\theta-1)$$

The dimensionless form of energy equation is given as,

$$\bar{u}\frac{\partial\bar{T}}{\partial\bar{x}}+\frac{1}{\bar{h}}\left(\bar{v}-\bar{u}\bar{y}\frac{\partial\bar{h}}{\partial\bar{x}}\right)\frac{\partial\bar{T}}{\partial\bar{y}}=$$
$$\frac{k_1}{k_2^2}\frac{1}{\bar{h}^2}\left(\frac{\partial^2\bar{T}}{\partial\bar{y}^2}\right)+k_1\frac{\bar{\eta}}{\bar{h}^2}\left(\left(\frac{\partial\bar{u}}{\partial\bar{y}}\right)^2+\left(\frac{\partial\bar{w}}{\partial\bar{y}}\right)^2\right) \quad (2)$$

The local film thickness is determined by taking into account the bearing geometry

$$\bar{h} = 1 + \varepsilon \cos(\bar{x} - \phi) + \delta_{B,P} + \delta_{B,T} - \delta_{S,T} \qquad (3)$$

3. RESULTS AND DISCUSSION

Equations (1-3) are solved using Finite difference method by applying appropriate boundary conditions. The influence coefficients for calculating the elastic deformation are obtained using FEM. Figure 1 shows the Pressure distribution along the circumferential direction at load= 2KN & N=2000rpm. Figure 2 demonstrates the effect of eccentricity ratio on elastic deformation.

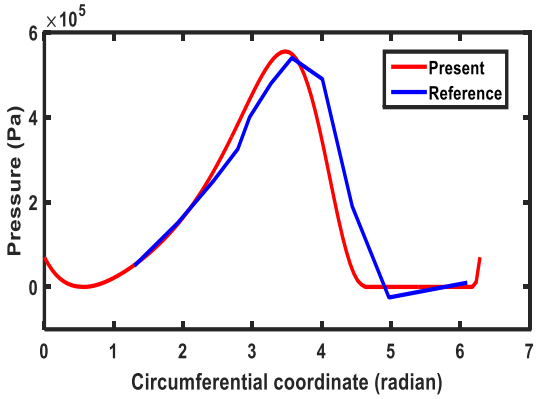

Fig 1: Pressure distribution

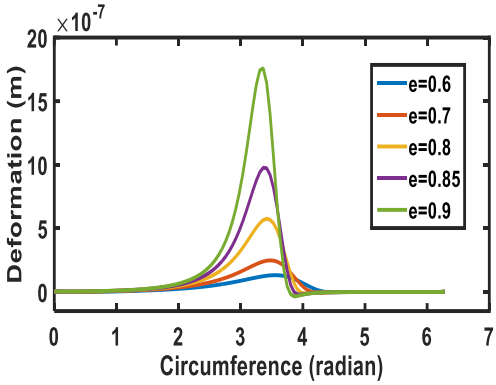

Fig 2: Elastic deformation

4. CONCLUSION

Performance characteristics such as maximum pressure, load carrying capacity, oil flow rate increases as eccentricity ratio increases. Whereas, minimum film thickness, attitude angle and frictional variable decreases with increase in eccentricity ratio. Elastic deformation increases with increase in eccentricity ratio. Rough surface with isotropic roughness pattern generates lower friction, lower flow rate and higher load capacity as compare to smooth surface.

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Housing light-weighting and its impact on bearing performance (ID:T061)

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Abstract: Drivetrain weight and stiffness plays a significant role in the vehicle performance. Housing material is one of the significant ways in which weight reduction can be achieved and whose impact can be studied on the performance of drivetrain components. In the current work, impact of housing material change, from Grey Cast Iron to Aluminium is studied on the bearing performance. Simulations were performed to predict the impact of replacing the Grey housings with Aluminium. Simulation results predicted reduction in the bearing life with the implementation of Aluminium housing. Observations in the lab tests were in-line with the simulation predictions. As a technology development process, efforts were concentrated on the bearing enhancements in such a way that the enhanced bearing life with the Aluminium housing should be equivalent to the Nominal bearing life with the Grey housing. Based on the simulation predictions and in collaboration with the suppliers, enhanced bearings were manufactured and procured. Eventual lab tests showed that the combination of Aluminium housings and enhanced bearings, meet the intended design goal.

Keywords: Drivetrain, Housing, Aluminium, Bearings, Weight-Reduction

1. INTRODUCTION

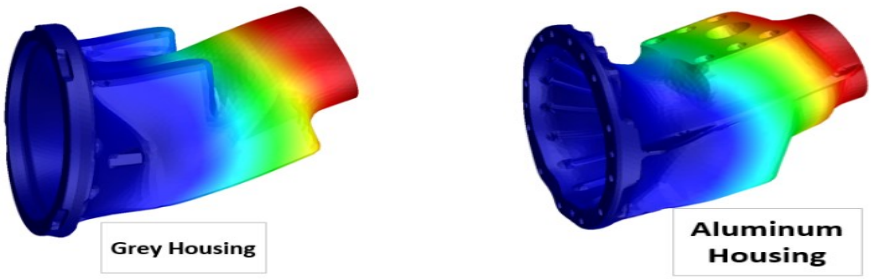
Over the last several decades the auto industry converted many iron castings and forgings to aluminium for reduced vehicle weight and improved fuel economy. Aluminium is one of the enablers to reduce weight without significantly effecting cost. Off-road vehicles are faced with the same challenges. A reduced vehicle base weight allows certain customers to carry more payload. This study addresses the challenges associated with conversion of structural castings from iron to aluminium. To achieve the goal, simulations and lab experiments were utilized to come up with the best assembly with aluminium housings, which could provide the same bearing performance as it is currently observed with the application of Grey Cast iron housing.

2. METHODOLOGY

As an alternate of grey cast iron housing, aluminium housing was designed and deployed in the drivetrain assembly. Comparative simulation, for the bearing lives, was run for both grey and aluminium housings under same design loads. In order to establish the concreteness of the simulation methodology, the two variants were tested in lab, resulting in the outcome in-line with the simulation – depicting significant decrease in the bearing lives with the implementation of aluminium housing. To overcome the additional system deflection caused by the aluminium housing, modifications were made in the micro-geometry of the bearing, which helped in better distribution of the stresses and eventually helped in meeting the life goal.

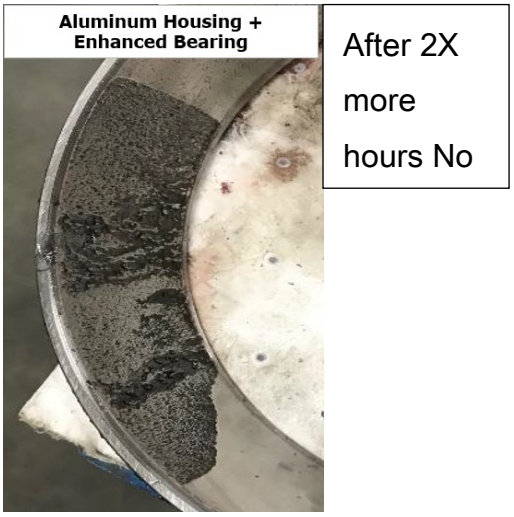
3, RESULTS AND DISCUSSION

On one hand, implementation of aluminium housing helped in weight reduction, however, on the other hand, due to the impacted stiffness, it led to increased system deflection, leading to concentrated bearing stresses causing bearing failure in significantly lesser amount of time. Deflection observed with the aluminium housing was around 2.5X higher than the deflection observed with the grey housing,



resulting in around 50% bearing life reduction. Bearing micro-geometry was iterated to optimize the stress distribution to achieve same life as it is observed with the grey housing and nominal bearing combination.

Eventually, with the enhanced bearing mounted into the aluminium housing, the desired objective was achieved.



4. CONCLUSION

Aluminium is a nice prospect for the vehicle weight reduction.
Stiffness plays a key role in the system durability.
Replacing grey cast iron straight away with aluminium might not work, especially in case of heavily loaded applications.
Bearing enhancements must be investigated to have optimum system performance.

DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

Effect of non-Newtonian lubricant on the linear and non-linear stability analysis of the double-layered porous journal bearing (ID:T037)

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Abstract: Present analysis investigated the rigid rotor linear and non-linear stability of the double-layered porous coupled-stress fluid lubricated journal bearing by considering percolation effect of the additives into pores and interface velocity slip phenomenon on the basis of Beavers-Joseph criteria. For linear stability analysis, effect of various design parameters on the stiffness and damping coefficients are demonstrated and for non-linear transient analysis, system stability is determined by observing the locus of the journal center and several trajectories of journal center locus have been represented for different operating conditions. Till date, due to very few published work in this research field, the results of the present study are compared with the traditional fluid lubricated porous bearing and found to be good agreement

Keywords: Coupled-stress, double-layered porous journal bearing, percolation, transient analysis, velocity slip, whirl instability.

A review on tribological performance analysis of multi-lobe journal bearing (ID:T050)

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Abstract*:* New journal bearing designs are sought to meet the new requirements and these bearings are usually characterized by their non circular cross section. In multi-lobe bearing oil pressure is released by draining the oil through the lobes. Thus, an optimum oil film thickness can be maintained while increasing the bearing load capacity. In view of this, an attempt can be made to explore the effect of cavitation, mount angle and groove locations of different parameters of bearing configurations with nanoparticles using CFD technique. Rotating machines are required to run at high speeds and loads, plain circular bearing is mostly replaced by some other bearings in many applications. As, the plain bearing does not suit the stability requirements of high-speed machines and precision machine tools. These conditions confront the tribological engineer with many new problems. The major problem with hydrodynamic bearing is failure of fluid film during the operation which may cause metal to metal contact between journal and bearing surface which leads to wear and friction which overheats the surfaces. Hence the power loss increases also it leads to increase the instability of the fluid film in lubrication. Changing the bearing profile is one of the methods to increase the stability of the fluid film. The novelty of the proposed work is to investigate the influence in viscosity variation of lubricant due to nano particles on the performance characteristics of lobe journal bearing. The major things which are planned to be executed in the proposed research are design optimization of lobe bearing.

Keywords*:* Multi-lobe journal bearing, optimization, nanoparticles.

Effect of Eccentricity Ratio on Damping and Stiffness coefficients for Journal bearing with flexible liner taking Micropolar lubrication (ID:T004)

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Abstract: The current work aims at finding the effect of eccentricity ratio on stiffness and damping coefficients for components of dynamic loads along and perpendicular to line of centers. Modified Reynolds equation is generated for hydrodynamic journal bearing considering lubricant as micropolar fluid. The effect of flexibility of liner is calculated taking in to consideration basic theory of elasticity. Solution of the problem is generated using FDM Technique. Linear Dynamic solution is generated using Perturbation Technique. Effect of eccentricity ratio on stiffness and damping coefficients is calculated. Results of study are useful to researchers and design engineers working in this area.

Keywords: Modified Reynolds equation- journal bearing - Micropolar lubrication

Limiting load capacity analysis of fgm texture bump foil journal bearing (ID:T013)

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Abstract: This paper combines the texture profile on bump type foil journal bearing using Functionally Graded Material (FGM) in order to discover the journal bearing's limiting load carrying capacity (LCC). An analytical model for limiting load capacity of texture bump foil journal bearing using FGM is presented. The theoretical model accounts for the texture profile on the foil surface with FGM and bump foil compliance. Distribution of pressure is calculated using high operating speed bearing approximation. Results of limiting load capacity of bump type foil journal bearing are compared for increasing texture bump height with FGM.

Keywords: Texture; Friction; Foil bearing; Load capacity; Functionally Graded Materials.

Performance behaviors of micro-pocketed/textured tilting pad thrust bearings (ID:T021)

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Abstract: This paper presents the performance investigations (min. film thickness, power loss, and max. temperature) of a tilting pad thrust bearing by incorporating three different micro-pockets/textures on the pad's surface. The finite element method is employed to discretize the mass-conserving Reynolds equation, followed by a solution of the system of algebraic equations using a Newton-type method to calculate the film pressure in the fluid computational domains. A parametric study is carried out in terms of the micro-pockets/textures' depth, circumferential/radial length of micro-pockets/textures to determine the optimum value of these micro-pockets/textures' attributes. Based on the dimensions of these attributes, performance parameters of three different micro-pockets are calculated, and a comparison with conventional plain and pocketed tilting pad bearings were done. It was found that the performance of the tilting pad bearing has significantly improved as compared to conventional plain and pocketed tilting pad bearing.

Bio-Tribology

Investigating the tribological properties of HAp/Cu-HAp-POM composites (ID:T016)

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Abstract: In recent years, Polyoxymethylene polymer has shown immense potential in the medical field owing to its remarkable properties like tensile strength, biocompatible nature, and thermal stability properties. The designing and manufacturing of the POM-C pin along with the interacting surface AISI 316L steel plate. The prepared samples were thoroughly characterized by XRD, Raman spectroscopy, SEM, DSC, and optical spectrometer. The complete experiment was conducted on a pin-on-disc tribometer. The further elemental and microstructural analysis of the worn surfaces was based on a non-contact profilometer, which indicated hydroxyapatite compound's role in reducing the friction and wear. A plausible explanation of the mechanism for enhancement of the tribological properties and details about the further development of the project will be discussed during the presentation.

Keywords: Polyoxymethylene, Nano-particle, Hydroxyapatite, Cu-HAp, Synthesis

1. INTRODUCTION

Hydroxyapatite, a bioceramic material, is the main constituent for our bones and teeth [1]. This material is widely available on earth in the forms of shells [2], scales [3], and corals . Polyoxymethylene used for the experiment is a copolymer. POM-C, a crystalline polymer, has excellent friction and wear property and POM-C copolymer shows better thermal and mechanical stability. Also, being copolymer in nature, POM has a hexagonal crystal structure making it more stable**.**

2. METHODOLOGY

Egg-Shell is with further addition of H_3PO4 (diluted) and hydroxyapatite power is obtained. The pin is made out of the polymer (Polyoxymethylene-C) with nano HAp, and nano Cu-HAp reinforced respectively in the provided weight percentage ratios 0%, 1%, 2%,3%, 4%, and 5%.

3. RESULTS AND DISCUSSION

For HAp-POM-C composite experiment conducted on pin-on-disc and the graph plotted in fig1

For Cu-HAp-POM-C composite experiment was conducted on a pin-on-disc and graph plotted according to fig2.

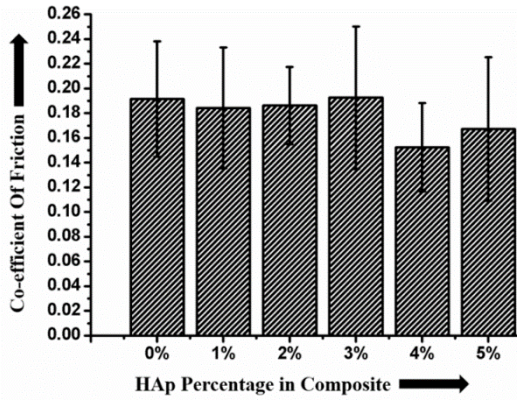

Fig 1. Coefficient of friction of nHAp-POM composites

4. CONCLUSION

From the above study, we can conclude that-

The coefficient of friction of 4%-HAp doped in Delrin in the dry condition is 21% lower than that of pure Delrin.

The coefficient of friction of 1%-Cu-HAp doped in Delrin in the dry condition is around 50% lower than that of pure Delrin.

5. DECLARATION

The work has not been presented elsewhere or not being considered for presentation in any journal.

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Bio-tribological performance of medical grade UHMW Polyethylene based hybrid composite for cartilage replacement (ID:T065)

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Abstract: Medical grade ultra-high molecular weight polyethylene (M-UHMWPE) is presently considered a gold standard in the orthopedic industry. It is commonly used as a load bearing spacer and cup liner for cartilage replacement in synovial joints. The failure of the implant in these joints mostly occurs due to the wear of these polyethylene spacer and cup liner. Therefore, to increase the wear resistance of these load bearing polyethylene components, 0.5%, 1%, 2% of Al_2O_3 and 2% of vitamin C respectively is reinforced in M-UHMWPE by the hot press process. The role of these fillers on the tribological properties of M-UHMWPE against Ti6Al4V counter-body materials under dry and human serum environment is assessed. Experimental trials were performed according to ASTM F732 on a reciprocating sliding tribo-meter (Pin-on-disc) at human body temperature of 37°C. It has been observed that the friction and wear behavior of the developed composites improve with increase in wt. % of Al_2O_3 and that the human serum offers better tribological performance than dry sliding. The results obtained in this study have been thoroughly analyses using various tribological characterization techniques and worn surface morphological examination.

Keywords: Biotribology, Polymer composite, Friction, Human serum, Wear

1. INTRODUCTION

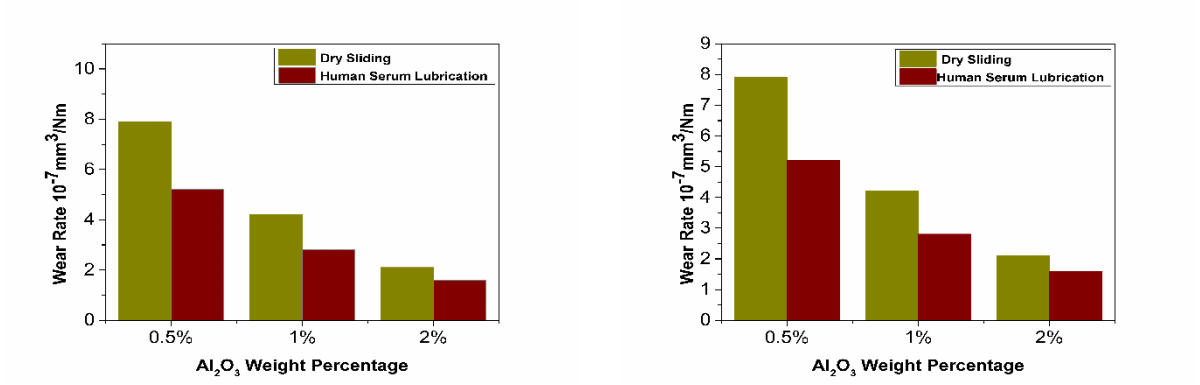
Medical grade ultra-high molecular weight polyethylene (M-UHMWPE) is used for TJR because of its outstanding properties such as low friction, biocompatibility, good mechanical properties, chemical resistance and high wear resistance. M-UHMWPE is the material of interest to many researchers in the field of orthopedics. The desirable properties of M-UHMWPE makes it the material of choice for joint replacement prostheses [1]. However, improving the mechanical and tribological properties of M-UHMWPE is of great demand, as the debris generated by the wear of the polyethylene polymer results in the decreased mechanical stability of the material, caused by continuous wear process, leading to artificial joint loosening, bone loss, osteolysis, and ultimately effects the life of an artificial joint [2].Therefore, incorporating of nano-fillers are extensively used to improve the functional properties of M-UHMWPE polymer composites. Although, the reinforcement method of nano-fillers into a polyethylene polymer matrix has proven effective and has been documented in the literature [3, 4].

In the present study, an attempt was made to develop novel nanocomposites based on medical grade ultra-high molecular weight polyethylene filled with varying weight percentage of alumina nano powder and constant vitamin-C concentration and their tribological investigations are deliberated. The tribological mechanisms have been analyzed using Scanning electron microscopy.

2. EXPERIMENTAL

The tests were performed at a load of 46N and 52N, stroke of 4mm, frequency of 5 Hz and test duration of 60 minutes. The tests were reiterated three times and average was values are reported.

3. RESULTS



(a) (b)

Figure 1. (a) Wear rate of composite material at 46N load and (b) Wear rate of composite material at 52N load

4. CONCLUSIONS

The wear rate decreases with increase in load irrespective of the testing condition whether dry or lubricated environment.

Human serum has shown lubricating effect as the wear rate has decreased as compared to dry under similar conditions of load and frequency.

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Electrochemical and biological behaviour of near β titanium alloy for biomedical implant applications (ID:T077)

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Abstract: Pulsed laser deposition technique (PLD) is one of the methods to coat hydroxyapatite on 316L stainless steel and Titanium alloys implants which are used in orthopaedics and dentistry applications. In this study, Hydroxyapatite (Hap) ceramics in the form of calcium phosphate

(Cap) were deposited on nearβ Titanium alloys (Ti-13Nb-13Zr) by the pulsed laser deposition method. The coated thin film was characterised by X-ray diffraction (XRD), scanning electron microscopy (SEM) with Energy dispersive spectroscopy (EDS) and atomic microscopy (AFM). The corrosion studies were carried out coated and uncoated samples using potentiodynamic polarisation studies in simulated body fluid (Hanks' solution). The bioactivity of the Hap-coated samples on nearβ Titanium alloys was evaluated by immersing them in simulated body fluid (SBF) for nine days. XRD and EDS analysis confirmed the presence of HAP. The corrosion studies showed that the treated samples have better corrosion resistance compared to uncoated substrates. The formation of apatite on treated samples revealed the bioactivity of the Hap-coated substrates.HAP-coated nearβ Titanium alloys provide higher corrosion protection than substrates, which can be used for biomedical implant applications.

Keywords*: Hydroxyapatite, pulsed laser deposition, corrosion, Ti-13Nb-13Ze*

1. INTRODUCTION

Hydroxyapatite is a commonly used biomaterial which is frequently used in orthopaedic implants such as bone and tooth implants because it resembles human tooth. It has also proven to be biologically compatible with the tissues. The aim of this work is to deposit hydroxy apatite coating over stainless steel by Pulse Laser Deposition technique.

2. METHODOLOGY

The surface morphology of the deposited hydroxyapatite coatings was characterized using scanning electron microscopy and atomic force microscopy, while the phase composition of the deposited hydroxyapatite coatings was determined using the X-ray diffraction method. The bioactivity of hydroxyapatite coatings was investigated by conducting immersion test in simulated body fluid environment which is the Hank's solution.

3. RESULTS AND DISCUSSION

A protective coating provides a barrier between the metal and the surroundings and so the corrosive chemicals will have to diffuse through the pathways within the coating to eventually reach the metal and initiate a corrosion reaction. Thus a good protective coating such as hydroxyapatite can significantly extend the useful lifetime of a metallic part.

4. CONCLUSION

Comparing the results of coated stainless steel and uncoated stainless steel it can be said that the coating greatly improves the efficiency of the implants.

5. ACKNOWLEDGEMENT

First and foremost, we express our heartfelt gratitude to our Chancellor Shri. T. R. Paarivendhar, we also thank the

Head of the Department of Biomedical Engineering, Dr. Varshini Karthik, for her invaluable guidance. Finally, we thank the department of Mechanical Engineering for allowing us to participate in this International Conference.

6. DECLARATION

This work has not been presented elsewhere and is not being considered for publishing in any other journal.

Mechanical behaviour of Hydroxyapatite dispersed Sulphonated Polyetheretherketone based composite membrane at microstructural length scale (ID:T028)

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Abstract: The proposed work involves the synthesis of a sulphonated polyetheretherketone (SPEEK) membrane with enhanced properties obtained through reinforcement of nanoparticle like nano-hydroxyapatite (nHAp) in optimal proportion to develop a suitable implant material for hip-joint. nHAp, a ceramic reinforcement, renders mechanical strength to the composite and enhances its biocompatibility. SPEEK exhibits better chemical interactions with -OH group of HAp and also prevents its migration from implant location and subsequent interference with the body metabolism. nHAp powder, synthesized through wet chemical route, was analyzed using XRD to determine extent of crystallinity and FTIR characterization confirmed presence of hydroxyl group. Extent of agglomeration was determined through SEM analysis while EDS Analysis produced Ca/P ratio closely resembling human bone. FTIR analysis of SPEEK/nHAp composite membrane was done to understand the effect of sulphonation. The surface morphology of the synthesized composite showed desired level of surface roughness and wide dispersion of nHAP fillers with minimum agglomeration, with average particle sizes of around 20-50 nm. The composite membrane appeared to have been well wetted by the polymer matrix indicative of improved mechanical properties. The bulk mechanical property, i.e. tensile strength of the composite membrane proportionally increases with filler content up to 8 wt. % and reduces thereafter owing undercuts and undulations inflicted during membrane cutting or due to presence of micro voids. In the current investigation the mechanical properties viz., nanohardness, reduced modulus, elastic recovery and wear rate, were evaluated at the sub-micron range using nano-indentation technique under depth-controlled mode to corroborate efficacy of the synthesized composite.

Keywords: SPEEK, nHAp, tensile strength, nano-indentation, wear rate,

Study and optimization of wear characteristics of PLA/PMMA biopolymer composites (ID:T033)

T.Gopi, K.Duraivelu

Abstract: Poly Lactic acid (PLA) and poly methyl methacrylate (PMMA) biopolymer has been synthesized by single screw extrusion process. The prepared PLA/PMMA biopolymer composite is most suitable for bioimplants and medical guides; the wear behavior of the composite material plays a vital role in concern with its applications in medical industries. The mechanical characterizations like tensile strength , compressive strength results reveals that the addition of PMA to the PLA leads to increase the mechanical strength (tensile strength, compressive strength etc.,) of the specimen.

In this study, the specimens with different blend ratios have been subjected to pin-on-disc (POD) apparatus (in accordance with ASTM standards) to evaluate its tribolgical behavior. Sliding velocity, applied load, sliding distance has been chosen as key parametric values for this study. The co-efficient of friction and wear rate has been studied under different parametric conditions and the results have been presented. Also, Taguchi's approach and TOPSIS techniques were used to identify the effects of sliding velocity, load and sliding distance over on the tribological behavior of the composite specimens. The addition of PMMA to the PLA exhibits the wear governing mechanisms such as adhesion, abrasion, softening has been identified.

Keywords: Pin-on-disc, Bio polymer composite, Wear rate, Co efficient of friction.

Wear evaluation of Polycarbonate Urethane core for artificial disc in lumbar region (ID:T056)

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Abstract: The wear on the hard polymeric bearing materials used in the replacement of intervertebral disc with artificial disc has caused changes in load transfer during range of motion of spine segment. Polycarbonate urethane (PCU) is a soft bearing material has gained popularity as an alternate to hard bearing materials such as Ultrahigh Molecular Weight Polyethylene (UHMWPE). However, it is not proved so far that a soft bearing material can be suitably used for long term with high resilient in artificial disc replacement. The present study was aimed to evaluate the wear performance of PCU bearing material against a metal endplate to find out the suitability of using PCU as a bearing material for a long term performance. The wear study was performed in the Linear Reciprocating Tribometer (LRT) with the loading of 150N and stroke length of 20mm. The wear rate was measured based on gravimetric changes due to wear and the microscopic analysis of the bearing surface was performed to characterise the type of wear. The material loss for the PCU samples appears to have been at least 24% lower than for the UHMWPE. Based upon these results, the PCU material seems to have potential for use as an alternative bearing material to UHMWPE for intervertebral disc replacement.

Keywords: Polycarbonate urethane, UHMWPE, Wear, intervertebral disc

AI based design of hybrid UHMWPE composites with enhanced tribo-mechanical behavior (ID:T059)

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Abstract: The current trends in the practice of ultra-high molecular weight polyethylene (UHMWPE) composites show a major role in the improvement of acetabular cups in hip prosthesis. This study emphasis on the trial to design and development of UHMWPE composites by integrating various micro and nanoparticles as reinforcements for enhanced performance. It is difficult to find an optimum combination of particle's composition via numerous experimental attempts because of its intrinsic complexity and may lead to disbursing lot of time and money. Thus, a data driven design approach is implemented exploiting the Artificial Intelligence (AI) techniques like artificial neural network (ANN) and genetic algorithm (GA). Experimental data relating the use of UHMWPE reinforced with carbon nanotube, graphene, carbon fiber and hydroxyapatite are collected through published literatures to contemplate the relationship between the volume fraction and the morphology of the particles with the properties of the composites using ANN modeling and sensitivity analyses. The optimization studies are done using GA on making use of the developed ANN models as the objective functions to find the optimum combination of reinforcements to achieve enhanced mechanical and tribological properties of the composites. This AI based approach of designing the UHMWPE composites will pave a way for further experimentation and in use for the hip prosthesis.

Keywords: Hip joint, UHMWPE, hybrid composite, coefficient of friction, wear rate, mechanical properties, artificial neural network, genetic algorithm.

Temperature and load Influence on adhesion wear in dry sliding contact in vacuum condition (ID:T071)

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Abstract: Even at high temperature and corrosion resistance, Ti-6Al-4V is one of the most commonly used engineering materials offering good strength and toughness. Research on high temperature tribology relating to hot stamping and in general has grown significantly over the last few years. Adhesion and abrasion have been identified as the most prevalent wear mechanism in the tribological system of high temperature but there is still inadequate understanding of the mechanisms in depth. Therefore, the aim of this work is to get a deeper understanding of the tribological phenomena associated with adhesion and abrasion at high temperatures. In this study, high temperature tribological tests of Ti-6Al-4V sliding against SS316L were performed using a pin-on-disc system under unlubricated conditions at five different temperatures ranging from 25 to 400 0C, three different loads: 13.7, 68.7 and 109.9 N (contact pressures of 2, 4 and 6 MPa respectively) and a sliding speed of 0.5ms-1. Scanning electron microscopy / energy dispersive spectroscopy (SEM / EDS) techniques were used in order to classify the resulting worn surfaces. The coefficient of friction usually increased as both temperature and load grew as a result of tribo-layers creation. The compaction and oxidation of the wear debris at temperature above 200oC contributed to the creation of a mechanically mixed layer as a wear safety coat. Consequently the wear rate decreased at elevated temperature for both products.

Keywords: Wear mechanisms, tribo layer, Ti-6Al-4V

Wear performance of UHMWPE and PCU artificial disc materials (ID:T103)

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ABSTRACT: Artificial disc replacements are used in Total disc replacement (TDR) procedures as an alternative to Lumbar Spinal Fusion, to treat degenerative disc diseases (DDD). Artificial lumbar disc devices have a core that typically uses Ultra-high molecular weight polyethylene (UHMWPE) but in recent times a new material, Polycarbonate Urethane (PCU) has been proposed and is being used in a few commercially available devices. These two materials by virtue of their bio-compatibility, chemical stability and load bearing capabilities have become good alternatives to closely replicate the functions of natural intervertebral discs. To further enhance the thermal, mechanical and tribological properties of UHMWPE and PCU, various reinforcements are used. UHMWPE typically uses n-HA (hydroxyapatite) to reduce wear rate and coefficient of friction, TiO2 and Al203 increases crystallinity, and increased hardness, wettability and decreased coefficients of friction are observed in serum and saline UHMWPE reinforced with ZrO3. For PCU, UHMPWE fibres, silicone elastomers, HA and Polyhedral Oligomeric Silsesquioxane (POSS) finds usage. In this paper we study and survey the available literature on the web about the different disc replacement devices made of UHMPWE and PCU and draw a comparison between their wear performances.

Keywords: Artificial disc replacement, UHMWPE, PCU, wear

Tribological investigations of biological interfaces: from cartilages to catheters (ID:T007)

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Abstract: Tribology of biological interfaces has a human factor associated with it. Be it the lubricating effect of eye drops, or fluids injected at joints, or development of healthier food and beverages, will only improve our quality of life. The current article puts together investigations carried out on various bio-tribological interfaces ranging from ocular system to cartilages, and catheters used as bio-medical devices. The biggest challenge during these investigations is to find appropriate surrogates for biomaterials and designing of test methodology to predict the behavior of the material in its real-life condition. This article also presents a case study wherein different surrogates for cartilage were investigated in order to find a suitable material for lab-scale testing.

Keywords: Bio-tribology, Extended Stribeck Curves, Cartilages, Catheters

New polycaprolactone polymer coated magnesium biodegradable alloy for cardiac stent application (ID:T068)

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ABSTRACT: The roles of biodegradable materials have been increasing due to its promising and improved features than conventional materials used for biomedical implants. Thus the need for developing a better biodegradable materials necessary which could deliver better properties for the implants . This present study aims to develop a better biodegradable material where magnesium alloy (AZ-31) chosen as the substrate is surface-modified by annealing followed by a chemical treatment and then PCL (poly (hexane-6-lactone)) having 12% N,N-Dimethylformamide and Dichloromethane content is coated over the modified surface . The coating of the polymer over the sample substrate is done by electrospinning. X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM) and Fourier transform infrared spectroscopy (FTIR) examinations demonstrated fruitful surface alteration and affidavit of polymer over the substrate. The defilement lead of the models was investigated through soaking gathers in impersonated body fluid (Hank's answer) . Nano-strong PCL covering got together with surface change is apparently a promising procedure to tailor the degradation and improve the utilization impediment of Mg composites which can be used as a prevalent material for biomedical additions. PCL Coated example of Mg combination is more bio viable than the uncoated example. The corrosion studies revealed the coated sample is good corrosion resistance. Cell culture study shows the PCL coated sample has higher compatibility than uncoated samples. Hence, PCL coated Mg biodegradable implants increases the lifespan of human system.

Fig.1.PCL coated Mg alloy

Keywords; Magnesium alloy (AZ-31) , Electrospinning ,Biodegradable implant, Polycaprolactone.

Condition monitoring

Ferrography – Specialized oil analysis for protection and diagnose gear & bearing detoriation (ID:T015)

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Abstract: Adani Dahanu Thermal Power Station (ADTPS) is one of the best power generation plant in India. Recognized with innumerable awards, this power plant is known for its distinctive features that set it apart from others in terms of technological innovation, international performance and sustainability for a longer period. Plant has strategically adopted Lube oil & grease monitoring program as one of the key Condition based maintenance management practices. Equipments are prioritized for close monitoring on basis of criticality index to ensure high plant availability by ascertaining health of equipments. Ferrography oil Analysis is microscopic evaluation of wear particles identifies the type & severity of wear and generation mode which helps in understanding source of wear component. This paper shares success story of Implementation of Condition Monitoring techniques at ADTPS, wherein Main Reducer Gearbox Bearing & Gear wear of Coal Mill 2AB was detected. Ferrography oil Analysis helped in diagnosing exact root cause of abnormity well in advance enabled Maintenance Engineers to decide whether to replace the oil or equipment parts avoiding downtime of critical equipment. This case study has clearly demonstrated that Lube oil testing is vital technique in rotating machinery analysis & detection of abnormality at early stage even no deviation in Vibration, Acceleration, Distress Level parameters. This has saved plant from huge losses in terms of generation, unplanned breakdown and associated maintenance & spares costs.

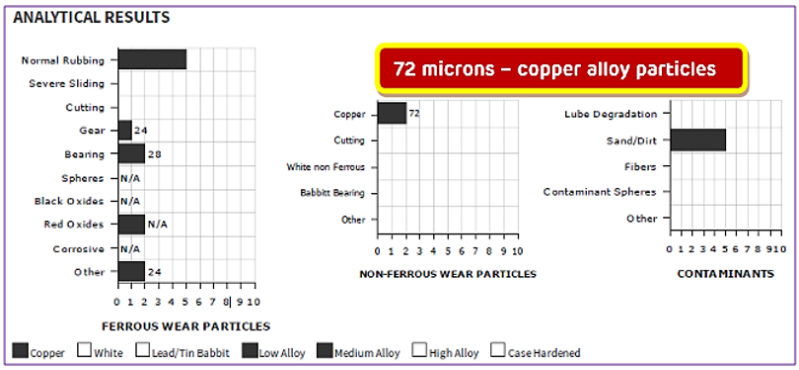
Keywords: Ferrography Analysis

1. INTRODUCTION

Following is a success story of the Implementation of Oil Condition Monitoring program at ADTPS, wherein imminent Detoriation of Main Reducer Gearbox Intermediate & Output Gear bearings of HT auxiliary Coal Mill – 2AB was detected.

2. METHODOLOGY

Wear debris analysis (Ferrography) report stated that wear particle concentration (WPC) value deviated from 586 to 1219 against limit value as 1000 WPC with Gear wear particles of size ranging up to 24 microns & bearing wear copper alloy particles of size ranging up to 72 microns. Meanwhile, Main Reducer Gearbox Vibration, Acceleration, Distress level, Noise & Ultrasonic readings taken. No deviations noticed. Decided to keep under close monitoring. As per Ferrography report recommendations, Main Reducer Gearbox internal inspection done & Output bearing clearances found on higher side as 0.5 mm against limit of 0.3 mm. Also, Micro pitting on rollers & scoring marks on inner race observed on intermediate bearing.



3. RESULTS AND DISCUSSION

During through inspection of Main Reducer Gearbox, minor looseness noticed in Intermediate Gear Spacer. No abnormality noticed for Input & Output Gears. During maintenance work, Intermediate Gear & bearings replaced with spare one. Both output shaft bearings replaced with new one. Oil filtration done & put in service again. After maintenance work execution, Coal Mill trial taken. Main Reducer Gearbox Vibration, Acceleration, Distress level, Noise & Ultrasonic readings found within limit. After filtration, impurities level in oil reduced from 0.24 to 0.10 %.

4. CONCLUSION

Coal Mill is an important auxiliary used to pulverize coal to required size for efficient combustion in boiler. Since Mill supplies coal as fuel to boiler, the reliability needs to be very high. It is very critical auxiliary in process as failure of the same directly affects to the generation loss which costs revenue of around Rs.4 Lacs per hour. This case study has clearly demonstrated that Oil Condition Monitoring is a vital tool in rotating machinery analysis & detection of abnormality at early stage even before deviation to be reflected in Vibration, Acceleration, Noise, Ultrasonic, Distress level & any other process parameters. High Wear Particle Concentration with presence of copper alloy particles of Main Reducer Gearbox oil analysis initiated a visual inspection & suspected for bearing detoriation with diagnosing root cause of abnormity in advance & timely action avoided major Gearbox repair due to secondary damage.

5. ACKNOWLEDGEMENT

This case study demonstrated that Routine Oil Condition Monitoring (OCM) identifies small problems within machinery components before they become catastrophic failures that can incur costly repairs & production to a halt even before deviation to be reflected in Vibration, Acceleration, Noise ,Ultrasonic, Distress level & any other process parameters.

6. DECLERATION:

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Vibration damping using MR fluid assisted worktable for drilling (ID:T017)

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Abstract: Vibration produced while machining a components is annoying and discomfort to the operators. If it is not damped properly, it reduces the machining performance. Magnetorheological fluid is type of smart fluid which changes is viscosity while under the influence of magnetic field. It has wide applications in dampers. In this present work, Magnetorheological fluid assisted smart worktable is designed and fabricated to damp the vibrations produced for drilling process. Finite Element Method Magnetics (FEMM) is used to optimize the design of the unit. The job is kept over smart table and vibrations produced on drill table while machining is measured using an accelerometer through DAQ Lab View software. The vibrations occurring in the drill table with and without the Smart table are compared. There is a significant reduction in the vibrations of the drill table, when the Smart table is installed. The analysis of data is done using MATLAB. Also the thrust force present in the drill process is determined experimentally.

Keywords: MR fluid assisted table, MR Fluid, Vibration damping, DAQ, Drilling

1. INTRODUCTION

Machining vibrations correspond to the relative movement between the work piece and the cutting tool. The vibrations result in waves on the machined surface. This affects typical machining processes, such as milling and drilling, and a typical machining processes, such as grinding. But in practice it is always difficult to avoid vibrations and hence it should be damped for better performance. Other than conventional methods of damping, Magnetorheological fluid (MR) assisted devices with variable stiffness can be used for controlled chatter suppression. MR fluid is a type of smart fluid which consists of a carrier fluid, usually a type of oil with carbonyl iron particles of micron size. When it is subjected to a magnetic field, the fluid greatly increases its apparent viscosity, to the point of becoming a viscoelastic solid. Importantly, the yield stress of the fluid when in its active ("on") state can be controlled very accurately by varying the magnetic field intensity. Hence, MR fluids are mainly used as dampers. Few researchers developed separate MR devices for damping tool vibrations while others developed MR assisted fixture for boring and deep drilling operations. In this present work, a new MR fluid assisted table is designed and fabricated , which supports the work piece while its get machined . By the influence of varying current, the MR fluid become viscoelastic and dampens the vibrations.

2. METHODOLOGY

The proposed design of the MR table consists of a head plate, a base plate, a bobbin and an O-ring. A clearance of 2mm exists between the T-section of the head plate and the base plate. The MR fluid is kept in this clearance. A copper coil is wound around the bobbin which acts like a core. The current is passed through this coil and the magnetic field produced forces the fluid to become viscous. This reduces the vibrations present in the drill table.

The electromagnets in MR table was designed based on the simulation done using Finite Element method magnetic (FEMM) software. The material chosen was mild steel for the head plate, the base plate and the bobbin which act as a core. Copper wire was chosen to be wound around the bobbin and the dimensions were chosen according to availability, design constraints and ease of assembly. Accordingly, the three types of coils were used while simulating- 18SWG, 24SWG and 36SWG. 18 SWG has a diameter of 1.2mm, 24 SWG has a diameter of 0.55mm and 36 SWG has a diameter of 0.19 mm. The main objective of this simulation is to determine the coils and the number of turns around the bobbin and the maximum amount of current, to produce the correct magnetic field around the MR Fluid.

A magneto rheological fluid of composition comprises 10-20% by weight of castor oil as a carrier fluid and 80-90% by weight of magnetic sensitive particles coated with magnetic sensitive particles stabilizer and dispersed in the carrier fluid as prepared and used for this study.

The entire MR Unit fabricated as per the design was finally interlinked such that there is a Base plate at the bottom ,Bobbin is given a tight fit inside the slot provided for it to fit in and then tack welded. Then the insulated rubber

covering was placed inside the T-Slot of the Head plate. Finally the T-Slotted Head plate is seated inside the U-Slotted Base plate with a certain area left for the fluid and the coil winding. In this way the entire setup is assembled

3. RESULTS AND DISCUSSION

The work piece is fixed on MR table and the accelerometer is attached to the drill table, and is connected to the Data-Acquisition card. The DA card is connected to the USB port of a computer, on which the data is read in the LAB View software. The accelerometer being used measures longitudinal vibrations and so care must be taken regarding the position of the accelerometer. As the drilling is started on the job, the data on the Lab View software shows the graphs of the vibrations induced in the drill table. The unit is in 'g', i.e. acceleration. The data can be acquired for the given time period and the data is read to a text file and plotted as in Figure 1

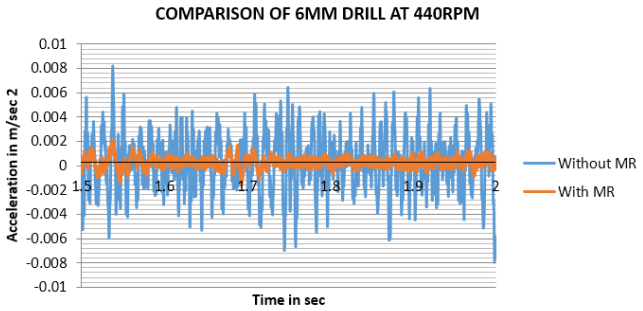

Figure 1 Vibration damping during drilling operations on MR table with presence and absence of MR fluid

4. CONCLUSION

A brief study on MR fluid assisted worktable was done. The drilling operation was conducted with and without MR fluid unit, on a radial drilling machine. The experiment was conducted at 600 rpm and 800 rpm with 6mm, 10mm drill bits and the vibrations transmitted on the work table were acquired using accelerometer. Using MRF unit there was considerable decrease in the vibrations which can be observed from the amplitudes of acceleration obtained using LabView software. Hence the properties of MR fluid are verified and used to dampen the vibrations.

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Friction analysis of aircraft landing gears due to landing impact (ID:T070)

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Abstract: In this work, Six degree of freedom Heave-pitch mathematical model has been developed for the aircraft with main and nose oleo pneumatic landing gear. Nonlinearities in stiffness, damping, bending characteristics of landing gears, and tire incorporated in the model. Friction is an incidental and inevitable reaction sticks along with the strut motion during the event of ground contact. Friction generated in the landing gear as a sum of the contribution from bearings and seals fitted in the landing gear. This study has focused on investigating the amount of frictional resistance that gained by the struts while aircraft landing on various sink rates .The strut vertical forces, seal friction forces and bearing friction forces generated in the main and nose landing gear during touchdown has been presented in this work. This preliminary estimation of friction forces for a range of sink rates aids the designer in developing optimal geometric or strut parameters in the design stage. This work also helps to calculate total landing loads for the certification of landing gear.

Keywords:- Nonlinear Heave-pitch model, Seal Friction, Journal Bearing Friction, Landing Gear Impact

1. INTRODUCTION

To understand the aircraft landing dynamic behavior, the heave-pitch mathematical model is an adequate one in concern of response captivation than full aircraft model by considering symmetric response in both main landing gear and nose one subjected to landing impact (1), (2). Contact between the runway surface and tire develops with an unavoidable bending moment in the half and full axle where the torque link endured it as a lateral force during landing (3). The knowledge in landing response of aircraft besides preliminary analysis (4) in bearing and seal friction aids the designers to decide a suitable seals to fit into hydraulic actuator (5) (6). Here, the developed mathematical model is useful for the investigation of frictional forces and its significance during landing gather from the aircraft response for different sink rates spotlighted.

2. NON LINEAR HEAVE-PITCH MODEL

The Landing dynamics equations of motion of the heave-pitch modeled system are written from Figure 2. The nose and main landing gear behave nonlinearly along the strut and tire individually as spring and damping elements. The frictional forces involved inside the strut was investigated with the developed non linear mathematical model. The friction forces generated in the strut was depicted in Figure 3.

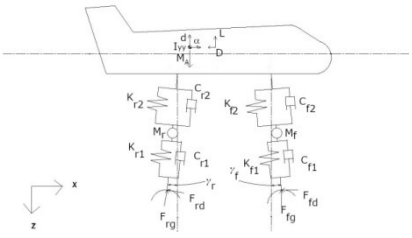

Figure 2. Heave-Pitch Mathematical Model

In this research work, MATLAB/Simulink is a numerical simulation tool used to acquire the response of heave-pitch model of aircraft during touchdown at different sink rates.

3. RESULTS AND DISCUSSION

During normal, critical and hard landing events, the seal and bearing in the main and nose landing gear contributes 11% of load as friction in the overall strut load, whereas 3/4 th amount of this frictional load is governed by bearing. For a given sink rate of aircraft touchdown, if the coefficient of friction in bearing was increased by a

value of 0.05, then it will results in the increment of friction force by 18 percentage as an outcome. This also results in 75% to 85 % rise in the value of frictional load in bearing as mentioned earlier. In a particular sink rate, if the coefficient of friction in seal is increased by a value of 0.02, it will results in the reduction of friction force by 2 percent.

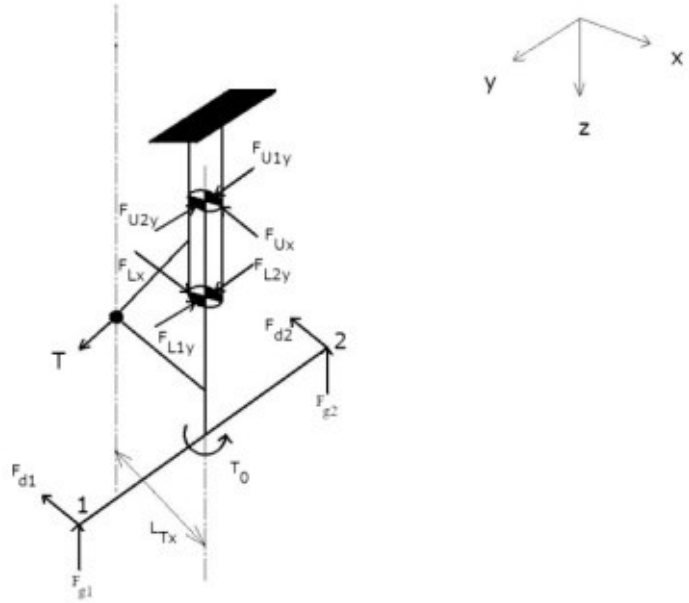

Figure 3 Main Landing Gear friction model

4. CONCLUSIONS

The estimation of friction forces involved in the nose and main landing gear has been investigated on different touchdown rates using the developed heave pitch mathematical model. The obtained main and nose landing gear forces in terms of seal and bearing friction can be used for design of landing gear strut, sealing rings and bearing components.

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Experimental study to compare the performance of engine fueled with diesel and biodiesel blend on the basis of vibration signature analysis (ID:T089)

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Abstract: Estimation of lubricating oil replacement schedule for IC engine based on change in physiochemical properties, has become a known area of research. For that a lot of research work have been performed on engines feuded with both diesel and diesel blends. These researches can also be supplemented by correlating the degradation of oil with change in vibration signature of engines feuded with diesel and bio diesel. This can provide a broader aspect to the study, which may be even further extended to providing the oil replacement schedule solely based on vibration signatures of the engine. The present study is intended to cater this aspect. The vibration signature of single stroke diesel engine fuelled with diesel and diesel blend i.e. BJ10 diesel (10 % jatropa oil) are recorded after every two hours of interval for an engine run of 100 hrs. The comparative studies are performed by correlating the lubricant degradation with the vibration patterns of the complete run. The vibration signatures are captured using FFT analyser and physio chemical properties of lubricant are analysed with FTIR, density meter and Rheometer. The details of the experiments with the observations are briefed in content. The results justify the novelty of the approach and emphasizes the extension of the study for other blends also.

Key words: Condition monitoring, vibration signature, biodiesel.

1. INTRODUCTION

The fossil fuels in recent years has taken a new shape in research as blended fuels. These blended fuels are mostly diluted with petrol diesel. The difference in composition of biodiesel blends with the raw fuel provides great opportunities for the researchers to do experiments and emphasis the results. On the other hand, a study in performance analysis and testing of diesel engine has also taken its degree of variation in testing and monitoring techniques [1]. Though there are many methods of monitoring the health of an engine, best method is yet to be identified [2]. A new approach of corelating the physio chemical properties of lubricant and the vibration signature of the engine is proposed for diesel biodiesel blend and raw petrol diesel. Even there are many methods in producing biodiesel among which high yielding method is preferred with 90% yield.

2. METHODOLOGY

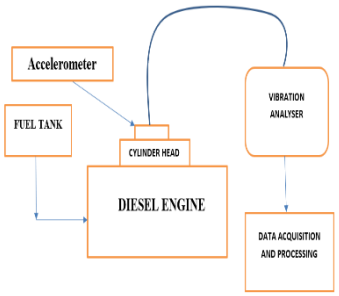

Figure 1- Line sketch of experimental setup

The experiments are performed on diesel engine with specification at constant speed of 1500 rpm. A single cylinder diesel engine with eddy current dynamometer is utilized for this experimentation work. The vibration signatures are captured using FFT analyser and physio chemical properties of lubricant are analysed with FTIR, density meter and Rheometer. The specifications of the Kirloskar engine is as follows. BHP 5, Speed 1500 rpm, No. of cylinder 1, Compression ratio 16.5:1, Bore 80 mm, Stroke 110 mm, Method of loading is by eddy current dynamometer. The vibration signatures are captured for every 2 hours run of the engine. The degradation of the lubricant is measured for every 20 hours of run. The physio chemical properties of the lubricant for every 20 hours of run is measured using density meter, FTIR and rheometer. Finally, an attempt is made to corelate the properties change and the vibration signature through a polynomial equation. Based on the vibration signature the condition

of lubricant shall be determined. From both the details, the corresponding features of the vibration signals are extracted, recorded using a self-locating chart through which detection of the faults and grouping of the diverse health status of the engine is monitored. These details would help in maintenance scheduling of the engine.

3. RESULTS AND DISCUSSION

The vibration signature captured using FFT analyser or every 2 hours of run as mentioned before. The lubricant properties are also recorded every 20 hours, then the fresh lubricant is introduced replacing the older lube oil. As the internal components of the engine is replaced for fresh start of experiments, first 20 hours of run will be wear out phase where the lubricant will degrade quickly with excessive wear of new components. The properties such as density, viscosity is recorded. The standard lubricant of SAE20W40 is utilized as engine oil, petrol diesel fuel with its density and viscosity is cross verified with ASME standard. The FFT analyser uses the single channel accelerometer or absorbing the vibration signal. Both horizontal and vertical vibration signature are captured.

Table 1: summary of sample results of lubricant degradation.

Lubricant 20W40(R)	Viscosity at 80^{o} C in Pa.S	Density Kg/m^3
Raw	0.0286	656.3
In first 20 hours of run	0.0922	821.8
Second 20 hours of run	0.0310	391.2

From the data of both table 1 & 2 a simple corelation between the properties of lubricant and vibration signature can be derived as a polynomial equation.

Table 2: summary of RMS vibration signature peaks-Vertical

Time After	Amplitude(m/s^2)	Frequency(hz)
first 20 hours	44.174	888
Second 20 hours	35.48	893

4. CONCLUSION

The use of vibration signature analysis for condition monitoring an engine corelating with oil degradation is a new method. This methodology is also an online measurement technique. The change in vibration signals provides corelated results of physio-chemical properties of lubricant and also the condition of the internal components.

5. ACKNOWLEDGEMENT

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6. DECLERATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Combination of analytical sciences with tribological quantities for an advanced condition monitoring (ID:SP001)

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Abstract: Condition monitoring of lubricants as a “machine element” in a tribosystem is important for ensuring the reliability of a system. The reduction of maintenance costs and positive environment effects are the obvious benefits. Both on-line and off-line condition monitoring of lubricants are mainly based on analyses of chemical and physical properties. The tribological performance of used lubricants (friction and wear) usually is not taken into consideration in condition-monitoring tests and consequently in the assessment of the quality of lubricant in the machine. The challenge was to optimize test parameters to be able to differentiate the tribological response of used oils. The results which correlate mostly with the state-of-the-art analysis of used oil are promising. This additional information can be of interest for assessing the machine reliability as well as for optimizing lubricant service life. Additionally, the modern tribometrical test systems provide the tools and test methodology enabling a deeper understanding of used lubricant behavior.

Cliff“ testing aims to identify in engine or gear tests the induction time or off-set point (“cliff“) after which wear and friction increased or failure occurred. Such “posttest” explanations for friction and wear increases as well as failures, which occurred during engine tests, can be derived from SRV® testing of oil samples taken or collected at different engine test times. The results will be discussed in his paper as well.

Lubrication

Investigating graphite added glycerol as metalworking fluid in turning of steel (ID:T006)

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Abstract: Metal working fluid is one of the most important element in machining industries, however many industries face the problems of producing highly finished surfaces along with disposal of the used metal working fluid due to environmental hazards. In this work focusing to propose Glycerol (GLY) based skin friendly cutting fluid for the hard metal machining process. To analysis the novel cutting fluid performance at the cutting zone the machining operation carried out in dry and flood condition (Pure GLY,GLY+ 0.1% grapite(GRT)). During the machining operation cutting force and temperature was absorbed because to improve the tool life, the temperature and cutting force is one of the important parameters. The absorbed result shows that maximum cutting force 1323.5N exhibited in dry machining condition the lowest cutting force exhibited 854.08N in micro GRT(0.1%) added cutting fluid. In the temperature concern the highest value 52.3^{o}C noted in dry machining condition and lowest value 32^{o}C absorbed in pure glycerol used as a cutting fluid condition. The result clearly shows that the friction modifier plays major role while adding with the glycerol.

Keywords: *Metal working fluids, glycerol, graphite, friction modifier.*

1. INTRODUCTION

To improve the quality of machining and tool life is important task in hard metal machining process. The cutting fluid act major role to reduce the temperature and friction between tool and workpiece. Reddy et al[1] Developed non-oil based cutting fluid it exhibited 58.3% and 28.57% less surface roughness, and 46.29% and 25.43% low temperature at the cutting zone. Additionally, the tool wear was 25.83% and 14.7% less than dry and o Eltaggaz, et al [2] investigated vegetable oil based Al_2O_3 and gamma particles added hybrid nano fluid in austempered ductile iron (ADI) machining operation It was observed that the hybrid nano particles cutting fluid improved the tool life in 120mm/min of cutting speed and 0.2mm/rev of feed rate condition. il based cutting fluid. Shubrajit Bhaumik et al[3] proposed glycerol(GLY)based skin friendly cutting fluid for replacing of existing non biodegradable cutting fluid also in the result concluded that micro graphite(.1%)added glycerol based cutting fluid exhibited better result compared to commercially available cutting fluid. So based on this concern the performance of .1%GRT is dispersed with glycerol also used as the cutting fluid. The machining characteristics concern reducing the temperature and cutting force is important parameter to improve the tool life.

2. MATERIALS AND METHODS

The Batch No.MCR-20747 glycerol was purchased from Chennai local market. It contains maximum limits of Impurities are Sulphated ash 0.02% and water 2%. The probe sonicator is used to disperse the micro graphite with purchased glycerol.MTT-1440 all geared lathe used to turn the 50mm diameter EN31 steel rod and carbide insert was used to turn the material. To absorb the temperature at cutting zone digital LCD Thermometer was used. Lathe tool dynamometer is used to measure the cutting force.

3. RESULT AND DISCUSSIONS

The maximum cutting force 1323.5N and exhibited dry machining condition the lowest cutting force exhibited 854.08N in micro GRT(0.1%) added cutting fluid. In the temperature concern the highest value 52.3^{o}C noted in dry machining condition and lowest value 32^{o}C absorbed in pure glycerol used as the cutting fluid condition.

4. CONCLUSION

There is chance to replace the commercial cutting fluid using glycerol with friction modifier. To improve the tool life friction modifier and optimized cutting parameters plays the major role.

5. DECLERATION

The work has not been presented elsewhere or not being consideration for presentation in any journal

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The enhanced tribological performance of hexagonal boron nitride (hBN) nanoparticle additives in various type of engine oil (ID:T043)

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Abstract: The prospect of modern tribology has been lingering with the dawn of nanomaterial-based lubrication systems, which facilitates one of the nanotechnology-based system developments. In this regard, hexagonal boron nitride (hBN) based nano-lubricants was developed with Mineral Engine Oil, Semi-Synthetic Engine oil, Synthetic Engine Oil, and Diesel based Engine Oil using the simplest approach of sonication and homogenization. The basic properties and the material confirmation of nano-additives (hBN) were done using appropriate physiochemical characterization tools. hBN based nano-additives were prepared, and its tribological performance (i.e., coefficient of friction, wear test) was carried out using a four-ball tribotester according to ASTM standard. The highest improvement in friction (COF) coefficient was attained by using the hBN nano additives in the Diesel-based Engine Oil of 10.35% compared to other lubricants.

Keywords: hBN, tribology, diesel engine oil, coefficient of friction, wear rate

1. INTRODUCTION

In recent years, the application of nanoparticles as additives in the engine oil plays a significant role in enhancing the engine's lubrication performance. The peculiar feature of nanoparticles is its size (nanometer range) permits in anchored/deposit in between the micro gaps and cracks on the mechanical parts of the engine, thereby behaving as ball bearing, which in turn steep the engine rate friction. [1, 2]. Therefore, minimalizing the combustion engine's friction level is of utmost importance to boost up its performance [3]. Hexagonal boron nitride (hBN) is also known as "white graphite" due to its solid lamellar lubricant like graphite structure [4, 5]. Based on its atomic layers, nitrogen is bonded covalently with boron to form a 2D atomic sheet-like structure bonded with van der Waals force. Owing to its unique properties, particularly chemical and thermal stability, it provides a higher level of resistance to oxidative degradation up to ~1000 °C [6]. Hence in this experiment, hBN nanomaterials were used as an additive by dispersing in Mineral Engine Oil, Semi-Synthetic Engine oil, Synthetic Engine Oil, and Diesel based Engine Oil, and its tribological properties were investigated.

2. METHODOLOGY

All the chemicals used in this experiment are analytical grade and purchased from Sigma-Aldrich. The nano oil is prepared by dispersing 0.025 vol.% 70nm-sized hBN in the Mineral Engine Oil, Semi-Synthetic Engine oil, Synthetic Engine Oil and Diesel based Engine Oil using the ultrasonic homogenizer 3 minutes with 30 seconds of interval time for four cycles. The tribological studies were then carried out to determine the coefficient of friction (COF) using a four-ball tribometer TR-30L-IAS of the oil sample with/without the addition of hBN nanoparticles, and the experiments were repeated thrice. The parameters like speed, load, time, and temperature were followed as per the ASTM standard D4172 procedures.

3. RESULT AND DISCUSSIONS

The zeta potential value observed for the hBN nanomaterials was 1280 mV, confirming the samples' excellent stability. Tribological performance of the hBN nano-additives in diesel engine exhibits the highest reduction in the friction of coefficient (COF); the value decreases from 0.0783 to 0.0702, which is approximately by 10.35% as compared with bare engine oil (Fig. 1). Moreover, there is also a reduction in the value of the steel ball's wear scar diameter from 331µm to 320µm, which has been used in the tribotester.

4. CONCLUSION

Based on the results, it is clear that the addition of hBN nanoparticles in the Diesel engine oil contributes significantly to reducing friction compared to Mineral Engine Oil, Semi-Synthetic Engine oil, Synthetic Engine Oil. COF, which in turn indirectly proportion to the performance of the engine. Hence, based on obtained results, the reduction in COF values may increase the engine performance of the machines by reducing friction and temperature of the mechanical moving parts in the machines and providing better protection for prolonged usage under extreme heat and pressure.

5. ACKNOWLEDGEMENT

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6. DECLARATION

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The role of surface roughness frequencies in controlling lubricant wettability in hierarchical engineering surfaces (ID:T054)

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Abstract: In this study, the emphasis is on understanding the role of surface roughness frequencies in controlling wettability in hierarchal engineering surfaces. For this, hierarchical rough surfaces were produced using mechanical texturing methods. Surface texture and roughness was induced on to hardened tool steels samples, thus producing hierarchal surfaces with average roughness ranging from ~Ra 800 to ~ 80 nm. It was also observed that in higher roughness range (Ra 800 nm, selected in the present study), the higher frequencies determine the steady-state wettability, and the low-frequency roughness that generates the texture doesn't contribute to wettability. As the roughness reduces to Ra~80nm, the frequency range that produces texture and roughness equally contributes to the wettability.

Keywords: *Wettability, Roughness frequencies*

1. INTRODUCTION

Every surface is rough; the scale of interpretation determines it. Although most previous studies have identified surface roughness as an important property that generally leads to an increase or decrease in wettability, there are occasional studies that show this trend is perhaps not completely dependent on the net average surface roughness. Engineering surfaces produced through various manufacturing and finishing processes can have different surface roughness values. These generated surfaces can be inherently hierarchal, having multiple roughness frequencies contributing to the average surface roughness. Based on the practical applications, these engineering surfaces deal with various kinds of lubricants, and the surface roughness can considerably affect the wettability[1,2]. Hence, in this study, the emphasis is on understanding the role of surface roughness frequencies in controlling wettability in hierarchal engineering surfaces.

2. METHODOLOGY

Hierarchical rough surfaces were produced using mechanical texturing methods. Surface texture and roughness was induced on to hardened tool steels samples, thus producing hierarchal surfaces with average roughness ranging from ~Ra 800 to ~ 80 nm. Wettability studies using a low viscosity lubricant was conducted using a contact angle goniometer.

3. RESULTS AND DISCUSSION

The results suggest that the wettability (Contact angle) can be the same, even for surfaces with different Ra values produced trough similar mechanical texturing methods. Fourier filtering of surface roughness frequencies contributing to the net Ra values revealed that not all frequencies contribute in defining the wettability behavior. There exist critical roughness frequencies that define the wettability of the lubricant over a surface. It was also observed that in higher roughness range (Ra 800 nm, selected in the present study), the higher frequencies determine the steady-state wettability, and the low-frequency roughness that generates the texture doesn't contribute to wettability. When the roughness reduces to Ra~80nm, the frequency range that produces texture and roughness equally contributes to the wettability.

4. CONCLUSION

From the experimental study it was concluded that in higher roughness range Ra 800 nm, the higher roughness frequencies determine the steady-state wettability, and the low-frequency roughness that generates the texture doesn't contribute to wettability. As the roughness reduces to Ra~80nm, the frequency range that produces texture and roughness equally contributes to the wettability.

5. DECLERATION:

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Evaluation of tribological performance of coconut oil-based grease with hybrid MoS_2/ SiO_2 additives under boundary lubrication regime (ID:T062)

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Abstract: The present work aims to evaluate the tribological performance of coconut oil-derived grease with hybrid nanoadditives. The grease was blended with MoS_2/SiO_2 in a variable weight ratio. The tribological performance of the grease was evaluated under the boundary lubrication regime. The MoS_2/SiO_2 (30:70) doses furnished the maximum reduction in friction and wear. The combination of rolling friction and low shear properties using the synergistic blend of the spherical nanoparticles (SiO_2) and nanosheets (MoS_2) showed significant improvement in tribological properties. This finding suggests that coconut grease with hybrid nanoadditives can be a suitable alternative to conventional greases.

Keywords: Boundary lubrication coconut oil, grease, MoS_2 nanosheets, and SiO_2 nanoparticles

1. INTRODUCTION

The coconut oil is the most saturated oil among all the vegetable oils. The presence of saturated fatty acid in coconut oil is more than 90%, and low iodine value 6-10 [1]. The investigations carried out on coconut oil-based lubricants have demonstrated promising tribological results [1–3]. Nevertheless, until now, coconut oil has not been explored as base-stock for grease lubrication.

2. EXPERIMENTAL DETAILS

SYNTHESIS OF NANOMATERIALS

The SiO_2 nanoparticles were prepared by a sol-gel approach [4]. The MoS_2 nanosheets were prepared by a hydrothermal reduction of sodium molybdate with thiourea [5]. The crystalline and morphological properties of MoS_2, and SiO_2 nanomaterials were probed by an X-ray diffractometer (XRD) and high-resolution transmission electron microscope (HRTEM).

SYNTHESIS OF GREASE

The coconut oil-based grease was formulated using a lab-scale overhead mechanical stirrer [6]. The ratio of MoS_2 to SiO_2 were varied in five combinations, i.e., 100:0; 70:30; 50:50; 30:70; and 0:100 for the formulation of coconut grease samples. The thickener concentration was fixed at 14 wt%.

CHARACTERIZATION OF GREASES

The antiwear properties of coconut grease were measured by a four-ball tribometer as per the ASTM D2266 standard. The morphological features of the worn scar on steel balls were captured using a scanning electron microscope (SEM). The elemental distribution over the worn scars of steel balls was collected by an energy dispersive spectroscope (EDS).

3. RESULTS AND DISCUSSION

CHARACTERIZATION OF NANOMATERIALS

The SiO_2 nanoparticles exhibit the spherical shape (Fig. 1a-b) with their diameter ranging from 20 to 35 nm. The MoS_2 displayed a hair-like structure in the form of lumps (Fig. 1c). A broad diffraction peak at 2θ of 23.5° signified the 101 plane of SiO_2 as per the JCPDS card NO. 89-8951. The notably broader XRD peak suggests the amorphous nature of SiO_2 nanoparticles. The MoS_2 nanosheets exhibit diffraction peaks at 2θ of 13.98°, 33.24°, 39.86°, and 58.89°, corresponding to (002), (101), (103), and (110), planes, respectively. These diffraction peaks are supported by the JCPDS data card No. 75-1539 and signified the lamellar structure of MoS_2.

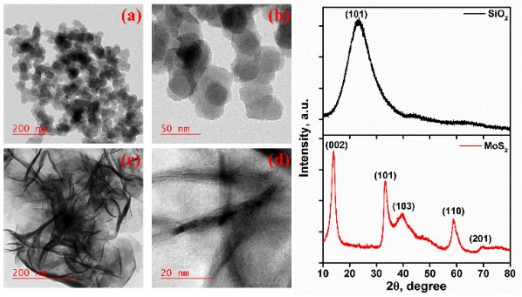

Fig. 1: TEM images of (a-b) SiO_2 nanoparticles (c-d) MoS_2 nanosheets and XRD pattern of SiO_2 nanoparticles and MoS_2 nanosheets

EVALUATION OF TRIBOLOGICAL PROPERTIES

Table 1: Changes in COF, WSD, and MWV for steel balls using the coconut grease blended with MoS_2/SiO_2 as nanoadditives.

Concentration MoS_2:SiO_2	COF	WSD (µm)	MWV x 10^{-4} (mm^3)
Raw	0.084	836.347	72.666
100:0	0.081	856.437	80.537
70:30	0.072	839.237	74.046
50:50	0.072	816.113	65.250
30:70	**0.067**	**749.620**	**45.870**
0:100	0.076	805.517	62.339

CHARACTERIZATION OF WORN SURFACES

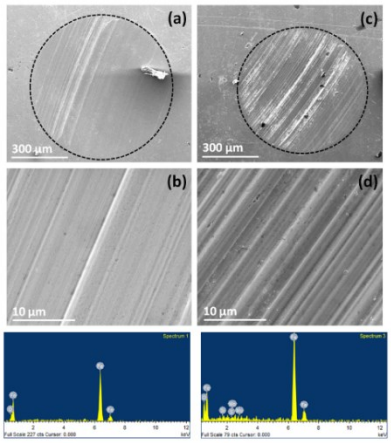

Fig. 2: SEM images of worn steel balls lubricated with (a-b) raw, (c-d) MoS_2/SiO_2-blended coconut grease with corresponding EDS spectrum

The formation of fatty-acids derived protective thin film of low shear strength is accountable for the lubrication effect by coconut grease. The blending of MoS_2/SiO_2 nanoadditives further improved the antiwear properties; thus, their presence between the tribo-interfaces led to a significant reduction in WSD. The distribution of Mo, S, and Si over the worn scar lubricated with MoS_2/SiO_2-blended grease confirm the roles of these nanomaterials in tribo thin film formation.

4. CONCLUSION

The optimized blend of MoS_2/SiO_2 (30:70) showed a significant reduction in COF, WSD, and MWV, drive by the synergistic effect of constituted nanomaterials. The spherical SiO_2 nanoparticles extended the low friction because of the micro ball-bearing effect, and the low shear strength of 2D lamellar sheets (MoS_2) decreased the friction under the tribo-stress.

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Viscous and molecular effects of fatty acid concentrations in thin film lubrication flow (ID:T069)

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Abstract: In this research multiple concentrations of fatty acids viz. Decanoic, Palmitic, Myristic and Stearic acids were tested with light mineral oil in laboratory conditions. The pressure and flow parameters were predicted in the confines of a controlled positive displacement piston and an end connected set of parallel plates. In the tests conducted there were large differences in the experimental and Fuller's theoretical pressures as shown in the combined plots. The pressure drop on account of the viscous forces was major whereas the drop due to the molecular forces was marginal. Due to the temperature increase lesser pressure was required to pump the oil across the thin space. It was seen in each case that as the concentration increased the viscosity increased resulting in an increase of experimental pressure. Under the same conditions the variations of film temperatures indicated that fluid friction was greater for the fatty acid mixture than for pure light mineral oil.

Keywords: positive, displacement, viscous, concentration, transducer

1. INTRODUCTION

Fundamental experimental data was needed to formulate mathematical models and predict the behaviour of thin films. The approach was to view the migration of thin films as flow through porus media viz. Darcy flow. In this case fluid flow was through a very thin space of approximately 0.02mm between parallel plates.

2. METHODOLOGY

The designed test device consisted of a long screw driven positive displacement piston controlled with instrumentation and a digital oscilloscope. External and relay ladder logic circuits were designed and developed to enable proper functioning of the connected equipment. The right end of the piston contained a socket into which a steel threaded plug was inserted as shown in Fig.1. Thus an annular space was developed through which a liquid was squeezed [1]. Two end connected plugs were used in the study to obtain film thicknesses of 0.04mm and 0.1mm respectively. The LVDT provided an output electrical voltage measured by the oscilloscope and served as a measure of its axial load [2]. The step by step experimental procedure for each run pertained to a particular flow rate, fluid, concentration and rpm. In Fuller's theoretical analysis [3] boundary film flow rate and local film thickness depended on pressure gradient, local velocity and permeability factor as in equation (1)

$$P = (12ul/b\,h^3)Q \qquad (1)$$

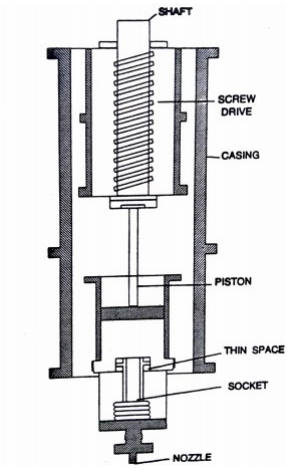

Fig.1 Cross-sectional view of a positive displacement piston with end connected set of thin spaced parallel plates

3. RESULTS AND DISCUSSION

The Fig.2 shows the experimental and theoretical values for the light mineral oil and 1% fatty acid solutions tested.

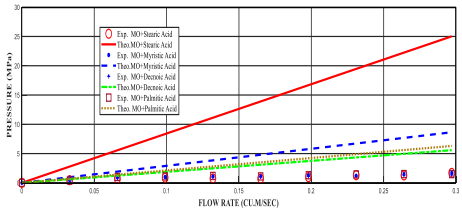

Fig. 2 Light Mineral oil & 1% Stearic, Myristic, Palmitic & Decanoic Acid

The results for concentration against pressure show maximum peak pressure for C_{18}, C_{14}, C_{10} and C_{16} acids which was justified. The over emulsification of Stearic acid in the oil medium was unique.

4. CONCLUSION

The graphs were explained in the order that the critical micelle concentration of a surfactant decreased as the number of carbon atoms in the hydrophobic group increased to 16. The effect of lowering surface tension was correctly attributed to appropriate charge ions lowering the critical micelle formation.

5. ACKNOWLEDGEMENT

The author acknowledges the cooperation extended by the technicians in installation of equipment and arrangement of samples at the University of Florida Mechanical and Chemical Engineering departments.

6. DECLARATION

The work has not been presented elsewhere or not being in consideration for presentation in any journal.

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Anti-wear behaviour of polyalphaolefins with oleic acid treated LaF_3 nanoparticles as an additive under extreme pressure conditions (ID:T088)

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Abstract: The present work focus on the extreme pressure characteristics of polyalphaolefins (i.e. PAO 4 and PAO 6) with LaF_3 nanoparticles as an additive. The surface of LaF_3 nanoparticles modified with oleic acid was synthesized by sol-gel method. The varying concentration (0.025-0.15 wt.%) of nanoparticles were dispersed separately in both PAOs with the aid of magnetic stirrer and ultrasonication to formulate nanolubricants. The extreme pressure properties of nanolubricants were obtained using four ball tester as per ASTM D2783 to examine the last non-seizure load (LNSL), initial seizure load (ISL), weld load (WL) and load wear index (LWI). The EP properties have been improved at all concentration of LaF_3 nanoparticles. However, 0.15 wt.% was found to be the optimum dose in both PAOs, which displayed the best EP behaviour, i.e. the highest LWI and lowest WSD at ISL. In comparisons with pure PAOs, at different concentrations (0.025-0.15 wt.%), PAO 4 showed the increment in LWI around 1 to 13% respectively, while in the case of PAO 6, the increment was in the range of 24-30%.

Keywords: Polyalphaolefins (PAOs), LaF_3 nanoparticles, nanolubricants, extreme pressure, wear

1. INTRODUCTION

Due to less availability of petroleum-based resources and exceed functional limits of mineral oils, the demands of synthetic base oils have been continuously increasing day by day. Polyalphaolefins (PAOs) are one of the most popular synthetic oil which are commonly used as automobile and industrial lubricants working in extremely cold climates or hot applications[1]. PAOs are generally categorized based on their kinematic viscosity at 100°C[2].

2. METHODOLOGY

Synthesis of LaF_3 nanoparticles

The LaF_3 nanoparticles were synthesized by sol-gel method and in-situ modified by oleic acid.

Characterization of LaF3 nanoparticles

The size, morphology and phase structure of as-prepared surface-modified LaF3 nanoparticles were analyzed through high-resolution transmission electron microscopy (HR-TEM) and X-ray diffraction (XRD).

Tribo testing and worn surface analysis

The extreme pressure properties of lubricants have been evaluated in four ball tester as per ASTM D2873. The worn surfaces of balls were analysed by various characterization techniques such as scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDS) and scan probe microscope (SPM).

3. RESULTS AND DISCUSSION

Figure 1 illustrate how all nanoparticle dose in both PAO diminished the wear scar diameter from initial seizure load onwards.

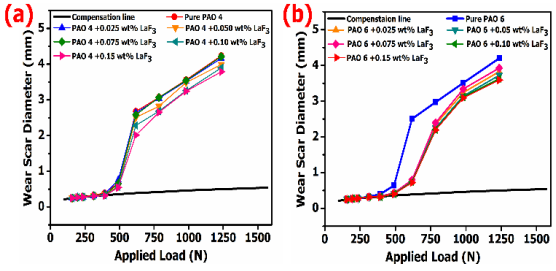

Figure 1: - Variation in wear scar diameter with applied load for (a) PAO 4, (b) PAO 6

Table 1 demonstrates how LaF_3 concentration in both PAOs decreases the WSD at initial seizure load (ISL) and before weld load, and consequently increases the LWI. The morphological and topographical micrographs of worn surfaces of steel balls lubricated by pure PAOs and with optimum dose of LaF_3 and tested under application of 784 N load are shown in Figure 2.

Table 1: - Results of extreme pressure condition

Tribological parameter	**Base oil**	**LaF_3 nanoparticles concentration (wt.%) in PAOs**					
		No additive	**0.025**	**0.05**	**0.075**	**0.1**	**0.15**
Last non seizure load, LNSL, (N)	PAO 4	392	392	392	392	392	392
	PAO 6	392	491	491	491	491	491
Initial seizure load, ISL, (N)	PAO 4	491	491	491	491	491	491
	PAO 6	491	618	618	618	618	618
Mean scar diameter at ISL, (mm)	PAO 4	0.67	0.76	0.59	0.66	0.56	0.55
	PAO 6	0.64	0.78	0.77	0.80	0.74	0.72
Weld load, (N)	PAO 4	1570	1570	1570	1570	1570	1570
	PAO 6	1570	1570	1570	1570	1570	1570
Load wear index, LWI, (N)	PAO 4	372	376	395	387	409	418
	PAO 6	377	466	474	462	482	490

4. CONCLUSION

In both oils, the EP properties were improved at all concentration of nanoparticles but 0.15 wt.% of LaF_3 exhibited the best EP behaviour.

At concentration 0.025-0.15 wt.%, PAO 4 displayed the increment in LWI around 1 to 13% respectively, while in the case of PAO 6, the increment in LWI was in the range of 24-30% in comparisons to pure PAOs.

Overall, PAO 6 demonstrated the best EP characteristics (i.e. higher LWI, ISL and minimum wear scar at ISL) as compared to PAO 4.

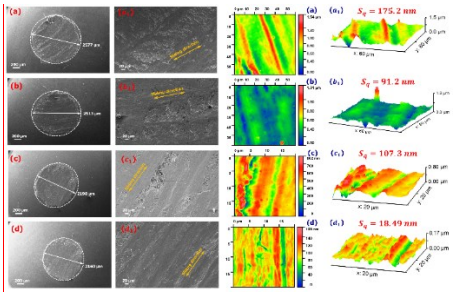

Figure 2:- SEM and SPM images of worn surfaces of steel ball under applied load of 784 N and lubricated ((a , a_1) & (b, b_1)) with pure PAO 4, PAO 4+0.15 wt.% LaF_3; ((c , c_1) & (d, d_1)) with pure PAO 6, PAO 6+0.15 wt.% LaF_3 respectively.

5. DECLERATION: The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Tribological characterization of simarouba glauca biodiesel (SGME) with oxide nanoparticles **(ID:T099)**

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Abstract: Biodiesel blends play vital role in conservation of the ecology. Biodiesels possess enhanced lubrication properties which save energy and enhance the engine life. In this investigation the lubricity of diesel, blends of Simarouba glauca methyl ester (SGME) in diesel, with and without addition of nanoparticles is assessed employing four ball tester. The biodiesel blends B10 (10% biodiesel in diesel), B20, B30 and diesel B0 were characterized. Copper oxide (CuO) nanoparticles were utilized. Nanoparticles exhibit excellent dispersion in the SGME due to its high oleic acid content. Tribological aspects in terms of run-in period and flash temperature parameter (FTP) were analyzed using four ball tester for the experimental conditions specified in ASTM D 4172. The advantageous combinations are 0.75 % (B20 and B30) which shown drop in run in time manifesting 81% decrease with respect to diesel. Moreover the favorable combinations are 1 % (B10), 0.5% (B10 and B20) which demonstrated significant increase in FTP presenting 158% enhancement over diesel. A combination of abrasive and adhesive wear was noted.

Keywords: bio diesel, Simarouba glauca, four ball tester, nanoparticles, run in time, flash temperature parameter.

1. INTRODUCTION

Biodiesel application enhances the durability engine components, specifically fuel injection equipment and high pressure fuel pumps which are lubricated by fuel itself. Also a number of unattended biodiesels like Simarouba glauca need to be analyzed in this context. Numerous researchers have employed a variety of nanoparticles to impart better tribological attributes to lubricant oils.

2. METHODOLOGY

The Bio diesel used for this work was extracted from Simarouba glauca seeds and made by transesterification process. The Copper oxide (CuO) nanoparticles were separately mixed in the base oil (SGME) with quantity of 0.2, 0.25, 0.75 and 1% wt.

Blends of SGME and additivated SGME in diesel were made with 10%, 20% and 30% amount by volume. Overall sixteen samples were prepared. The tribological tests were conducted on a four ball tester according to ASTM D4172. Wear rates were estimated in terms of the average WSD of the three lower specimens. The friction coefficient was noted in real-time. The run in time and FTP were estimated from COF vs. Time graphs and WSD values respectively [20].

3. RESULTS AND DISCUSSION

All the amounts of CuO exhibit the decrease in run in time as the biodiesel percentage goes on increasing. CuO proves to be the best option of for B20 and B30 blends. Increase in the percentage of nanoparticles beyond 0.75% is not seen to be beneficial as the run in time increases for B20 and B30 blends. The beneficial combinations are 0.75% (B20 and B30), which give lowest run in time. 1% combination shows the highest increase in the FTP. The beneficial combinations are 1 % (B10), 0.5% (B10 and B20) as well as 0.5 % (B20), which give appreciable increase in FTP.

4. CONCLUSION

Based on these pioneering investigations on SGME (as per the literature survey) following conclusions can be drawn.

Rise in the percentage of nanoparticles does not show the drop in run in time consistently, but the increase in

biodiesel percentage shows good and nearly consistent behavior with respect to decrease in run in time.

Biodiesel blends with addition of nanoparticles show low run in time giving satisfactory run in process as compared to pure diesel.

All the nanoparticle percentage combinations prove to be beneficial exhibiting the increase in FTP as their percentage goes on increasing. Increase in the percentage of nanoparticles shows the increase in FTP more consistently than increase in biodiesel percentage.

Biodiesel blends with addition of nanoparicles consistently show high FTP giving acceptable behaviour as compared to pure diesel.

5. DECLARATION

The work has not been presented elsewhere or not being considered for presentation in any journal

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Addition of surfactant in CeO_2 nanoparticles and its synergistic effect on diesel fuel (ID:T041)

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Abstract: The depletion of conventional fossil fuels, due to their enormous consumption. The rising prices, strict emission norms regarding pollution and ever-increasing environmental issues leads to the human kind to develop an alternative sustainable energy for automotive engines.

The present research focuses on production and testing of surfactant modified nano-fuel derived from cerium oxide nanoparticles with conventional diesel fuel. The experimental investigation chronicles the synthesis of cerium oxide nanoparticle by precipitation method. In the first phase of work, the surfactants were prepared and synthesized with cerium oxide nanoparticles. These are then characterized using advanced techniques like TEM, SEM and EDS. Secondly, diesel fuel is mixed with surfactants modified nanoparticles at definite proportion.

Experimental investigation was carried out to study the engine performance and emission parameters of a single-cylinder four stroke diesel engine. The results from the current study envisages that the addition of nanoparticles into the diesel fuel shows negligible effect in efficiencies but the results are better for the surfactant added nanoparticle blends. The nano-fuel was beneficial to improving the mixing of air and fuel due to the presence of oxygen content in the nanoparticles. The metal-based nanoparticle additive is beneficial to improving performance and decreasing the CO, NOx and HC emissions. As well as the surfactant added nanoparticle additives in the blend fuels can further improve the overall combustion quality and decrease the emissions.

Keywords: nanoparticle; precipitation; surfactant; addictive; fuel

Comparative study of thermo-physical and tribological properties of coconut oil based nano lubricant using CuO nanoparticle and MoS_2 nanoparticle (ID:T040)

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Abstract: In this research the thermo-physical and tribological properties of coconut oil based bio lubricant using CuO nanoparticle and MoS_2 nanoparticle with surfactant modified are compared and studied. We can see that the thermo-physical properties increased more for coconut oil lubricant with MoS_2 nanoparticle than with the addition of CuO nanoparticle. The tribological properties of both the nano particle are studied with pin on disc tribometer. The friction-reduction and anti-wear properties are studies in both ambient and elevated temperature. For the result with MoS_2 nanoparticle with surfactant modified at elevated and ambient temperature on the pin-on-disc tribometer, there is improvement in anti-wear and friction reduction properties than with CuO nanoparticle. The wear scar analysis are carried out using FESEM. There is an improvement in thermo-physical properties using both the nanoparticles.

Keywords: Anti-Wear, Bio lubricant, Nanoparticles, Surfactant

Tribological properties of h-BN additivated lubricants (ID:T008)

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Abstract: Lubricants move the world forward. From manufacturing, to transportation, to entertainment, lubricants are a critical factor in all industries and affect every life on the planet in multiple ways every day. For this reason lubricants are one of the fastest evolving and most researched technologies in the world. This rapid evolution has caused lubricants to take many different forms and has forced them to diversify to meet changing environmental standards as well as tighter mechanical tolerances. One of the newest variants on an old type of technology is hexagonal boron nitride (h-BN), commonly called a ceramic lubricant. The present work summarizes the possibility of using h-BN as a solid lubricant in lubricants. Recent developments in nanotechnology have allowed h-BN to be emulsified with high quality engine and gear oils. The molecular structure of h-BN is that of layered lattice, covalently bonded hexagonally with the different layers having weaker Van der Waals bonds. h-BN micro particles have excellent metal adhesion and are able to be dispersed throughout an engine, gear, or bushing in standard oil. As the h-BN particles flow through the lubrication system some of the particles settle or are forced into contact with the metal surfaces where they then coat that surface. Thus, the tribological properties of h-BN added lubricants has been reviewed in this work.

Friction and wear behaviour of non edible oil based lubricant (ID:T042)

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Abstract: Degradability and disposal of mineral lubricants are the two challenges the industry is facing in recent years. In addition, strict norms against environmental degradation embedded by the government have led researchers to think of an alternative lubricant which is non toxic and biodegradable. In this context, the present work is undertaken for the production, characterization and properties of the non-edible oil based lubricant. Transesterification process will be performed for biolubricant production. Fatty acid profile of the biolubricant is determined using Gas Chromatography-Mass Spectroscopy analysis. Formation of ester in biolubricant will be confirmed by FTIR method. The properties of the biolubricant will be done as per ASTM standards. Friction and wear characteristics of the blended biolubricant will be performed as per ASTM D1472 using Ducom TR30L four ball tester under a normal load of 15 kg and 40 kg running at constant speed of 1200rpm for 3600s. Finally, a comparison will be made to study the coefficient of friction and wear behaviour between different blends of SAE15W40 and biolubricant.

Flash temperature of sliding contacts - a comparative study (ID:T047)

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ABSTRACT: Solid friction and related frictional heating are considered to be generated within the real area of contact between two machine elements in relative sliding motion. The frictional heating process is originated by a few micron-scale interactions with the top interacting layers of the contacting machine elements, and most of the energy dissipation takes place in the bulk solid under the contact region by plastic deformation process. Frictional heating and the resulting contact temperature rise with sliding velocity can have a significant effect on tribo-failure of machine elements. Flash temperatures at the contacting asperities and near-surface temperatures can reach high enough to trigger changes in the microstructure and properties of the sliding materials possibly due to oxidation of the surface and melting of the contacting bodies even. The present work emphasizes to predict and compare *flash temperature rise* for specific pairs of materials, having with/without significant variation of thermal and mechanical properties, using existing contact temperature models. Specific to the chosen two different sliding pairs of materials and operating condition, the maximum computed variation of *flash temperature rises* amongst the five different analytical models is around a factor of 1.58. The *flash temperature rises* for all the individual models increase almost linearly with the increase of sliding velocities from 1 ms^{-1} to 3.0 ms^{-1}. The normalized *flash temperature rise* as well as the heat partition factor decrease with increasing Peclet number.

KEY WORDS: Contact temperature; Flash temperature; Heat partition factor; Peclet number; Sliding velocity

Surface morphology studies in end milling of AA7075 under MQL environment using Tri-hybridized carbonaceous nano cutting fluids (ID:T048)

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Abstract: Increasing need in quality of production and minimizing costs in end milling process has paved the way for green machining. To sustain this machining environment, concern on ecosystem and health of worker, minimization and elimination of cutting fluids is an important aspect to be considered. Therefore, this work aims in exploring the feasibility of some carbonaceous nano-particles dispersed in coconut oil as the base fluids. In this case, Multi-walled carbon nanotubes (MWCNT), Hexagonal Boron Nitride(h-BN) and Graphene nano particles were dispersed in both individual and tri-hybridized condition in base fluid. Further, the surface morphology of both chip and machined surface was observed from AA7075 subjected to an end milling operation in a vertical milling machine under Minimum Quantity Lubrication (MQL) environment. In addition, the rheological properties like thermal conductivity, viscosity and density was studied to find the scientific performance correlation. The results obtained from the experiments confirm that the tri-hybridized carbonaceous nano lubricant has reduced the cutting force, tool wear and surface roughness when compared to monotype nano fluids. The SEM images of the surface and tool was studied and it was found that the surface quality was maintained while end milling with tri-hybridized carbonaceous nanofluid. Thus, the present work indicates that the additivity of carbon-based nano particles with coconut oil has offered better performance and found to be a credible alternative to existing conventional cutting fluids. An improvement of 12%, 16% and 21% was found in reduction of cutting forces, surface roughness and tool wear was observed.

Keywords: *End milling; MQL; Carbonaceous nanofluids; Tri-hybridization; Surface Morphology*

Formulation and tribological evaluation of vegetable oil based grease (ID:T072)

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Abstract: Greases is a semi-solid type of lubricant which is a combination of base oil, thickener and additives. They are applied in between the metal contacts to reduce frictional resistance. The most common base oil used for commercially available greases are mineral oils. These mineral oil based greases are considered to be highly toxic and non-biodegradable in nature. The excess usage of these non-biodegradable greases in the industry are causing environmental problems and human health issues. Researchers are suggesting vegetable oils as an alternative to these mineral oils. In this work, bio-grease was formulated using rice bran oil as base oil. Rice bran oil was selected due to its excellent lubricant properties and availability. The thickener commonly used for commercially available greases are lithium complex. The increase in industrial usage of lithium for electric vehicle battery has suddenly forced the grease manufacturers to find an alternative due to the scarcity of lithium. This work used calcium thickener which was obtained by mixing calcium hydroxide to 12-hydroxy stearic acid for formulating grease. The experimental study formulated two grease sample with different weight percentage of thickener. Whereas, the remaining grease formulation parameters were maintained constant for both the grease samples. The consistency and tribological results of the grease samples were measured as per ASTM standards. The experimental results obtained from the formulated calcium greases have indicated that the variation of weight percentage of thickener plays an important role on the evaluated properties.

Keywords: Bio-grease, Rice bran oil, Calcium thickener, Tribological properties, Consistency

Transesterification of blended vegetable oils as cutting fluids and prediction of cutting forces using machine learning techniques (ID:T073)

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Abstract: The majority of the lubricants, around 85% used nowadays are mineral oil-based. Several environmental and health hazards occur due to the excess use of these oils. The poor biodegradability of mineral oils pressurizes the industry to develop eco-friendly biodegradable lubricants. The biodegradability, renewability, low toxicity and excellent lubricating performance of vegetable oils are the main reason behind the use of vegetable oil as an alternate source of lubricants. Despite the above-mentioned advantages, vegetable oils have some disadvantages such as poor oxidation stability and pour point. Blending, chemical modification and additives can enhance the thermal stability, oxidation stability and other properties of the oil. Rice bran oil (RBO), Jatropha oil (JO) and blended RBO and JO (BRJO) are used in this study. Chemical modification of the base oils was done using the transesterification procedure. The tribological, physical and chemical properties of pure RBO and JO, BRJO, transesterified RBO and JO, transesterified BRJO (TBRJO) are evaluated as per ASTM and international standards. Performance test on the developed cutting fluid was performed on a lathe machine attached with a tool dynamometer and the cutting forces were compared with the commercial cutting fluid. Cutting forces were also predicted using Machine Learning techniques and are compared with the experimental values. The error between the predicted values and the experimental values are evaluated using statistical error analyzing techniques. It was found that the 1:1 blend of RBO and JO after the transesterification has shown better COF and oxidative stability when compared with pure oil.

Keywords: Transesterification, Blending, Bio-cutting fluids, Machine learning

A comparative study on the tribological performance of solid lubricants over PEEK polymer (ID:T074)

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Abstract: Polyetheretherketone (PEEK) and its various composites possess a wide range of utilization in various industries like automobile, mechanical and aerospace and are continually replacing metals in Tribological and Structural applications due to sound mechanical and chemical resistance characteristics. Even though PEEK material having inherent young's modules and creep behaviours among the polymer group, it exhibits very high co-efficient of friction which limits its utility as an antifriction material. The effect of the solid lubricants hBN and PTFE with PEEK polymer in equal concentrations was studied based on dynamic mechanical behavior and their tribological properties. The Tribological properties of virgin PEEK, PEEK fortified with 10% Polytetrafluoroethylene (PTFE), along with PEEK reinforced with 10% hexagonal Boron Nitride (h-BN) are compared and analysed in this study. Twin screw extrusion production method is preferred for the preparation of specimens. The tribological properties were compared with the help of Pin on disc tribometer test in which each material was tested for about 6 km under varying loads of 25N, 50N, and 100N. The Dynamic mechanical properties were compared with the Dynamic Mechanical Analysis (DMA) analysis in which each of the materials was tested under the same testing conditions. Both the Tribological properties and the Mechanical properties of materials were tested as per ASTM standards. It was found that PEEK with hBN was better at the wear rate under a few conditions, but PEEK with PTFE was found to better overall. It can be seen that adding solid lubricants to PEEK polymer does improve the wear rate.

Keywords: PEEK, PTFE, hexagonal Boron Nitride, DMA, Wear rate, Coefficient of friction

Wear Behavior of Alloys and Composites

Cavitation erosion behavior of MoNbTiZr medium entropy alloy (ID:T045)

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Abstract: Cavitation erosion poses significant challenges to the engineering materials used in hydraulic machinery, hydraulic turbines, ship propellers, etc. The devastating characteristics of the cavitation erosion lead to an increased loss in efficiency and the service life of the components resulting in a significant economic impact. The present work focuses on a prospective equimolar medium entropy alloy (MEA) MoNbTiZr as a potential candidate for limiting cavitation erosion. For comparison, conventionally used SS316L stainless steel, and Ti6Al4V alloys were also investigated. The MEA was composed of a BCC lattice. Further, the microstructure showed the presence of a typical dendritic structure. The detailed analysis also showed different intermetallic phases, as confirmed by x-ray diffraction and energy dispersive spectroscopy studies. The microhardness was measured for MEA (435 HV) was higher than 220 HV, and 335 HV was measured for SS316L and Ti6Al4V, respectively. Similarly, the MEA also showed higher yield and tensile strengths. Under cavitation erosion studies performed using vibrating horn showed significantly higher resistance to cavitation erosion. The cumulative volume loss measured for the MEA was almost 10 times lower than that observed for SS316L and Ti6Al4V. The eroded surfaces showed pits, striations, and fatigue signatures. The better cavitation erosion resistance of the MEA is attributed to higher hardness, tensile strength, and better strain-hardening ability compared to the conventional materials. The results showed that the MEA composition possessing superior cavitation erosion resistance is a potential candidate for improving the efficacy of the fluid machines.

Keywords: cavitation erosion, medium entropy alloy (MEA)

1. INTRODUCTION

Cavitation erosion is a result of bubbles formation when the liquid pressure drops below its vapor pressure followed by subsequent collapsing on the material surface. This results in generation of micro-jets and shock waves which causes material removal from solid surfaces. The cavitation erosion possess a significant challenge to the engineering materials used in hydraulic machinery, turbines, ship propellers [1-2]. The present work explores a new medium entropy alloy (MEA) composition for countering cavitation erosion problems.

2. METHODOLOGY

The MoNbTiZr medium entropy alloy was cast using arc-melter in presence of Ar. The cavitation erosion studies were conducted using an ultrasonic vibrator in indirect mode. Prior testing, samples were polished down to 2000 grit size. The mass loss was measured each hour using a precision weighing balance. For comparison, conventional structural materials SS316L and Ti6Al4V were also tested. The testing parameters are listed in Table 1.

Table 1 Slurry erosion setup parameters

Parameters	Value
Stand-off distance	500 µm
Frequency of tip	20±0.5 kHz
Medium	Distilled water
Duration	20 hr

3. RESULTS AND DISCUSSION

The MEA was composed of BCC crystal lattice with the microstructure showing typical dendrites. The presence of different intermetallic phases was also observed. The MEA showed a microhardness of 435HV.

The cavitation erosion results shown in Fig 1 indicates significantly high erosion resistance of MEA. The total

cumulative volume loss (CVL) measured for the MEA after 10 hrs was almost 10 times lower than that observed for SS316L and Ti6Al4V.

The better cavitation erosion resistance of the MEA is attributed to its higher hardness, tensile strength, and better strain-hardening ability compared to the conventional materials. The analysis of the eroded surfaces showed the presence of pits, striations, and fatigue signatures.

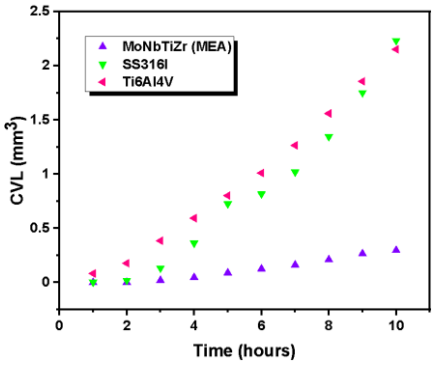

Fig 1: The cumulative volume loss (CVL) of different materials as a function of exposure time under cavitation erosion

4. CONCLUSION

This study has shown that MEA possesses significant cavitation erosion resistance than conventional materials and hence is a potential alternative for improving the performance of many engineering systems.

5. DECLARATION

The work has not been presented elsewhere or not being considered for presentation in any journal.

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Erosion wear behaviour of A357/fly ash composites (ID:T053)

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Abstract: In this present study, the erosion wear behaviour of A357/fly ash composites was investigated. The developed composites were prepared through squeeze casting technique with different weight percentages of fly ash (0, 2.5, 5, 7.5, and 10). The erosive wear experiment was carried out with the help of air jet erosion tester with different impact velocities (48, 70, 82, 109 m/s), impingement angles (30, 45, 60, 90) and silica (300 µm) having angular shape as erodent particle. The effect of impact angle and impact velocity on the erosion rate of the composites were studied and discussed. The results revealed that the erosion rate of the composites increases with increasing impact angle up to certain angle after that it starts decreasing. The matrix alloy shows high erosion rate at 45º whereas A357/fly ash composites display greatest erosion rate at 60º impact angle, indicates semi ductile behaviour of the composites. The minimum erosion rate was obtained at 10 wt. % of fly ash composites as compared with other composites. The eroded surface of the matrix alloy and composites was examined by scanning electron microscope (SEM) to study the eroded surface texture.

Keywords: A357 matrix alloy, fly ash, erosive wear, impact velocity, impingement angle, erosion rate, SEM, squeeze casting

1. INTRODUCTION

Erosive wear occurs due to continuous impact of solid or liquid particles on the target with some velocity for very short time period. This results in loss of the materials in various industries such as chemical plant, propeller system, coal gasification, and aerospace engine. Despite of the material loss in the erosive wear, it has great advantage in various situations like sand blasting of casting, cutting of hard and brittle materials (Summers, 1979).

The present work is to investigate the erosion wear behaviour of Al357/fly ash composites under steady-state conditions.

2. METHODOLOGY

A357 used as matrix, obtained from the local market. It consists of 7.5% silicon, 0.07% beryllium, 0.2% iron, 0.2% copper, 0.7% magnesium, 0.2% titanium, 0.1% zinc and 0.1% manganese and balance is Al. In the present study, fly ash used as reinforcement and was procured from National power Engineers, Kolkata. Fly ash is waste by-product of power plants. It is a heterogeneous material, consists of SiO2, Al2O3, FeO3 and CaO. Fly ash particulates of 250 µm were incorporated into A357 matrix alloy molten metal in varying concentration of 2.5 wt.% c/s, 5 wt.% c/s, 7.5 wt.% c/s, and 10 wt.% c/s by squeeze casting method. Erosion test was carried out at ambient temperature using ASTM G 76 standard air jet erosion test rig. The specimen was weighted before and after the experiment after a thorough cleaning with cotton dipped in acetone. The test was carried out for a fixed period of 60 min (six test cycles were performed with a period of 10 minutes) when all the specimens are in a steady-state condition.

The erosive worn out samples were examined by field emission scanning electron microscope.

3. RESULTS AND DISCUSSION:

Effect of impingement angle on erosion rate: The erosion rate of the composites increases with increasing impact angle up to certain angle after that it starts decreasing. But for the matrix alloy, the erosion rate drops with increasing impact angles. The erosion rate attains a maximum value at 45° impingement angle for matrix alloy. Whereas, the peak erosion shifts from 45° to 60° for (2.5 wt.%, 5 wt.%, 7.5 wt.%, and 10 wt.% fly ash) for all the velocities. However erosion rate attains a peak value at 60° impingement angle for reinforced composites.
Effect of impact velocity on erosion rate: The steady-state erosion rate of all unreinforced and reinforced composites increases with increase in impact velocity. The least-square fits to data point were obtained by using power law.

4. CONCLUSION:

The wear rates of all samples were higher at higher particle speed.

The A357/fly ash composites behave as semi-ductile in nature.

The SEM studies revealed that the main mechanism of material removal for the composites was micro ploughing and micro cutting.

5. ACKNOWLEDGEMENT

We are thankful to the authorities of NIT Rourkela, India, for providing facility for carrying out this research work.

6. DECLERATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Machine learning approaches for analyzing tribological behavior of aluminium matrix composites (ID:T064)

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Abstract: Two different machine learning approaches, viz. artificial neural network (ANN) and genetic programming (GP), have been employed to analyze the tribological behavior of alumina reinforced aluminium matrix composites (AMC). The learning by the two techniques has been compared towards the role of the input variables in determining the tribological properties of the composite. It has been found that among the alloying elements, Cu, Mg and Mn pay significant role to enhance tribological properties of AMC. In addition, the suitable range of alumina addition has also been determined.

Keywords: Aluminium matrix composite, Coefficient of friction, Wear rate, Artificial neural network, Genetic programming.

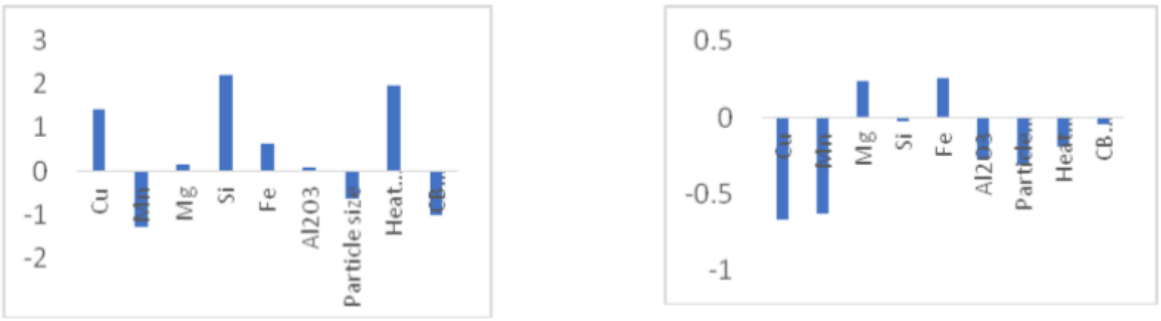
1. INTRODUCTION

Aluminium alloy has found wide applications due to its high strength-to-weight ratio with adequate ductility. A constant effort is noticed in design and development of Al composits to meet the need in transport industries. Since wear is a complex phenomenon with nonlinearity, it is hardly possible to capture the entire process in an analytical platform. In handling such situations, data driven models are successfully employed to explore solutions of such problems [1-4]. The objective of the present work is the creation of two sets of data driven models by different machine learning approaches to analyze the tribological behavior of the AMC. Learning by the two techniques, ANN and GP, are compared.

2. METHODOLOGY

Around 500 data of last forty years were acquired from published papers. In this work, a multi layered feed forward type architecture is used, trained with scale conjugate gradient back propagation method. In GP modeling the same database is used. The evolving structures in GP are hierarchically well organized with the aid of mathematical expressions, size and form of which change dynamically in a process of simulated evolution.

3. RESULTS AND DISCUSSION



(a) *(b)*

Fig. 1: Sensitivity analyses from the ANN models of (a) wear rate and (b) COF

Table 1: Models generated by genetic programming

Properties	GP Models
Total Elongation	$\left((10.2209 + Amt) * \left(\frac{Mg}{Amt}\right)\right) + ((Si + Amt) + Heat)$
Wear Rate	$((Amount * Mn) - (Cu + Load)) * \left(\frac{0.2298}{Cu}\right)$
Coefficient of friction	$\left(\frac{Cu}{Cu - 3.8998}\right) + \left(\frac{Amt/SV}{Cu - 0.3287}\right)$

The sensitivity of wear rate and coefficient of friction (COF) shown in Figure 1 and the GP models shown in Table 1 have some similarity. In some cases, they are dissimilar. In case of nonlinear models it is not possible to compare two different models for all parameters.

4. CONCLUSION

(i) Both ANN and GP are capable to develop transparent data-driven models having properties of complex MMC system. (ii) In composites having superior tribo-mechanical performance Cu, Mg and Mn play the most important role. (iii) The suitable range of alumina addition has also been determined

5. DECLERATION

The work has not been presented elsewhere or not being consideration for publication in any journal

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Dry and wet tribology of carbon nanotubes under Al/steel and AMMC/steel sliding contacts (ID:T079)

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Abstract: In recent years carbon nanotubes (CNTs) is getting huge attention from the tribologists worldwide, due to its outstanding intrinsic properties. Several studies had reported that the CNT can be a potential friction and wear reducing agent that can be used as reinforcement, lubricant additive or as protective film. However, the scope and the potential of CNTs for the lightweight tribological applications and the underlying friction-wear mechanism of CNT are yet to be explored to realize its commercial viability. Hence, a comprehensive tribological investigation is inevitable to explore to the underlying tribo-mechanism of CNT for such types of contact. The present study is focused on the friction-wear performance of CNT and the underlying tribo-mechanism thereof for the Al/Steel and AMMC/Steel tribo-contacts. The tribological characteristics are evaluated for both dry and wet sliding conditions. For this purpose CNTs had been used as the dry lubricating agent, lubricant additive, and as the reinforcement for the composite. The results indicated that the CNTs exhibit the excellent tribological characteristics under the lubricated contacts, as compared to the other modes of sliding conditions. Based on a separate investigation on the prepared suspensions, it is observed that the rheological, thermophysical, and structural configuration of stressed CNTs are responsible for the improved tribological behaviour.

Keywords: Carbon nanotube, AMMC, Additive, Functionalization, Tribology

1. INTRODUCTION

From the last few decades, the use of solid additives to enhance the lubricating oil properties has been gaining immense interest. Recently, CNTs have gained unusual attention amongst the tribologists aiming to reduce the friction and wear of sliding surfaces, as shielding (or protective) film and even in metal matrix composite to fulfil the functional requirements of various tribological applications [1-5]. Most of the particle based liquid lubricants are formulated and optimized for contacts other than composites. Aluminium metal matrix composites (AMMCs) have established their visibility as fine alternatives to aluminium monolithic and its alloys. Although, some tribological studies are available involving CNT as a potential oil additive, yet most of these studies are carried out for steel-steel tribo-contacts. The present study is focused on the friction-wear performance of CNT and the underlying tribo-mechanism thereof for tribologically severe Al/Steel and AMMC/Steel tribo-contacts.

2. METHODOLOGY

In the present investigation, Aluminium alloy-Al6061 is used as a base matrix and SiC along with of graphite is used as reinforcing materials, for the fabrication of hybrid composite (h-AMMC) via a low cost and reliable stir-casting technique. MWCNT-in-oil dispersions were prepared using ultrasonication process. The tribological performance of CNT is assessed for dry particulate-lubricated and oil-lubricated sliding conditions under the Al/Steel and h-AMMC/Steel contacts. Comparisons of tribological performance of these contacts are also made with that of CNT-reinforced AMMC. All friction-wear tests were performed using a pin-on-disc type tribometer.

3. RESULTS AND DISCUSSION

The friction-wear responses under the various contacts are shown in Table 1. It can be seen that the MWCNT remarkably enhances the antifriction and antiwear capabilities both for Al/steel and h-AMMC/steel contacts, however, the effect being more prominent in case of composite contacts.

4. CONCLUSION

From the present study it is observed that MWCNT can lower the coefficient of friction and specific wear rate for Al/Steel by 49% and 92%, respectively, as compared to fresh oil condition. On the other hand, it can influence in the reduction of friction and wear rate by approx. 38.3% and 80%, respectively, for the composite-steel contact. It is also observed that self-lubricating MWCNT-reinforced AMMC performs inferior to that of tribological performance depicted by the MWCNT-in-oil lubricant under composite contact.

Table 1: Average coefficient of friction (μ) and specific wear rates (SWR) for various conditions.

Test condition	**μ**	**SWR (mm^3/Nm) $x10^{-4}$**	**μ**	**SWR (mm^3/Nm) $x10^{-4}$**
	Al/Steel contact		h-AMMC/Steel contact	
Unlubricated	0.410	7.070	0.269	1.560
Dry MWCNT lubricated	0.122	5.473	0.084	0.0045
SN500	0.099	1.233	0.060	0.0041
SN500+MWCNTs	0.050	0.096	0.037	0.0008
MWCNT-reinforced AMMC			0.201	0.2049

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Effect of reinforcements on graphite/ TiO_2/ Al nanohybrids composites (ID:T091)

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Abstract: Aluminium alloys and their composites are often used in aerospace, automobile and biomedical applications. However, mechanical and surface properties of those alloys have not reached up to the expectation. This investigation focused to improve the wear properties along with structural and surface properties of aluminium based materials by physical and mechanical tests. Here, we have developed the novel aluminium matrix hybrid composites using titanium oxide and graphite as reinforced using powder metallurgical route. The sintered samples were analysed by different tests such as, hardness, surface roughness, wear tests and other structural analyses. The obtained results showed that some new compounds formed during sintering were responsible for improved mechanical and surface properties for different applications. The wear test showed that there was rapid graphite worn out from the composites, where Al-matrix of 75 and 50 wt%, due to the high content of graphite (10 and 20wt%, respectively). In addition, due to the increase of porosity in the different hybrid composites there was an increase in coefficient of friction observed. Therefore, optimized hybrid composites with proper sintering condition would significantly help to get suitable structural, mechanical as well as tribological properties for many advanced applications.

Keywords: Hybrid composite; Porosity; Wear; Aluminium; Titania

1. INTRODUCTION

Wear properties of aluminium (Al) matrix composites is a huge challenge to the several industries. The main advantages of the particle reinforced aluminium-matrix composites (AMCs) are the wear properties can be controlled, the creep behaviour tendency gets lower, and so on. These composites are used as abrasive in high speed machining tools and as heat shields in the aerospace applications [1]. Several reinforcements, recently graphene or graphene oxide, are being tried by many researchers to Al-matrix for improving their wear properties [2,3]. But still the result is not up to the expectation till date. Therefore, the present study aimed to improve the physical and wear properties of the Al-MMCs by making nanohybrid composites.

2. METHODOLOGY

The aluminium matrix hybrid composites were developed with different combinations of titanium oxide and graphite reinforcement using powder metallurgical route followed by step-sintering at 650°C/2h at a rate of 10°C/min and around 900°C/1.5h.

3. RESULTS AND DISCUSSION

Density was found to decrease for all the hybrid composites after sintering process. The hybrid composites having composition 80, 15, and 5 wt% of Al, titania and graphite, respectively showed best wear resistance properties but moderate density and optimum hardness compared to other compositions of the present nanohybrid composite systems.

4. CONCLUSION

The hybrid composites having composition 5 wt% graphite has shown lowest wear rate due to the formation of carbides and the graphite in other batches wear out rapidly. Thus, the coefficient of friction for the hybrid composites would increase as the graphite increase since the porosity of the other hybrid composites increased. Therefore, optimization of compositions of hybrid nanocomposites with proper sintering condition would significantly help to tune the structural, mechanical as well as tribological properties for many advanced applications from automobile to aerospace industries.

5. ACKNOWLEDGEMENT

Authors acknowledge Department of Mechanical Engineering, Nanotechnology and Research Centre (NRC), Physics and Nanotechnology, SRM Institute of Science and Technology, Kattankulathur.

6. DECLERATION

Authors declare that the present work has not been presented elsewhere or not being consideration for presentation in any journal.

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The effect of sliding speed on dry sliding wear behavior of A356 alloy with minor additions of magnesium (ID:T100)

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Abstract: In this paper, the effect of sliding speed on dry sliding wear performance of A356 alloy without and with 0.7%Mg were studied. Commercial Al-20%Mg master alloy was used for strengthening of A356 alloy. Master alloy and the worn surfaces of wear specimens were characterized by image analyzer and SEM/EDX. Results suggest that the wear rate of A356 alloy decreases with increasing sliding speed and shows less wear rate for 0.7%Mg addition to A356. Change in microstructure, improvement in mechanical properties and formation of oxide layer between the mating surfaces leads to improvement in wear properties of A356 alloy.

Keywords: Wear rate, Sliding speed, A356 alloy, Worn surface, Magnesium.

1. INTRODUCTION

The wear behaviour of Al-Si alloys is linked with material related mechanical properties, microstructure & service conditions [1]. A. T. Joenoes and Gruzleski [2] in their study on the A356 (Al-7%Si) alloy with minor addition of Mg, concluded that with higher addition of Mg to Al-7%Si alloy results in the formation of Mg_2Si phase [3] and the final structure consists of a fine lamellar and even possibly a fibrous structure. In the present work, an attempt has been made to study the effect of sliding speed on the wear behavior of A356 alloy with and without Mg addition and to correlate with microstructure and mechanical properties.

2. METHODOLOGY

A356 alloy was melted in a resistance furnace under a cover flux and the melt temperature kept at 720^0C. Degassing is done with solid C_2Cl_6,. Al-20%Mg master alloy chips were added to the melt. The melt was stirred for 30 sec with zirconia-coated iron rod. Melts were poured at '0'min. and '5'min. into a split type graphite mould for preparing wear & tensile specimens. The '0' min. refers to the melt without the addition of Mg. The size of the wear test pin taken was 10mmϕ X 32mm length (ASTM G99 standards). A pin-on-disc wear test machine was used. The disc material is En-31 steel with a hardness of HRc45. A constant 90mm track dia. was used. An analytical balance with a precision of 0.0001g was used to measure the weight of the pin before and after the each test. The wear rate was calculated from the weight loss method.

3. RESULTS AND DISCUSSION

The effect of Mg addition on the wear rate under varying sliding speeds are shown in Fig.1. It shows decrease in the sliding speed from 0.942m/sec to 3.768m/sec, this decrease in wear rate is for both the case of treated and untreated A356 alloys. The reason for this is that, at lower sliding speeds, time available is more for the formation and growth of micro welds, resulting in increase in the force required to shear off the micro welds to maintain the relative motion, due to which wear rate increases. At higher speeds, there is less residential time for the growth of micro welds leading to lower wear rate and this supports the earlier work of Sarkar [4].

4. CONCLUSION

Wear rate of A356 alloy decreases with increase in sliding speeds. Wear rate of A356 alloy with 0.7%Mg addition is less when compared to as cast conditions under varying sliding speeds. Increased hardness, strength of A356 alloy results in improved wear resistance. Change in microstructure and formation of iron-oxide layer between the mating surfaces controls wear & friction surfaces in the present study.

5. ACKNOWLEDGEMENT

Ministry of Defense, Naval Research Board (NRB), New Delhi, INDIA.

6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Wear performance analysis using worn surfaces of different aluminium alloy composites- A comparative study (ID:T090)

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Abstract: This work is based on wear mapping of three different LM25 alloy composites reinforced with fibrolite, boron carbide, and silicon nitride. The percentage reinforcement of the three ceramic particulates in each composite is 8%wt. The three composites were prepared using the stir casting method. The wear tests were carried out under dry sliding conditions using a pin on disc apparatus for ASTM G99 standards. The disc is made of steel EN31 of 165 mm in diameter and 8mm thickness. Aluminum alloy LM 25 casted composites were used as pin specimens of 12 mm diameter and 32 mm length. The worn-out surfaces obtained from the pin on disc wear test were subjected to SEM analysis in order to analyse the wear mechanisms caused by the abrasive medium. The worn surface analysis at constant sliding velocity and varying loads of 19.62N, 38.24N, and 58.84N is carried to find its significance on the alloy and the composites' wear behaviour.

Keywords: LM25, loads, abrasion, worn surface, wear, sliding wear.

1. INTRODUCTION

Global research in the last decade in the area of metal matrix composites (MMCs) has brought to the forefront the advantages of Aluminum matrix composites (AMCs) among all the other base alloys such as copper alloys, magnesium alloys, etc. The unique mechanical properties of AMCs have made them as the most widely used engineering composite in different parts of mobility engineering applications, from ship hulls to automobile pistons, cylinder heads, clutches and brakes, etc. AMCs are preferred because most of these components are in surface contacts and AMCs exhibit excellent wear properties, they are tough and maintain their strength at elevated temperatures. In most of the applications wear is generally abrasive in nature. Abrasive wear is defined as the displacement of the material caused by hard particles or protuberances where these particles are forced against and moving along a solid surface. It has been reported that the wear behavior of composite depends on microstructural parameters like shape, size, volume fraction, and distribution of the reinforcement and the experimental parameters like abrasive size, applied load, sliding distance, etc. A number of fabrication techniques such as stir casting; squeeze casting and powder metallurgy are available for the development of aluminium matrix composites. Among them all, stir casting is one of the most elementary and cost effective method to fabricate AMCs. Baghchesara et al. [1] fabricated aluminum composites reinforced with nano magnesium oxide powder by stir casting and powder metallurgy process and microstructural results observed more porosity in composites fabricated by powder metallurgy. Kandpal et al. [2] suggested that the quality of fabricated composites by stir casting can be highly improved by controlling stirring temperature, stirring speed, stirring time, preheating time etc. Singh and Rai [3] fabricated aluminium alloy composites reinforced with preheating boron carbide at 650°C for one hour in order to remove moisture and gasses and high drop temperature after mixing. The significant challenges in the stir casting process are a uniform distribution of the reinforcement particles, wettability, porosity, erosion of the stirrer blades and reinforcement mixing rate [3]. Wettability of reinforcement particles with aluminium matrix can be enhanced by adding wetting agent. Magnesium is the most common using wetting agent and suggested to add about to 1-2% by many researchers [4]. This paper aims to examine the effect of different loads on LM 25 matrix reinforced with three different reinforcing materials namely fibrolite, Silicon Nitride and Boron Carbide. Fibrolite is fine-grained, acicular high-temperature variety of Al_2SiO_5 with a density of 3.24 g/cm^3. Silicon Nitride is a thermally stable ceramic with a density of 3.16 g/cm^3. Whereas, Boron Carbide is a very hard mineral with a density of 2.5 g/cm^3. The three ceramics are chosen on the basis of increasing hardness on Moh's scale, fibrolite has a hardness of 6.5, Silicon Nitride 8.5 and Boron Carbide 9.5 respectively. The three sets of composites F1, S1 and B1 are fabricated with weight percentage of 8% and tested at 19.62N, 38.24N, and 58.84N under constant sliding distance and velocity. The worn surfaces were compared, analyzed and studied.

2. RESEARCH METHODOLOGY

The composites of the different reinforcing materials namely fibrolite, silicon nitride and Boron carbide with LM25 matrix were fabricated using stir casting technique. The method involves the melting of LM25 matrix with continuous stirring, followed by the addition of preheated reinforcement particles, namely F1, S1 and B1 at 400°C for 30 minutes. The furnace temperature initially was 450°C which was gradually elevated to 850°C. The next step involved pouring the melt into a preformed cavity, followed by cooling and solidification. Although, stir casting is an easy and economical technique for fabrication of composites, but a common problem is agglomeration of reinforcement particles. This problem can however be minimized by vigorous stirring at high temperature. For this investigation, the molten mixture was poured into cylindrical steel molds and allowed to cool and three sets of LM25 composites with weight fractions of 8wt% of F1,S1 and B1 were fabricated.This experiment was carried out under dry conditions and used ASTM G99 standards. This test was performed at constant sliding velocity and at various sliding distances with varying normal loads. The amount of wear was measured in terms of mass loss, for that, a weighing machine with the least count of 0.00001 g has been used—this pin-on-disc tribometer is equipped with a high-quality frictional sensor to give fractional force at the contacting surface. Each test is repeated three times for each composites sample to maintain accuracy. Acetone was use to clean the surfaces of the disc and composites pin before the commencement of the tests. To maintain uniformity the normal applied load, and relative speed of the disc were kept constant during the running period of the experiment. The disc was maintained at a fixed rotating speed, and the track diameter of the disc was fixed according to the requirement for each experiment. The normal load was applied by using a dead weight with the help of pulley wire system.The worn surfaces of the three set of composites were studied under scanning electron microscope.

3. EXPERIMENTAL

The LM 25 was first tested at each speed and the worn surfaces of the three set of composites at each sliding speed were compared with that of the base alloy. The sliding wear surface of the three set of composites at the speed of 1.93 m/sec and at the applied pressure of 0.2 Mpa is shown in Fig 3.2(a, b,c). The grooves are noted to be continuous and shallower as compared to the base alloy . The wear surface during seizure at this speed demonstrates severe surface damage for S1 and B1.The grooves become more defined when the speed increases (Fig 3.3)). It is also noted that at 5.5 m/sec and before seizure the damage of the surface is relatively low (Fig 3.3(c)) as compared to that at the lower speed (Fig 3.1(a)). However during seizure at this speed, the surface damage is more severe (Fig 3.4) as compared to that observed in Fig 5.30(b). Indications of particle fracturing were also observed in the composite as marked by the arrow in Fig 3.5.

4. RESULTS

Results of Dry Sliding Wear at Various Loads of LM 25 + 8% Reinforcement composite of Samples F1,S1 & B1.

5. CONCLUSION

Wear rate of the alloy and the composite depends on the applied load and the abrasive size. It is seen that at lower loads and finer abrasive sizes the wear rate of the alloy is more than that of the composite. However it was observed that this trend was reversed for higher loads with coarser abrasive sizes.

NOMENCLATURE

Al – Aluminium, MMC – Metal Matrix Composites, AMC – Aluminium Matrix Composites

SEM – Scanning Electron Microscope, wt % - weight percentage

Tribo-mechanical behavior assessment of magnesium based fibre metal laminates (ID:T026)

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Abstract : Fibre metal laminates (FML) play a significant role in the transportation industries. A novel attempt has been made in the present study to reveal the mechanical and tribological properties of the FML (Glass/AZ91D/Glass). The glass fibre used is of bi-diagonal fabric to enhance the shear properties of the FML. The laminates were prepared by hand layup technique, which was cured in the compression moulding machine. Mechanical tests such as tensile, compression, flexural, and low-velocity impact were conducted on the FML samples. The mechanical properties obtained by the Magnesium based FML are the tensile strength of 227.3 MPa, the compression strength of 124 MPa, the flexural strength of 231.3 MPa, a flexural modulus of 15618.5 MPa, and the energy absorbed by the plate was of 93.648 J, respectively, which were better than the conventional laminates. The wear rates were also found to be better than conventional laminates. The present work will be highly beneficial in material handling equipment.

Keywords: Fibre metal laminates, hand layup, tensile, compression, flexural, low-velocity impact.

1. INTRODUCTION

Composites play a significant role in the aerospace and defense sectors. These materials have many advantages over other metallic materials such as high strength to weight ratio and lightweight. Therefore incorporating a polymer layer and a metallic layer led to the novel attempt of fibre metal laminates. Quagliato et al. [1] studied the properties of FML where carbon fibre (woven type) was used as core material while steel was used as a skin layer. A three-point bending test was carried out, and it showed a rise of 48% improvement in its strength. Sharma et al. [2] investigated the tensile behavior of Al-GF-based FML. The strength of the FML was higher under high strain rates, which was due to the presence of metallic layers. Nallusamy and Karthikeyan [3] reveal the wear characterization of GFRP composites with granite powder. The filler material was blended with the matrix with varying concentrations of 0-5 wt%. It was concluded that the wear rate of the 5 wt% granite powder had a better wear resistance than the other composites' compositions. Ansari et al. [4] studied the wear and friction characteristics of CF with stainless steel wire mesh polymer composite. Pin-on-disc test was carried out on the CF/SSWM FML with high carbon alloy (EN31 steel) as a pin. It was concluded that when the load was increased from 10 to 40 N, the disc's wear rate also increases. The above literature discussed the fibre metal laminates and the gap was identified with Magnesium-based fibre metal laminates. Much work has not been reported on this type of FML. Therefore the current work deals with the mechanical and tribological properties of Mg-based FML.

2. METHODOLOGY

Magnesium based FML is made using the hand layup method. The materials used for this FML are Magnesium AZ91D cast alloy which is a high-purity alloy that has excellent corrosion resistance, excellent castability and good strength. As the name suggests, it is a combination of Aluminum and Zinc with 91% of Magnesium. Magnesium is one of the lightweight structural elements. Like aluminum, most of the place's Magnesium is used in the form of an alloy. Combining Magnesium with other metals or non-metals may become a great asset in a magnesium alloy. AZ91D sheet of 2mm thickness is the core, and bi-diagonal fabric of 0.5 mm thickness are placed above and below the Mg sheet in the form of three layers so that the thickness of the laminate is 5mm. Various tests such as tensile, compression, flexural, and low-velocity impact have been performed to study Mg-based FML's mechanical properties. Also, a pin-on-disc test is performed on the FML to know the wear properties of the laminate. The following section discusses the outcomes of the tests performed.

3. RESULTS AND DISCUSSION

The outcomes of the mechanical tests obtained by the Magnesium based FML are the tensile strength of 227.3

MPa, the compression strength of 124 MPa, the flexural strength of 231.3 MPa, a flexural modulus of 15618.5 MPa and the energy absorbed by the plate was of 93.648 J, respectively, which were better than the conventional laminates. Pin-on-disc test was carried out according to ASTM G99 standards. Wear was calculated using the weight-loss method, and the specific wear rate was calculated using the equation

$$Specific\ wear\ rate = \frac{\Delta m}{\rho\ x\ N\ x\ l}\ (mm^3/\ N\text{-}m) \qquad (1)$$

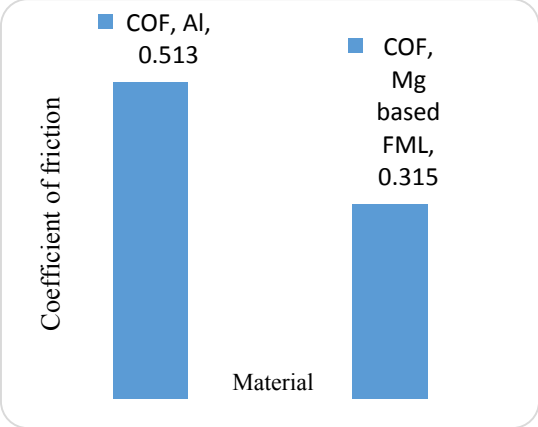

Fig 1 Coefficient of friction – Al, FML

The specific wear rate of the Mg-based FML is found to be $2.72x10^{-9}$ cm^3/N-m. Also, the coefficient of friction of Al and Mg-based FML is represented in Fig.1. It was found that the FML had less COF when compared to Al.

4. CONCLUSION

The mechanical properties obtained by the Magnesium based FML are such that its tensile and compressive strength was found to be 227.3 MPa, and 124 MPa, respectively. Its flexural strength is231.3 MPa, the flexural modulus of 15618.5 MPa, and the energy absorbed by the plate was 93.648 J, respectively. This FML is better than conventional laminates. The wear rates were also found to be better than conventional laminates.

5. ACKNOWLEDGEMENT

I want to thank the Tribology and Surface Interaction Research Laboratory, Department of Mechanical Engineering, SRMIST for utilizing the facility.

6 DECLARATION:

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Evolution of metallurgical mechanical and tribological behaviour of composites under dry and wet conditions (ID:T098)

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Abstract*:* Among all metal matrix composites, A356 is the most applicable matrix due to its low density and exhibits nominal strength with soft nature. This proposed study is concerned with examination of mechanical and tribological properties of pure A356 reinforcement with 10wt% power plant waste flyash particles composites were processed by liquid metallurgy stir casting technique. The fabricated composites expose enhanced higher hardness and compression properties due to existence of reinforcements. The wear behaviour of casted composites was tested in Pin on Disk tribometer apparatus under dry and wet sliding condition at the presence of lubricant (SAE 80W-90) by varying sliding load of 10N-40N and sliding velocity of 1-3 m/s respectively. Wear rate increase with the increasing load and sliding velocity. The usage of lubricant tends to decrease the wear rate by reducing the friction when compared to dry sliding method. This was ascribed due to lubricant and constructive embedding with bonding ability of flyash particles over the A356 matrix. This outcome shows the improved abrasion resistance and adhesive properties.

Keyword: Composites, Metallurgical Mechanical and Dry and wet Tribological behaviour.

1. COMPOSITE PREPARATION

By the method of liquid metallurgy the aluminium based matrix alloy and composites were prepared. First, for the preparation of pure alloy, a homogeneous liquid phase was obtained by melting the A356 alloy in form of ingots at a temperature of at 725°C. Then the molten metal was poured into a die which was preheated at 225°C and solidified pure alloy was obtained. Secondly, by adding 10 wt% of fly ash particles the composite was prepared. The particles were preheated in air at 600°C for 2 hours the vortex was created with the help of mechanical stirrer rotating at a speed of 400 rpm. Dispersion of flyash particles in the melt was carried at 725°C. The die steel moulds were preheated to around 250°C before pouring the melts. Then the liquid metal was poured into the pre heated mould and applied for squeeze pressure 140MPa for few minutes. Thus the composite specimen is prepared and ready for testing.

2. RESULT AND DISCUSSIONS

Microstructure and mechanical study

For this the A356 alloy and stir cum squeeze casted A356 reinforced with 10 wt% flyash were carried out by microscopy and scanning electron microscope. In this regard it is evident that A356 reinforced with 10 wt% flyash composite sample posses uniform distribution of flyash over the aluminium matrix and also no clusters were observed. The observed hardness was 58VHN for A356 alloy and 82VHN for stir with squeeze casted A356 reinforcement with flyash respectively.

Examination of wear rate

The wear rate of A356 metal matrix and stir cum squeeze casted A356 alloy with 10 wt% fly ash particles were examined in this study. When both the testing samples were subjected to wet sliding condition there were slight increases in the wear rate with varying load (10kN to 40kN). Thus, better results of wear rate were found under wet sliding environment than dry sliding condition. This attributes to the presence of lubricant SAE80w90. The existence of lubricant forms a thin film of friction resistance layer between counter surfaces of sample and pin on disk apparatus which paves way to reduction of acting frictional force and observes heat produce by striking of two surfaces.

3. CONCLUSION

The study was concluded as follows;

The composite material A356 with 10 wt% flyash were productively manufactured through stir cum squeeze casted technique.

Through SEM examination it was absorbed that stir cum squeeze casted composite have fine grain structure and uniform diffusion of composite particles (fly ash).

The hardness value of A356 reinforced with flyash (950 mpa) was found higher than the base alloy A356 (640mpa).

Stir cum squeeze casted composite produces low wear compared to A356 matrix. The wear rate found to be increase on increasing the applied load for both tested specimens [1]. The sample under wet sliding conditions had lower wear than samples tested under dry sliding environment.

4. ACKNOWLEDGEMENT

The authors wishes their warmest times to the institutes “Sri Krishna College of engineering and technology, Coimbatore, Tamil Nadu for support and guidelines to complete the work successfully.

5. DECLARATION

The work has not been presented else were are not being consideration for publishing in any journal.

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Assessment of mechanical properties for aluminium composites using rice husk ash as a reinforcement (ID: T097)

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Abstract: In this present investigation Al (6061) alloy has been used as a matrix material and agro waste rice husk ash (RHA) as an reinforcement to form a composite by using two step stir casting process. RHA has been used because it is the only agro waste which contains the maximum amount of silica. To assess the performance of the composites the mechanical properties, microstructural analysis were used. Here tensile strength, hardness, compression, frictional force, coefficient of friction with sliding time and ductility. All of these mechanical properties of the composite were tested. The results reveal ultimate tensile strength (UTS) variance from 115 MPa at 0% RHA to 132 MPa with maximum value at 12% RHA, compression strength variance from 280 Mpa at 6% RHA to 150 Mpa with minimum value at 12% RHA, % elongation values varies from 10.03% at 0% RHA to 6.59% with maximum value of 12%. The result reveals that the compressive strength of the aluminum alloy decreases with increase of RHA particles or with the increase in the weight fractions of RHA particles decreases the ductility of the composites. The frictional force with sliding time in this study shows a decrease with the percentage change in RHA likewise coffececient of friction is also decreased. Though the resultant composite product has stable hardness, strength. At every level of replacement of the ash addition there are prominent differences among the means of each property of composites are seen by analysing the variance. Different tests have been done so that analysis of performance can be completed. The study of aluminum composites can lead us to new phase of different products, parts and production. By XRD we get the SiC presence in maximum proportion for RHA samples.

Tribological characterization of iron based self-lubricating composite under dry sliding conditions (ID: T005)

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Abstract: In the present study, iron based self-lubricating composites were prepared using powder metallurgy process. Tribological as well as mechanical properties of Iron Molybdenum based composites with varied content of Barium Fluoride as solid lubricant were studied under different experimental conditions. The influence of normal load as well as sliding distance on friction and wear behaviour was studied. Dry sliding tribo-tests were conducted on a Reciprocating ball-on-disc tribometer. From the results, it is reported that hardness and compressive strength is higher for base composition compared to the composites samples. Introduction of Barium Fluoride increases the tribological properties of the composite. The coefficient of friction as well as wear volume was least for 8 wt. % solid lubricant sample. Self-lubricating behaviour of the reinforcement was responsible for the improvement in the tribological properties of the fabricated composite samples.

Keywords: Metal–matrix composites, Coefficient of Friction, Wear, Self-Lubrication.

Review on optimization of process parameters for Hybrid Metal Matrix Composites (HMMCs) (ID: T002)

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Abstract: The development of lightweight materials is a trending topic in research for application of automobile industry, defense applications and aerospace applications. The metal matrix composites combine the properties of metal matrix material as well as reinforcement material with addition of particulates to form a lightweight material called as hybrid metal matrix composite. The most common materials used as a reinforcement material are Aluminum, Tungsten, Magnesium, Titanium and their alloys whereas reinforcement materials are carbides, oxides, boride, and nitrides. This paper summarizes the effect of different reinforcement materials and addition of particulates on the mechanical properties and tribological properties of Al HMMCs. The different optimisation techniques like response surface methodology, artificial neural network, Taguchi method, and fuzzy logic as soft computing optimization methods are reviewed.

Wear behaviour of magnesium hybrid composite reinforced with Al_2O_3 and MoS_2 particles through PM route (ID: T044)

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Abstract: In this work, AZ61 magnesium composites was processed using powder metallurgy method. The wear behaviour of powder metallurgy-processed AZ61 magnesium alloy reinforced with with Al_2O_3 and MoS_2 was investigated using pin-on-disc equipment. The density, porosity, hardness, microstructure and abrasive wear behaviour of the alloy were evaluated. Microstructural characterization of AZ61Mg alloy showed normally uniform composition distribution. As compared with AZ61 magnesium alloy reinforced with Al_2O_3 and MoS_2, the density and hardness values of AZ61 P/M Mg were decreased. The abrasive wear tests showed that the wear loss of AZ61 P/M Mg was increased 8% than reinforced AZ61 Mg. This was due to the strong particulate-matrix bonding and lubrication properties of the reinforced composites.

Keywords: AZ61, Tribometer, Powder Metallurgy, Reinforcement

Tribological characterization of aluminium metal matrix composites (ID: T057)

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Abstract: The mechanical components often undergo metal-to-metal contact causing friction and consequently wear between the contacting surfaces. It has been a great challenge for the tribologists to reduce the friction and wear. The present work focuses on the dry sliding wear behavior, based on ASTM G-99 standard, of three different types of materials, i.e., aluminium alloy Al 6063 and its two composites- 5% and 10% volume reinforced Al_2O_3 with particle sizes of 3µm and 35µm respectively using a typical pin-on-disc arrangement. The counter body, the disc, is made up of stainless steel, SS-304. The simulation of the tests has been carried out through the finite element simulation tool Ansys 18.1 by invoking the Archard's wear model. For all the tests, normal loads of 25N, 37.5N, 50N, 62.5N and 75N are applied to the pin at two values of sliding speeds, i.e., 0.15m/s and 0.25m/s for sliding distance of 1000m. The experiments have shown that the wear increases as the load and the sliding speed increases for all the three materials. The value of coefficient of friction (CoF) decreases continuously with the applied load except for the random increment for 5% volume reinforced composite at 50N load and 0.15m/s sliding speed. Further, it is found that the wear resistance is enhanced by increasing the reinforcement content of the Al_2O_3 particles with 10% volume of 35µm size reinforced composite being the most wear resistant material. The simulation result, being coherent with the experimental result, is able to predict the wear behavior closely and can be used to design the machine components. Also, since the various input parameters (load, sliding speed, sliding distance and reinforcement content of Al_2O_3) have distinct influence on the tribo-performance of wear and CoF, they have been ranked according to their effect by employing the Taguchi analysis. Accordingly, it is observed that the reinforcement content of Al_2O_3 has the highest effect on wear followed by load, sliding distance and sliding speed respectively while the load has the highest effect on CoF followed by sliding speed, reinforcement content of Al_2O_3 and sliding distance respectively.

Keywords: Wear, Coefficient of friction, Finite Element Analysis, Ansys, Taguchi analysis

Effect of ball milling duration on tribological properties of CNT reinforced Al matrix composites (ID: T063)

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Abstract: Recent days Carbon Nanotubes (CNTs) have been considered as an ideal reinforcement in fabricating Aluminum (Al) metal matrix composites. Uniform dispersion of CNTs in the matrix and interfacial bonding between CNTs and Al matrix are the major challenges in fabrication. Several researchers attempted with different techniques like mechanical mixing, ultrasonication, ball milling, etc. to improve dispersion of CNTs in Al matrix. The present work is focused on the influence of ball milling time on distribution of CNTs in Al matrix and to study the tribological properties of fabricated composites. The ball milled Al-CNT composite powders for milling times ~~of~~ 1, 6, 12, 18 and 24 hrs were compacted and sintered. The sintered specimens were tested using pin on disc wear testing machine. The wear behavior of the composites are compared with that of pure Al samples fabricated by same route and milling durations. It was found that the ball milling route is an effective way to achieve homogeneous distribution of CNTs in Al matrix and introducing CNTs in Al matrix reduces the CoF values.

Keywords: Carbon Nanotubes, Aluminum, Ball Milling, wear behaviour

Fabrication and optimization of wear parameters of B_4C reinforced Al_2O_2 nano metal matrix composites (ID: T039)

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Abstract: The automobile industry needs metals or composites with properties such as lightweight, and an uncompromising strength & specific stiffness with higher wear-resistant and coefficient of thermal expansion. Various other areas like aerospace engineering need far more traditional material characteristics to maintain severe environmental conditions. The above-said qualities led to the use of Aluminum Matrix Composites (AMCs) which are a specific type of MMCs that are replacing conventional engineering materials in various engineering fields. In the present investigation, Aluminum based metal matrix composite is reinforced with 3%, 6%, 9%, 12%, and 15% weight percentage of Boron Carbide (B_4C) nanoparticles, powder metallurgy technique is used to fabricate to achieve the desired composites. The effect of wear rate of the fabricated Al 2024 & B_4C Nanoparticle MMCs is investigated by the wear parameters such as % composition of B_4C (3% , 6%, 9%, 12%, 15%),within range of Load(10, 20 and 30 N), sliding distance of (1000,2000,3000 m) also sliding velocity of 1, 2, 3 m/sec. The results of the conducted wear test for the above-mentioned parameters are discussed with respect to FESEM and microstructure of the composites in addition to optimization techniques.

Keywords: Powder Metallurgy Technique, Optimization of Wear Parameters, Microstructure Analysis of Nano Composites.

Assessment of mechanical and tribological characteristics of A356 reinforced with *x* wt% CaB_6 composites (ID: T075)

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Abstract: This paper involves the study of mechanical and tribological characteristics of as-cast aluminium A356 metal matrix composites reinforced with calcium hexaboride (CaB_6) particulates. Composite specimens of two varying reinforcement weight percentage of 2.5% and 5% were fabricated using stir casting method. The hardness and tensile strength of as-cast and composite specimens were studied and its tensile fracture surface behaviours were examined under scanning electron microscope. In addition, wear and friction characteristics were observed for as-cast and composite specimens by using pin-on-disc tribometer under dry sliding atmospheric condition. The wear and friction test were performed with three different loads of 10N, 20N and 30N and two velocities of 1m/sand 3m/s parametric conditions. The responses of wear rate and coefficient of friction measurements were recorded for further analysis. Worn out surfaces of test samples were analysed by using scanning electron microscope and wear mechanisms were studied. From experiments it was found that, the hardness and tensile strength increased in higher weight percentage addition composites followed by decrease in wear rate and coefficient of friction than other combinational test samples. The developed higher weight percentage addition composite is recommended for replacing automobile components.

Keywords: A356, Calcium hexaboride, tensile strength, wear & friction

Assessing the tribological behaviour of stir casted AA 6063 with *x*wt% $ZrSiO_4$ and 6wt% TiB_2hybrid composites (ID: T076)

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Abstract: A new combination of Aluminium Alloy (AA) 6063 was taken as the matrix material with Zirconium Silicate ($ZrSiO_4$) and Titanium Diboride (TiB_2) as the reinforcement particles were fabricated hybrid composites by stir casting method. The specimens were fabricated as cast condition initially in further by varying the reinforcement particles of 2 and 4 weight percentage of $ZrSiO_4$ and 6wt% of TiB_2were kept constant. The prepared three specimens were subjected to tribometer test under dry sliding condition at room temperature with applied loads of 20 N and 50 N and sliding velocities of 1, 2 and 3 m/s respectively. The responses for all the test specimens are wear rate and Coefficient of Friction (COF) were measured and calculated besides worn out wear surface mechanisms were studied through Scanning Electron Microscopy (SEM). The observed results revealed that higher weight percentage of AA6063 with 4 wt% $ZrSiO_4$ and 6wt% TiB_2 hybrid composite sample shows lower wear rate and higher COF than other test samples for all the applied load and sliding velocity conditions. This is due to harder particles plays in the softer alloy shows higher hardness. SEM analysis revels, when the applied load of 50N with a higher sliding velocity of 3 m/s condition, deep grove and sever delamination was observed for soft natured test samples followed by absence of crack, delamination, particle pullout and mild surface damage was observed for highest weight percentage addition test specimen. The new combination of hybrid composites has better tribological behavior in which it was recommended for automobile and aeronautical component replacement.

Keywords: AA6063, TiB_2 , $ZrSiO_4$, Tribometer, wear and friction

Polymer Composites and Friction Materials

Tribological characterisation of banana/ sisal composites and hybrid composites: A Review (ID: T058)

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Abstract: Natural fibres are naturally supple and have various properties depending upon their chemical composition and physical aspects. Banana fibre is a derivative of processing of "banana plant's pseudo stem" (Musasepientum) whereas the sisal fibre is acquired from the leaf of "Agave Sisalana" plant. Banana and Sisal fibre are a type of natural fibre that largely constitutes of hemicellulose, lignin, and cellulose thus named lignocellulosic fibre. Due to the structure and chemical composition of natural fibres, they have outstanding mechanical properties when used as a reinforcement. However, if the adhesion on the fibre-matrix interface of natural fibre composite is enhanced, better mechanical and tribological properties can be obtained. The loss of useful energy in the form of heat due to friction is the major issue for the design engineers, and this can be reduced with the help of green tribo material. Increase in the fibre loading of sisal fibre improves the wear and friction characteristics whereas with the increase in banana fibre loading, tribological properties remain stable and tensile strength increases. Since the automotive and biomedical equipment's including the area of wear, lubrication and friction are the major scope of tribology. This paper reviews the tribological properties of banana, sisal composite and their respective hybrid composites in order to broaden the scope of green materials for tribological applications.

Keywords: Natural fibre; Banana fibre; Sisal fibre; Tribology; Tribological applications;

1. INTRODUCTION

In all over the globe, burden on eco-system is gradually increasing due to the use of synthetic materials. As they are hazardous to the environment and toxic to the nature, the only solution to reduce these threats is to maximize (as possible) the use of biodegradable and natural materials. So, in order to this natural fibre reinforced composite are the subject of colossal interest among the scientists and researchers from both environmental and ecological outlook [1], [2]. Natural fibres (NF) are the cellulose dominating material generally composed of approximately 10-20% of lignin, 60-70 % of cellulose and some other inconsequential constituents including waxes, pectins, etc[3]. This paper is mainly focused on sisal and banana composites and hybrid composites.[4].Natural fibres are the centre of attraction due to their characteristics for instance low density, comparable strength, cheaper than synthetic fibre (as natural fibres are the by-product), renewable, abundantly available, bio degradable, eco-friendly, etc.. Due to these versatile characteristics of NFs are admired to be used as a substitute for synthetic fibre in automotive, aerospace and construction industries[5]. Wear, friction, design and lubrication properties of the contacting surface having relative motion are studied under tribology. From 1996 onwards the related studies were given a name as tribological studies. There are six several tests through which the tribological characteristics of the material can be defined. Each of these tests' method is briefly described in second section of the paper. Tribo material have wide range of scope in automobile sector i.e., brake pads, clutch plate, etc, and Medical science for design of bone joints, reinforcement for bone fracture, etc[6].

2. TRIBOLOGICAL TEST METHODS

Following are test methods used for tribological testing

2.1 Block on disc test: In this test, the block-like specimen of dimensions 10 × 10 × 20 mm^3, as per ASTM G699 standards, is held vertical against a counterface such that the contact are remains constant.

1.2.2 Pin on Disc test: The operation of pin on disc test is similar to that of block on disc except that contact surface is horizontal unlike the later. The test specimen is of dimensions 10 × 10 × 20 mm^3 as per ASTM G699 standards.

1.2.3 Block on ring test: In this process, the test specimen of dimensions 10 × 20 ×50 mm^3in accordance with the ASTM G77, G137-95 is brought in touch with longitudinal side of a rotating cylindrical ring such that the arc of

contact varies along with the sliding time. The load cell measures the frictional force at the interface.

1.2.4 Linear tribo machine: The abrasive surface in these test moves linearly using a power screw while the test sample placed in the vessel with liquid containing abrasive particles slides. The connection of "friction indicator" is direct with the load cell and the speed regulator.

2.5 Pin on drum test: In contrast to linear tribo machine, in the pin on drum test the specimen moves in linear motion using a power-screw while the drum rotates by the help of chains.

2.6 Dry sand rubber wheel: This test is in accordance with the ASTM G65 norms with specimen dimensions being 70 × 20 ×7 mm^3. The rubber wheel makes contact with the specimen on the application of load. To simulate abrasive wear test sand is added to the contacting surfaces.

3. RESULTS AND DISCUSSION:

Banana fibre reinforced hybrid composite (BFRHC): Masrat Bashir et al [7]analyzed the application of banana fibres in brake pads to enhance thermal stability. Powder metallurgy technique was used in the construction of samples. Thermal stability of the specimens was obtained by subjecting them to "differential scanning calorimetric (DSC) and thermo gravimetric analysis (TGA) using a Mettle Toledo thermal analyzer". It was observed that the specimen with 7% of banana fibre obtained negligible wear, enhanced binding stability, better thermal stability and fade resistance. The conclusion also stated that addition of banana fibres leads to stable friction coefficient and enhanced tensile strength.

Sisal fibre reinforced hybrid composite (SFRHC): V. K. Shrivastava et al [8]analyzed the behavioural characteristics of sisal fibres as a composite reinforcement.. It was observed that, the Young's Modulus of the material is proportional to the fatigue strength of the material. The conclusion stated that the sisal fibre's incorporation into the composite as a reinforcement, the tribological properties of the composite enhanced

4. CONCLUSION:

The following points can be gathered from the review: The addition of banana fibres results in a stable friction coefficient. The addition of sisal fibre as a composite reinforcement enhances the wear resistance and overall tribological behaviour of the composite. With an increase in composition of sisal fibre the wear resistance of the composite increases due to a decrease in specific wear of the PLA composite with the addition of natural fibres. Lowering the fibre content to ≤ 10 wt% of banana fibre largely improves the tribological characteristics of phenolic friction materials.

5. DECLERATION:

The work has not been presented elsewhere or not being under consideration.

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New multiscale polymer composites for water lubricated tribological contacts (ID: T066)

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Abstract: Usage of environmentally friendly tribological materials is critical to the continued development of various tribological systems. Ultra High Molecular Weight Polyethylene (UHMWPE) has exhibited good performance when used as a contact surface in water lubricated tribological contacts. However, it's wear performance leaves much to be desired. In this study, newly developed hybrid composites with UHMWPE as base polymer and Graphene Oxide (GO), Nano Diamonds (ND) and Short Carbon Fibres (SCF) as fillers were manufactured. The tribological performance of these composites in a water lubricated sliding contact and the effect of inclusion of the fillers on the mechanical and thermal properties of the composites were investigated. Compared to unfilled UHMWPE, composite with all the fillers incorporated had 21% lower friction coefficient and 15% lower wear. It is found that the friction and wear are affected by the quality of the lubricating water. Both DI and sea water prevent the formation of a transfer film. In sea water lubrication, deposits are formed from the various salts present which affect the tribological process. It was also observed with the use of hygrothermal aging at a temperature of 80°C that the friction and wear of the composites were not significantly affected by the aging conditions, which was attributed to the structural integrity of the newly developed UHMWPE based hybrid composites.

Keywords: UHMWPE, Graphene, Nanodiamonds, Short Carbon Fibres, Lubricant

1. INTRODUCTION

Traditionally, only specific grades of UHMWPE, with a narrow particle size and molecular weight distribution have been deemed suitable for tribological applications. Now, various grades of UHMWPE are available that differ from each other based on their particle size and molecular weight distribution. The present study attempts to address the question of whether the particle size of UHMWPE affects its performance and properties. Additionally, the effect of processing of the UHMWPE is studied. Furthermore, based on the information gathered from studying the UHMWPE viscoelastic properties, various UHMPE composites containing carbon-based reinforcements such as Nano diamonds, Graphene oxide and Short Carbon Fibres are manufactured and characterized for their tribological and physical and other properties.

2. METHODOLOGY

Various UHMWPE were selected (Table 1)

Table 1: UHMWE grades

Particle size	Molecular weight ($\times 10^4$)[g/mol]	Density [kg/m^3]
10µm	180	0.94
30µm	200	0.94
120µm	200	0.94
140µm	350	0.93
160µm	240	0.935

DMA tests were carried out in amplitude, frequency and temperature sweep modes. The thermomechanical analysis was supported by purely thermal analysis in the form of DSC and TGA tests. Tests in Pin on Disk

configuration were carried out at different velocities and loads. A variety of lubricants including sea water and DI water were used. The UHMWPE composites were immersed in water for the duration of 120 days at 80°C to study the effect of aging on performance and properties.

3. RESULTS AND DISCUSSION

It was observed through dynamic mechanical analysis and 3-point bending tests that the particle size and molecular weight distribution did not affect the thermomechanical properties and tribological performance of UHMWPE. At a frequency of 1Hz in DMA freq. sweep, the difference in G' and G" values between 10µm and 160µm is approximately 31\% and 11\%. Similarly, processing had no effect on the performance of various UHMWPE.

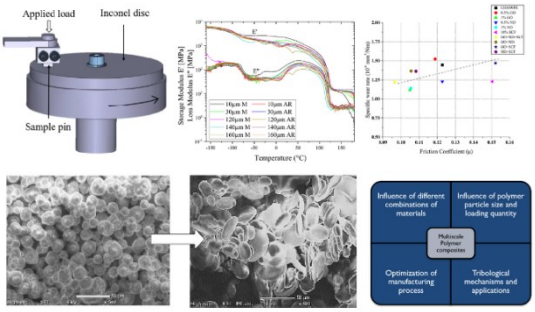

Figure 1: Pin on disk setup and summary of some results.

Composites performed better than neat UHMWPE in tribological tests. Friction and wear are reduced as much as 21% and 15% respectively in DI water. Friction and wear are observed to be affected by the quality of the lubricating water. It was also observed that the tribological performance of the composites were not significantly affected by the hygrothermal aging, due to the excellent structural integrity of the newly developed UHMWPE based hybrid composites.

4. DECLARATION:

The work has not been presented elsewhere or not being considered for presentation in any journal.

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Indentation behaviour of cellulosic fibres/fly ash incorporated polymer composites at sub-micron scale (ID: T001)

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Abstract: Chemically treated short cellulosic fibres (jute and sisal) reinforced heat treated silanized fly ash (FA) dispersed hybrid polymer composites were synthesized by compression moulding technique. Different fillers loading as 5, 15, 25, 35 and 45 wt. % were incorporated within unsaturated polyester (UP) matrix. The mechanical behaviour of the UP matrix and UP based composites was successfully assesses at the sub-micron length scale using the nanoindentation or depth sensing instrumented indentation technique. From the present investigation it is observed that along with filler addition, the mechanical properties at sub-micron scale improved significantly. A successful attempt to investigate the effect of fillers inclusion within the UP matrix through various nanoindentation derived parameters viz., nanohardness, storage modulus, reduced modulus, elastic recovery as well the dynamic mechanical properties was also executed.

Keywords: Cellulosic fibres, Fly Ash, Unsaturated Polyester, Nano indentation, Wear rate.

1. INTRODUCTION

Fly ash (FA) is major part of coal combustion waste by-product of power plant which is a big environmental concern that can only be disposed through dumping [1]. The loss on ignition value plays an important role for its performance as dispersing phase by suitably removal of the residual carbon content. Chemically modified fly ash severely affects the mechanical properties of orthophthalic unsaturated polyester resin as reported elsewhere [2]. A few studies have been reported where by dispersing natural fibre along with the metal/metal oxide particles can be significantly improved the mechanical and thermal properties of the polymeric matrix [3-4]. The current research is to utilize the waste modified FA along with jute and/or sisal fibre as the reinforcements within the unsaturated polyester (UP) matrix to obtain an economical and partially biodegradable composite

2. METHODOLOGY

The UP based composites with fillers (cellulosic fibres viz., jute and sisal along with ZrO_2 particle with a ratio of 45:45:10) were successfully fabricated by compression moulding technique.The detailed nanoindentation studies of the UP and UP based composites were successfully conducted by CSM NHTX S/N: 55-0019 nanohardness tester with a triangular pyramidal (Berkovich) diamond indenter (Ref: B-I 93, radius of curvature = 20 μm) under a static load of 10 mN and frequency used from 2 to 10 Hz at an interval of 2 Hz for sinusmode and holding time used from 10 to 120 seconds for standard loading mode, respectively.

3. RESULTS AND DISCUSSION

Load-depth of penetration profiles

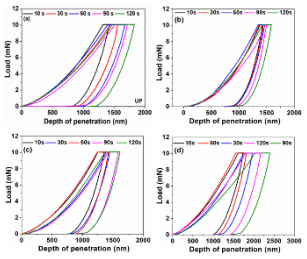

Figure 1. Load *vs.* depth of penetration profiles for (a) UP matrix, (b) UP/Jute/FA, (c) UP/Sisal/FA composite and (c) UP/Jute/Sisal/FA composite.

7.7.2 Variation with holding time

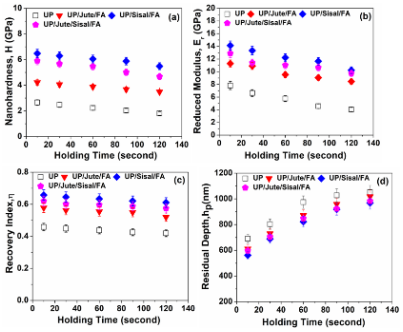

Figure 2. Variation of (a) nanohardness (*H*), (b) reduced modulus (E_r), (c) recovery index (η), and (d) residual depth (h_p) with holding time for UP matrix and UP based composites.

7.7.4 Nano DMA

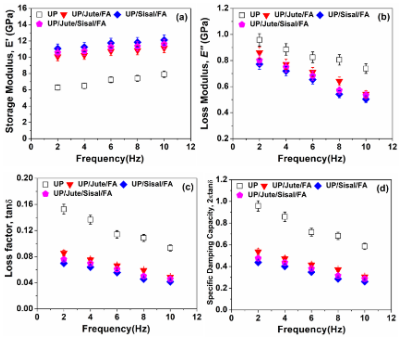

Figure 3. Variation of (a) Storage modulus (*E'*), (b) loss modulus (*E''*), (c) loss factor (*tan δ*), and (d) specific damping capacity (*2π tan δ*) with frequency for UP and UP based composites.

4. CONCLUSION

Along with filler addition the Nanoindentation properties improves significantly. It was observed that the optimum properties observed for 35 wt. % UP/Jute/Sisal/Fly ash composite.

5. ACKNOWLEDGEMENT

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6. DECLERATION

The work has not been presented elsewhereor not being consideration for presentation in any journal.

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Synergic effect of metallic fillers as heat dissipaters in tribological performance of a non-asbestos disc brake pad (ID: T020)

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Abstract: Brake lining materials are composite materials with highly complex formulation which helps in improving the braking performance. Selection of friction materials with good physical, mechanical and thermal properties is very important which will decide the braking performance. Apart from giving good physico-mechanical properties, functional fillers acts as heat dissipaters. The aim of this work is to study the synergetic effect of prominent heat dissipaters namely copper, brass and zinc powders. Three simplified formulations were developed with 10%, 14% and 18% by weight of these heat dissipaters and named as DB1, DB2 and DB3 respectively. Tribological properties are tested using chase machine following SAE J661 and inertia brake dynamometer following JASO C406 standards. It was observed that addition of heat dissipaters increased the thermal properties. DB2 with moderate heat dissipaters had consistent μ with less wear, better fade % and recovery % at elevated temperatures. Wear mechanism was analysed using Scanning Electron Microscope (SEM). Preference selection index (PSI) was applied to evaluate the overall performance parameters of the brake friction composites, as a result DB2 (14 wt. %) was ranked first followed by DB1 and DB3.

Keywords: *Heat dissipaters, dynamometer, fade, PSI*

1. INTRODUCTION

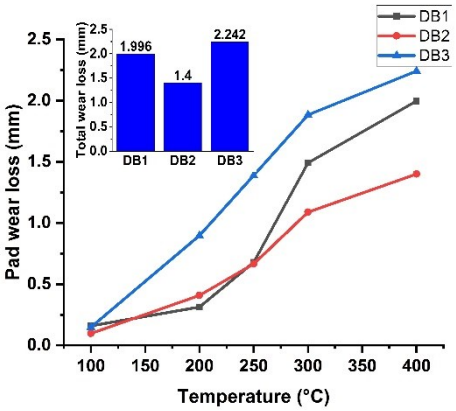
Metallic fibers are commonly used in brake pads as reinforcement to improve mechanical strength and stiffness, acts as an aid to promote the formation of plateaus to improve the real area of contact (to increase μ) and good thermal resistance. Metal constituents like steel-wool, iron powders, copper powders/fibers and its alloys, Tin and zinc powders are regularly used for efficient heat removal between the pad/rotor interface. A.Sellami et al [1] analysed the variations of brass in brake pads and 4.5% of brake pad resulted in good fade resistance and wear resistance above which the particles were removed from the matrix. Similar study was carried out by Bijwee [2] which results in the fact that, thermal conductivity alone will not improve the performance. Accordingly, it is observed that, mostly copper and brass powders seemed to have more benefits when compared to other metal fibers. Hence, in this work, the synergetic effects of these selected metal fibers namely Cu, Brass and Zn acting as heat dissipaters are studied. Three brake pads are fabricated by varying the amount of these heat dissipaters and their properties are studied as per industrial standards. Frictional performance was examined using Inertia brake dynamometer as per JASO C-406. To identify the wear mechanism, surface analysis is carried out on brake pad samples.

2. METHODOLOGY

The selected Metallic fibers (Copper, Brass and Zinc) are added to brake friction composites as varying ingredients. Three brake pads are developed with the total of 10%, 14% and 18% by weight of these heat dissipaters and named as DB1, DB2 and DB3 respectively. The mixed ingredients are compressed using compression moulding machine followed by curing and post curing. The brake pad along with the calliper assembly is fitted in the IBD for carrying out tribological testing following JASO C 406 standards. The tested samples are then taken for surface analysis to study the wear mechanism.

3. RESULTS AND DISCUSSION

The performance were in the order of DB2 > DB1 > DB3 as shown by the wear graph.



Increased amount of heat dissipaters doesn't enhanced the performance because of the following:

Glazing effect by encouraged by the presence of non-ferrous and soft metals

Increase in metal content leads to more metal to metal contact creating lot of noise and dust.

Moreover higher heat rise at the interface destructs the contact patches causing the destruction of μ.

This higher contacts increases the temperature at the interface indicated from the time.

4. CONCLUSION

Following are the conclusions drawn from the test conducted,

The addition of heat dissipaters enhanced the friction and wear till 14 wt.% and the heat were dissipated to the ambient.

Though the Co-efficient of friction at 18 wt.%, more metal content makes the rotor wear and increases the temperature at the pad/rotor interface.

5. ACKNOWLEDGEMENT

Authors sincerely thank the Management of BSA Crescent Inst. of Science & Technology for extending the Chase testing facilities in the Friction Materials Laboratory. Authors would like to record their gratitude to Mr. Venkataswamy, M.D. of Pyramid Precision Engineering, Chennai, for guiding us in knowing about technical details of Inertia brake dynamometer testing.

6. DECLERATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Influence of alkali treatment in areva javanica fiber and its effect in physical and tribological behaviour in nao brake friction composites (ID: T023)

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Abstract: Areva Javanica, a wild grown natural fiber, was chemically treated with 5% (W/V) NaOH by varying the soaking time of the fiber as 45, 60 and 75 minutes. The treated fiber specimens were characterized for its chemical and thermal properties. The TGA evaluation showed that thermal stability of the alkali treated fiber was seen increased to 310°C in the 60 min sample. To check the compatibility of alkali treated fiber in composites, the samples were added in the formulation of the friction composites. From the results it was conclusive that the 60 minute friction composites specimen exhibited significant improvement in properties such as density, hardness, porosity and heat swell. The tribological evaluation of the composites was carried out through a pin on disc tester adopting ASTM G99 protocol at varying load and speed conditions. The worn surface of the specimens showed the formation of the contact plateaus and third body layers which were influential in managing the tribological properties of the composites.

Keywords: Natural fiber, TGA, friction, wear, surface treatment

1. INTRODUCTION

In recent trends, the usage of synthetic and metallic fibers has been regulated in the friction material composition because of stringent environmental regulations [1]. To increase the cellulose percentage, reduce hydrophilicity, improve surface roughness, and to reduce polysaccharides, the Areva Javanica fiber was subjected to an alkaline treatment process using NaOH solution of 5 (w/v%), and three samples were prepared by varying the soaking time as 45, 60, and 75 minutes and named as $5AJ_{45}$, $5AJ_{60}$, $5AJ_{75}$. To apply the fibers in the composites, the AJ treated fiber specimens were added in the formulation of friction composites and were tested for their physical, mechanical and tribological properties.

2. METHODOLOGY

The selected fiber called Kapok bush (or) *Areva Javanica* (or) desert cotton was subjected to alkali treatment with 5% (weight per volume) solution of sodium hydroxide pellets stirred in distilled water with varying soaking duration of 45, 60, and 75 minutes. The fiber characterization such as chemical properties, FTIR, XRD, Optical Microscopy analysis, AFM, SEM of the specimens were determined using the techniques prescribed [2].

To check the compatibility of AJF as a composite, a total of three NAO friction composites were formulated and prepared and were named as $5AJ_{45}FC$, $5AJ_{60}FC$, and $5AJ_{75}FC$. In the formulation (or) adding of ingredients, the constituents weighing percentage in all the samples were kept the same as 11 wt%. The physical properties of the AJF FC's, such as hardness, specific gravity, porosity, water absorption test, Loss of weight on ignition, acetone extraction test, hot and cold shear strength and pin - on- disc Tribology evaluation test were estimated as per the protocol [3].

3. RESULTS AND DISCUSSION

Through the chemical composition analysis, it could be noticed that the increase in cellulose content was more than that in the AJ_{raw} sample in all the specimens with the maximum value being seen in the $5AJ_{60}$ sample as 65.91% which was also verified through FTIR and XRD. The TGA showed the maximum degradation peak for the $5AJ_{60}$ specimen as 310°C. Through the SEM, OM and AFM analysis, it was seen that the treated specimens were more fibrillated and rough to be better suitable for composites.

The LOI was comparatively high in the AJF FC's because of more fiber content. The average range for the density in the treated samples composites was between 2.32 and 2.42 g/cm^3. The friction performance from the specimens showed that the $5AJ_{75}FC$ had 20% less μ than $5AJ_{60}FC$ and $5AJ_{45}FC$ at maximum load and speed conditions. In

the $5AJ_{75}FC$ the fluctuation for COF was observed to be more. The wear analysis showed that the highest wear loss in terms of thickness occurred for the $5AJ_{45}FC$ (5.3%) with more plateau formation as verified through SEM evaluation.

4. CONCLUSION

The results provided sufficient evidence that the properties of the fiber specimens were further enhanced than the 3% and raw fiber when they were subjected to 5 wt% NaOH treatment. The physical, mechanical and tribological results showed that the 45 and 75 minute specimens had more wear than the 60 min friction composite.

5. ACKNOWLEDGEMENT

Authors sincerely thank the Management of BSA Crescent Inst. of Sci & Tech for extending the Chase testing facilities in the Friction Materials Laboratory.

6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Tribological behavior of cera –metallic clutch friction material in agriculture tractor applications (ID: T029)

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Abstract: Cera-metallic friction material used for higher driveline energy transmissions for stable performance and increase the clutch life. New cera-metallic friction pad has developed through Powder metallurgy route and validated in the agriculture tractor application. It has coupled with a standard gray cast iron pressure plate (FG 250 grade) and checked for tribo performances, which include (μ, fade, recovery, and wear), evaluated with clutch chassis machine. The tractor level severe test carried out for 25k cycles for understanding the engagement characteristics and thereby predicting the useful life in a number of engagements. Results show that the sintered friction pad has a very stable range of friction coefficient (0.522-0.593) even after 25000 engagement cycles. The surface roughness characteristics have evaluated before and after to understand the engagement and wear pattern characteristics of cera-metallic and gray cast iron. Both sintered friction pad and pressure plate showed adhesive wear scoring marks along the sliding direction. Microscopic features of worn sintered friction pads show silica particle providing the required wear resistance for the pads. The pressure plate showed a transfer layer of oxides and carbon with less scoring marks.

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

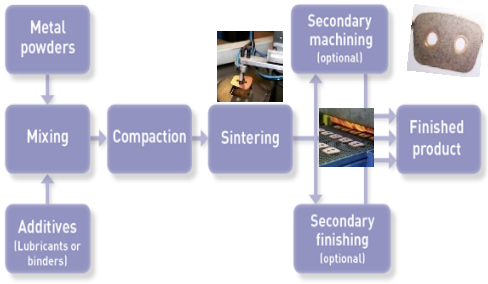
1. METHODOLOGY

1.1. Alloys composition

The import (Europe) sintered friction material composition to analyze and composition of the material is described in Table 1.1a.

Chemical analysis :		Contains metals Copper - Iron - Tin in combination along with lubricant & in-organic abrasive
Chemical composition :		Chemical composition on ingredient is as under
Sr.No.	**Chemical Name**	**%Weight**
1	Copper powder	15 – 25
2	Iron Powder	25 – 35
3	Tin powder	2 – 3

Table -1.1a Material Composition in % of weight.



2. TESTS PERFORMANCE

2.1 Testing machine

The samples were submitted to a milling process to guarantee that both the imported and the local sintered materials in the same dimensions. The samples' wear test has performed as per **SAE J661** in CHASE and is presented in Figure 4.3a. A commercial automobile brake disc, made of grey cast-iron, was used as abrasive agent. An electrical motor was linked to the disc using a belt in order to start it.

2.2 Wear

The wear test was made by keeping the material pressurized against the disc for 100 applications. The samples mass were measured before and after each test, so it was possible to evaluate the wear suffered by the material. The friction coefficient was measured after each test to make sure the material was well-adjusted with the disc. Wear was measured using the following formula:

$$W = \frac{mass\ loss(g)/density\ (g.mm{-}3)}{Traveled\ ditance}$$

2.3. Friction

The friction coefficient of the material was calculated using the following formula: $\mu = \frac{Iz\omega 0}{FN.r}.(\frac{1}{ta} - \frac{1}{ti})$ (2)

3. RESULTS AND DISCUSSION

3.1 Physical properties

3.2 Wear analysis

3.4 Vehicle level validation.

After the subjective rating, the clutch disc in the vehicle level it has validated at severe condition like filed applications for 25K cycles to ensure the wear pattern and life of clutch.

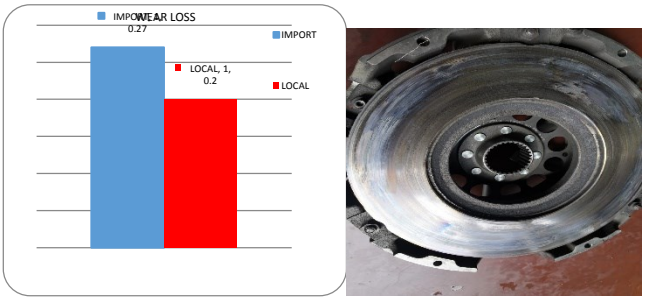


Fig 3.2a Clutch disc Clutch assembled

After the validation the clutch disc were removed from the vehicle and measured the wear loss and tribological behavior of the Cera-metallic friction pad. Disc thickness before test: 10.50mm, Disc thickness after test: 10.35mm, Delta: 0.15mm

4. CONCLUSIONS

This study investigates the effect of frictional characteristics comparison between local Vs import Cera-metallic clutch friction pad and the material composition has verified and made a local equivalent Cera-metallic pad for the comparison study. Based on the vehicle level validation the product is performing good and after 25K cycles the wear of friction pad and matting part wear also less. Sintered friction pad showed dense crack networks around the periphery due to thermal cycling during engagement and disengagement cycles. Microscopic features show silica particle providing the wear resistance for the pads. Slight scoring marks were observed in the pressure plate with little transfer layer of carbon and iron oxide mixture.

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A review on tribological behavior of silicon nitride based ceramics (ID: T038)

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Abstract: Silicon nitride ceramic owing to its excellent fracture resistance and high strength behavior, has find its place in industry as well as in biomedical applications. The works related to the tribological behavior of silicon nitride based ceramic materials against different material combinations were reviewed in this study. The experimental studies which include POD pin-on-disc (POD) tribometer (mostly for commercial applications), hip simulator (for orthopedic applications) and computational approaches were mostly used to investigate the wear behavior. The effect of friction, wear rate and hardness of these ceramics based on other influencing parameters were summarized. Overall, the tribological behavior of silicon nitride-based ceramics showed better tribological behavior rather than silicon nitride depending on various applications. The use of different bio-lubricants also showed improved wear behavior because of reduced dissolution rate of silicon nitride for biomedical applications. The parameters like loads, sliding distance, type of lubricant used, material combination influencing tribological behavior were highlighted in this study based on field of applications.

Keywords: silicon nitride; tribology; POD; hip joint; composite

1. INTRODUCTION

Silicon nitride (Si_3N_4) being non-oxide ceramic has superior mechanical properties compared to that of alumina (Al_2O_3) and zirconia (ZrO_2)[1, 2]. Due to the absence of oxide groups, which is comparatively brittle in nature, silicon nitride has better wear resistance and finds its applications in many fields like automotive, industrial and biomedical. Usage of Si_3N_4 from tribological applications point of view were reviewed for the first time in this study. Different parameters influencing the tribological behavior such as load, sliding distance, type of lubricant were also reviewed in this current study. In addition to that, computational approach using modeling software like ANSYS/ABAQUS to investigate the contact pressure and its influence on wear were also discussed.

2. IN-VITRO TRIBOLOGICAL BEHAVIOR OF SI_3N_4/ SI_3N_4 COMPOSITES

In-vitro experiments are conducted to mimic the biological environment outside the real biological medium to identify the behavior of material under simulated conditions. This approach is widely used to evaluate the behavior of materials intended for biomedical applications. The parameters considered in tribological study of Si_3N_4/ Si_3N_4 composites for hip joint replacement include gait load, duration of test being carried out, type of bio-lubricant used, cup inclination angle, head diameter and microseparation[3].

3. CONCLUSIONS

Silicon nitride has gradually found its applications in major fields with its remarkable mechanical and biocompatible properties. Several studies highlighted the improvements in mechanical, tribological and biocompatible properties of silicon nitride by adding additives to form composites. Recently developed Si_3N_4 composite with titania and calcia proved to be excellent biocompatible material for joint replacement. Also, silicon nitride based coatings showed improved wear rate.

4. DECLERATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Wear and morphological analysis on basalt/sisal hybrid fiber reinforced poly lactic acid composites (ID: T094)

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Abstract: The wear behavior study on the basalt and sisal fiber reinforced poly lactic acid (PLA) composites are carried out in this research. Basalt saline treated chopped fiber and treated sisal chopped fiber of 13 µm and 183 ± 35 µm diameter respectively are blend mixed with PLA in twin screw extruder machine, and the specimens were prepared using the injection moulding process. Three weight fraction specimens were prepared such as PBSi-1(90 wt% of PLA, 5 wt % of basalt and 5 wt % of sisal), PBSi-2 (85 wt % of PLA, 7.5 wt % of basalt and 7.5 wt % of sisal) and PBSi-3 (80 wt % of PLA, 10 wt % of basalt and 10 wt % of sisal). The wear behavior of the prepared specimen was examined using the pin-on-disk apparatus. The wear rate and coefficient of friction were measured for four different loads (10N, 20N, 30N & 40N) and four different sliding velocities (100 rpm, 150 rpm, 200 rpm & 250 rpm). The wear mechanism map was generated based on the wear regime nature using the Fuzzy Cluster C-means algorithm. Based on the clustering, mild wear, severe wear, and ultra-sever wear were categorized. The PBSi-3 composite exhibits a low wear rate compared to other composites due to the presence of more weight percentages of basalt fiber. The scanning electron microscope images of the wear region were procured, and the wear mapping was developed by correlating the wear mechanism with the corresponding regions in the images.

Keywords*:* PLA biopolymer composite, Sisal fiber, Basalt fiber, wear mechanism

1. INTRODUCTION

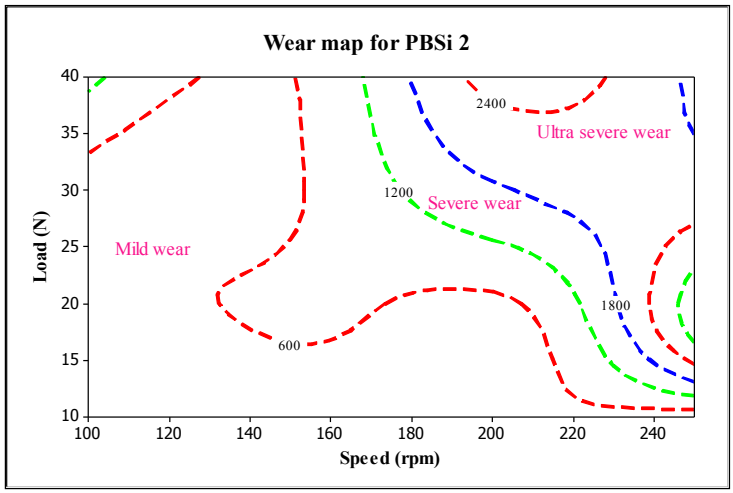
Many researchers have reported that, in composite materials, the matrix and reinforcements phases occur in proximity with the interface producing a complex structure that is different from the basic materials [2]. Few researchers have proved that the reinforcing fiber delivers high moduli and strength, while the matrix absorbs the load and resists corrosion and weathering [3]. Hence, an attempt is made through this investigation to study the influence of different process parameters, including the load (N), sliding velocity in (rpm), % of fiber reinforcement, and their interactions on the wear rate and coefficient of friction (COF) of the PLA composites. The objective of this investigation is the development of a biodegradable green composite with PLA as matrix and a hybrid combination of basalt fiber and sisal fiber as reinforcements.

2. MATERIALS & METHODOLOGY

The abiotic processes are found to break down the PLA with the hydrolysis of the ester-bond without the need for enzymes [18]. As long as the monomers (L.A.) are attained from renewable origins by fermentation, the enzymes are responsible for the collapse of the residual oligomers. This happens until mineralization takes place during the biotic degradation stage of the biodegradation process. The 3052 D lactic PLA of injection molding grade was procured from Nature-Tec India Pvt. Ltd., Chennai, Tamilnadu, India. The Polylactic acid was pre-warmed at 80°C for 8 hours before mixing with the fiber in the twin-screw extruder.

3. RESULTS AND DISCUSSION

The wear map for PBSi-1 hybrid composites is revealed in Fig. 3. The observations made from the wear map showed the occurrences of mild specimen wear for lower loads of 10 N and elevated pin speed. An increase of load beyond 10N and speed resulted in the occurrence of severe wear. With higher load and speed, the ultra-severe wear was observed, which was evident from the poor wear characteristics of the fabricated PBSi-1 composite. In the wear map, the mild wear occupies a small area.



4. CONCLUSION

The tribological behavior and the worn surface morphology of PBSi composites were successfully completed. Based on this research work, the following conclusions are listed.

1. A wear map was drawn for the PBSi-1, PBSi-2 and PBSi-3 specimens. Wear values less than 1200 were termed as mild wear. Severe wear corresponded to the areas between 1200 to 2400. The area beyond 2400 was termed as ultra-severe wear.

5. ACKNOWLEDGEMENT

Authors acknowledge CIPET, Chennai for providing the facility of Pin-On-Disc wear tester.

6. DECLERATION

Authors declare that the present work has not been presented elsewhereor not being consideration for presentation in any journal.

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Effect of Zirconium Silicate and Mullite with three different particle sizes on tribological behavior of Non-Asbestos Organic (NAO) brake pad (ID: T014)

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Abstract: The present work investigates the behavior of two different abrasives: zirconium silicate and Mullite with three different particle sizes (5µ, 44µ, and 149µ) on the frictional characteristics of brake pads. Six brake pads were developed using these two abrasives with three different sizes. The effect of the abrasives towards fade, recovery, and wear was investigated by carrying out the tribological test in a chase tester following SAE J661 standards. Results indicated that brake pads with coarser particles generated excellent resistance to fade and an acceptable rate of recovery. This effect was explained based on the formation of stable friction film observed through the Field Emission Scanning electron microscopy (FESEM) and testing the microhardness at the surface of the samples after dry sliding. However coarser particles exhibited poor wear resistance. In comparison, smaller abrasive particles exhibited poor friction stability with excellent wear resistance. A detailed examination of the wear surfaces was conducted to identify the possible wear mechanism.

Keywords: Zirconium Silicate, Mullite, Abrasives, Wear Resistance, Friction Stability

Tribological /mechnical investigations of additive manufactured polymer composites (ID: T012)

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Abstract: Fused Deposition Modeling (FDM), a category of Additive Manufacturing (AM) is a versatile form of manufacturing technology that enables the development of the part layer by layer, of any complex geometry. The development and utilization of polymer composites for has seen a wide range of implementation. The development of polymer composite by fused deposition technology and evaluation of its Tribological /mechanical properties will find out in this study. Bronze was added as reinforcement at to ABS matrix. The test pieces will be fabricated in diverse directions to examine the influence of FDM Process parameters.

Keywords: Addtive manufacturing, FDM, Polymer composites, Tribological/Mechacal properties

Tribological and mechanical performance report of epoxy-resin composites reinforced with multi-walled carbon nanotubes (ID: T022)

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Abstract: The objectives of the current work are focused on fabricating and testing epoxy- nanocomposites reinforced with different concentrations of multi-walled carbon nanotubes (MWCNTs). MWCNT-epoxy resin nanocomposites are prepared with the help of ultrasonic cell crusher and compression moulding process. Samples are subjected to different mechanical testing such as tensile strength, tensile modulus, flexural strength, flexural modulus, impact strength and hardness test in accordance with ASTM standards. It is found that the mechanical performance of MWCNT-epoxy nanocomposites are improved significantly with the addition of MWCNTs. Pin-on-disc (POD) was used to analyse the tribological characteristics of nanocomposites at varying loading conditions. Worn surfaces of POD samples are analysed using Scanning electron microscope (SEM) to elucidate the wear mechanisms. In addition, it is experimentally proven that strong interaction between epoxy and MWCNTs exist and it helps to improve the interfacial strength between the particles.

Keywords: Epoxy; MWCNT; Nanocomposites; Pin-on-disc; SEM; Tribology

Influence of aluminium foam on dry sliding wear behaviour of glass fiber reinforced epoxy composites (ID: T051)

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Abstract: The usage of sandwich panel structures syndicates low weight with high energy absorbing capacity. Hence they are suitable for applications in automotive, aerospace and shipbuilding industries where the lightweight design philosophy and the safety of vehicles are very important. In the present work, glass fiber polymer composites (GFPC) with aluminium foam were fabricated using the hand-layup method. Sliding wear experiments were conducted under the dry condition on the fabricated samples. The effect of operating parameters like sliding speed (m/s), load (kg), sliding distance (m), and seaweed filler loading on specific wear rate (W_s) was investigated. The results showed a minimum wear rate of 2.4 µm was obtained for the sliding velocity of 1.5 m/sec, applied load of 2 N, and sliding distance of 1000 m. Scanning electron microscopy (SEM) was used to study the worn surface to determine the wear mechanism. The exceptional wear resistance was due to fiber fracture mechanism and microcracking.

Keywords: Wear, Glass, Fibre, Aluminium, Foam

Wear behaviour of basalt fiber reinforced Polypropylene (PP) hybrid polymer composite –Influence of Polylactic Acid (PLA) (ID: T024)

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Abstract: In this work the influence of hybridization of polylactic acid (PLA) in the wear behaviour of basalt fiber (BF) reinforced polypropylene (PP) polymer composite were analysed using pin-on-disk under dry sliding condition. The components of composites PP, PLA and BF (Chopped fiber) are melt mixed in twin screw extrusion and followed by injection moulding. The specimens are named as PPB1 (PP-50%, PLA- 35%, BF- 15%), PPB2 (PP-55%, PLA- 30%, BF-15%) and PPB3 (PP-60%, PLA-25%, BF-15%) based on their volume fraction. The wear-rate and coefficient (COF) is measured for each sample subjected to three different loads and sliding velocities. It is observed from the wear mapping that the wear behavior of sample PPB3 is relatively higher compared to other samples. The scanning electron microscope (SEM) images of worn out region of the sample shows the fracture and dislocations of fibers in the matrix and the sample PPB3 shows uniform wear region. It is due to the better cohesion between the fiber and the matrixes compare with the other samples. The adhesion of matrix and fibers was confirmed by Fourier-transform infrared spectroscopy graph, which indicates the stretching of molecular structure for the occurrence of C-O, and C–H links.

Key words: Polylactic Acid, Basalt Fiber, Wear Behavior, Co-efficient of Friction, Wear Region, Sliding velocity

Thermo-mechanical analysis of ventilated and solid disc brake pad model (ID: T095)

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Abstract: This work attempts to present a study of the automotive disk brake's thermo-mechanical behaviour during the braking period using the Static Structural and Transient Thermal analysis for vehicle disk brake pad system using finite elemental analysis. In this work Static and thermal analysis was performed on solid disc and ventilated disc for single configuration of pad using ANSYS 15. The pure pad profile along with both discs has been studied. The analysis is conducted on the model that lacks thermal properties first. It is predicted for structural performance such as deformation and von-mises stress. After that, with the introduction of heat flux, convection and adiabetic components, thermo-mechanical analysis is performed on the same model. The estimate results of temperature distribution, total deformation and von-mises stress are presented. The software tools CATIA and ANSYS Workbench have been selected for modelling and analysis. CATIA is a widely used 3D modelling technology in the design process. ANSYS is a software package for general purpose finite element analysis (FEA). The outcome of this investigation assists brake engineers in choosing appropriate research to determine the disk brake assembly in structural and contact behaviour.

Surface Engineering & Tribology

Eco-friendly and facile fabrication of superhydrophobic aluminium alloy (ID: T003)

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Abstract: Synthetic superhydrophobic surfaces have drawn significant interest owing to their water-resistant and self-cleaning applications. However, most of the fabrication practices involves complex processes that are unsustainable to withstand large scale fabrication to transform into standard industrial practice. The desired durability of these surfaces is another crucial challenge that makes the translation of these products difficult. In this paper, we reported the fabrication of superhydrophobic aluminum alloy with a simpler, low cost, and ecofriendly technique using the hydrothermal treatment. Subsequently, the surface energy of the processed substrate was modulated using a chemical vapor deposition technique. The developed surface shows an extreme water repellency with a contact angle above 1600 and very low contact angle hysteresis and rolling angle (<50). Surface morphological characterizations showed the formation of nanoscale hierarchical structures which resulted in stable Cassie state due to effective entrapment of air and exhibiting self-cleaning ability. The developed surface showed extreme wetting resilience during exposure to droplet impingement under various heights. Further, these superhydrophobic surfaces were exposed to atmospheric weather conditions to check the robustness. During rain simulator testing developed surface showed low contact angle hysteresis (<100) after enduring multiple cycles. The processed surface also showed significant de-wetting behavior during condensation experiments and chemical resistance under prolonged exposure. Weathering tests performed under outdoor conditions showed an insignificant influence on the de-wettability of the processed sample. The present study highlights the fabrication of superhydrophobic durable metallic surfaces through a facile and green fabrication route for multifunctional applications.

Keywords: aluminium, nanostructures, superhydrophobicity, anti-fogging, self-cleaning

1. INTRODUCTION

Ever since the discovery of “lotus leaf effect”; extreme water repellent surfaces have gained researchers attention and has become a cornucopia for various multi-functional applications (Zhang et al., 2012). Owing to the limitations associated with conventional fabrication techniques (Feng et al., 2013); a simple, low-cost, and environment-friendly technique (Saadi et al., 2017) has been utilised to fabricate superhydrophobic (SHB) aluminium alloy (Al-1100). The evolved surface morphology, wettability and durability assessments has performed under various extreme conditions for a variety of potential applications.

2. METHODOLOGY

Hierarchical structured Al-1100 substrates was achieved by abrasive machining followed by hot water treatment (HWT). The surface free energy of processed substrates was tuned using 1H,1H,2H,2H perfluorooctyl-trichlorosilane (FOTES). Surface morphologies were characterised using atomic force microscope and scanning electron microscope. Wettability examinations were carried out through the sessile drop method.

3. RESULTS AND DISCUSSION

The mean spacing of the processed channels was observed to be 12.40 ± 0.79 µm and R_a was observed to be around 144.2 nm. The HWT resulted in the formation of nanoscale flakes.

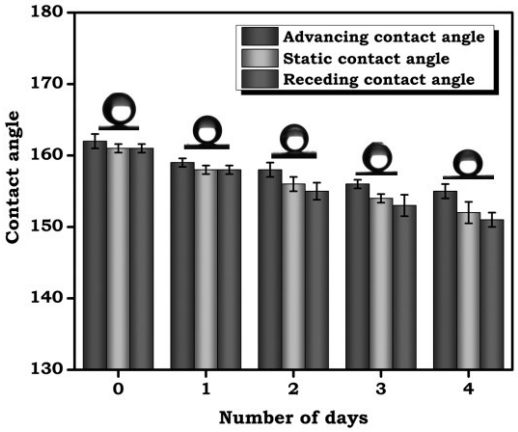

Fig: Weathering test results of SHB Al

The advancing and receding contact angles of SHB samples were observed as 162º and 161º with an extremely low CAH of 1º. This causes significant diminution in the droplet adhesion. High coefficient of restitution (COR) of 0.5 was observed during droplet impact test indicating stable Cassie state. The samples showed good chemical and mechanical stability during weathering, simulated rain and long-term immersion test.

4. CONCLUSION

This works clearly shows a possibility of tuning wetting to various multifunctional applications for future work.

5. ACKNOWLEDGEMENT

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6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Tribological characteristics of thermomechanically processed 7075 Al alloy through nano-scratch characterization (ID: T019)

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Abstract: Precipitation hardening through the formation of $MgZn_2$ intermetallic phases is one of the well-known methods of strengthening in the 7075 Al alloy. In the present investigation, a solution-annealed 7075 Al alloy specimen was subjected to rolling at sub-zero temperature regime and artificial aging at 120°C for 5 h. The tribological behaviour has been studied through parameters like co-efficient of friction, plastic energy and recovery index as well as wear resistance coefficients, recovery resistance parameter, and the wear coefficients were also estimated from the nano-scratch data using Archard's equation.

Keywords: 7075 Al alloy; Sub-zero temperature rolling; Aging; Wear; Nano-scratch.

1. INTRODUCTION

The strengthening of the 7075 Al alloy can be achieved through the formation of $MgZn_2$ intermetallic phases involving the process of precipitation hardening [1]. The mechanical properties of such alloy can be further improved by the combination of different strengthening mechanisms, *viz.,* grain refinement and work hardening along with the precipitation hardening.

2. METHODOLOGY

A solution-annealed 7075 Al alloy specimen was subjected to sub-zero temperature (approx. -20°C) rolling (~25% and ~85% thickness reduction) and artificial aging at 120°C for 5 h. The selected aging duration is the peak-aging duration for this alloy, determined by conducting aging treatments for various durations on specimen's solution-annealed at 480°C for 1 h.

3. RESULTS AND DISCUSSION

The peak ageing condition for T6 sample was found out to be at 120°C for 5 h duration. This arises due to probable formation of the primary equilibrium precipitate phase $MgZn_2$. The tribological behaviour has been studied through parameters like co-efficient of friction, plastic energy and recovery index and the scratch hardness was also estimated using nano-scratch measurements.

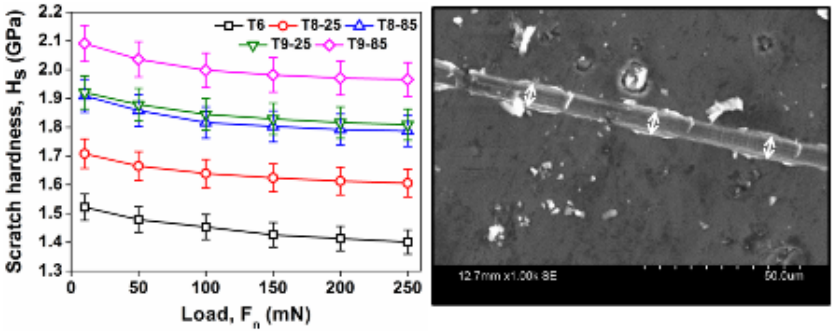

Figure: Scratch hardness of the various thermomechanically treated alloy samples and scratch track on T9-85 sample.

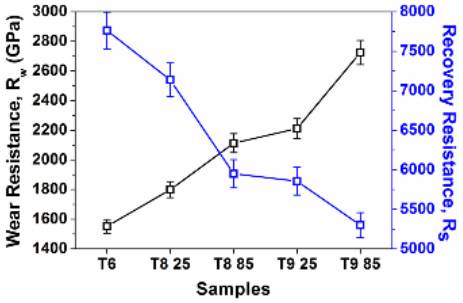

Figure: Wear resistance and recovery resistance of the thermomechanically treated samples.

The scratch hardness was found maximum for the T9-85 samples. Wear resistance coefficients, recovery resistance and wear coefficients of the thermomechanically treated samples were estimated from the nano-scratch data using Archard's equation. The results show that the alloy sample subjected to 85% thickness reduction after aging treatment of 5 h at 120°C shows the highest resistance to wear.

4. CONCLUSION

The peak ageing condition for T6 sample was found out to be at 120°C for 5 h duration. This condition is maintained for all the other thermomechanical processing (T8 and T9 schedule). It has been observed that the alloy sample subjected to 85% thickness reduction after aging treatment of 5 h at 120°C shows the highest resistance to wear.

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Wettability of hydrophobic micro-dimpled hss surfaces (ID: T080)

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Abstract: Hydrophobicity is a significant property of a surface, which proves to be a deciding factor for usage in areas such as lubrication retention, material wear reduction, self- cleaning surfaces, fluid flow analysis, development of Oleophobic (lipophobic + hydrophobic) coatings etc. Surface energy and surface texture are important parameters which influence the hydrophobicity of a material. Micro dimpling of a surface leads to low surface energy, which has proven to be favourable for enhancing surface hydrophobicity. This paper analyses, fundamental concepts pertaining to surface hydrophobicity, which have been experimented on and discussed. The experimentation involved laser textured discs of HSS material having dimple shapes namely circle, triangle and square. The parameters varied were the dimple density in (%) and dimple area in (mm^2). The microtextured discs were individually subjected to a drop of distilled water, and drop profile was observed for a time span ranging 0-30 seconds, to determine the most optimum surface exhibiting the highest contact angle. Thereby affirming its adherence to property of Hydrophobicity. Amongst the textured discs subjected to experimentation, it was verified that the disc with triangular shaped dimples having parameters (dimple density = 10% and dimple area= 0.01mm^2) has displayed maximum Hydrophobicity (Contact Angle = 112.6^0). Also, experimentation results reconfirm that non textured surfaces are least hydrophobic as compared to any of the adopted textured surfaces i.e. Circle, Triangle and Square.

Keywords: Micro Texturing, Laser Surface Texturing, Hydrophobicity, HSS.

1. INTRODUCTION

Hydrophobicity defines how water interacts with the surface of a material, and whether this water repels or has affinity to the surface.

Surface hydrophobicity is a major characteristic taken into consideration for applications in fields related to surface tribological properties, hydrodynamic friction reduction, water repellent textiles, environmental protection, dust and water repellent capacity of solar panels, photovoltaic cells and thermal and energy systems, water-proofing, anti-biofouling (Celia *et al.*, 2013).

2. METHODOLOGY

In this study, experimentation was done on micro dimpled discs having varying parameters such as dimple density (7.5 to 15%), dimple size (0.01 to 0.09 mm^2) and dimple shape (Triangle, Square and Circle). The apparatus used for experimentation was a DIGIDROP Sessile drop profiler and the simulation software used was Visiodrop. The contact angle was observed at the initial stage (zero to three seconds) and culmination stage (thirty seconds from start). The contact angles obtained for each individual set of experiment for circular shaped dimples, have been graphically represented in fig. 1.

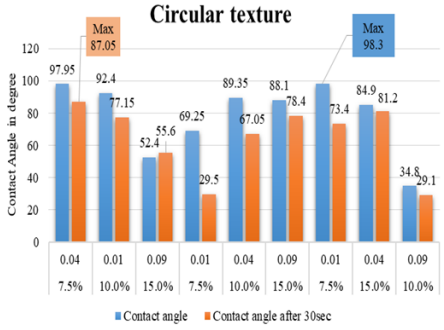

Fig. 1 Plot of contact angle for each experiment of circular dimple.

3. RESULTS AND DISCUSSION

From Fig. 1 analysing circular dimples of size (0.01 to 0.09 mm^2) and dimple density (7.5 to 15%), it was observed that maximum contact angle (98.3^0) at the initial stage (zero to three seconds) was observed for dimple size of $0.09mm^2$ and dimple density 7.5%. At the culmination stage (thirty seconds from start) the maximum contact angle (87.05^0) was observed for dimple size of 0.04 mm^2 and dimple density 7.5%. Hence it was noted that the circular dimples with moderate dimple area 0.04 mm^2 and least dimple density 7.5% gave us the most optimum results for culmination stage and the circular dimples with maximum dimple area 0.09 mm^2 and least dimple density 7.5% showed the most optimum results for initial stage.

4. CONCLUSION

Results indicate that non textured surfaces are least hydrophobic as compared to any of the textured surfaces. Also, it was observed that the percentage variation in contact angle at initial stage and culmination stage was maximum (135%) for circular dimple having dimple density 7.5% and dimple size $0.01mm^2$.

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Wear behavior of friction stir welded AA7075 and AA6063 aluminum alloys (ID: T081)

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Abstract: This work deals an experimental study on wear behaviour of friction stir welded dissimilar AA7075-T6 and AA6063 aluminium alloys. The weldments are fabricated by varying tool traversing speed (45–60 mm/min), rotational speed (1000–1020 rpm), and axial force (3-5 kN). Effects of tool traversing speed, rotational speed, and axial force on wear behaviour of weld zone are analysed by conducting wear tests, measuring microhardness values and examining microstructural images of worn surfaces. Taguchi technique is used to analyse the effects of each welding parameter on wear behaviour. The results of this work indicate that the tool rotating speed is the most influencing parameter on the wear rate of weldments, when compared to traversing speed and axial force.

Keywords: Friction stir welding, weight loss, micro-hardness, Taguchi technique.

1. INTRODUCTION

The second most abundant metallic element available on earth is aluminium, also in engineering applications recently become a financial competitor. The demand of three essential modern industrial improvements was adapted to aluminium and its compounds having interesting characteristics and reliable material attributes to meet the demands, extraordinarily advantage development in the creation and utilization of the new metal. FSW is an advanced solid-state welding method broadly used in building of aerospace and military structures (Thomas W.M et al., 1991). In fusion welding process heat generation was more so the weld metal (aluminium) went to liquefied level so that aluminium alloys were not suitable for other fusion welding techniques like TIG, MIG, Gas, Electric arc welding process. The efficiency of the joints achieved 80-90 % when using friction stir welding process which does not depend on the working material's thickness of plate because 1mm plate is also obtained by this process only (Mohan. D et al., 2014). In order to minimize the wear rate, Taguchi method has been used to optimize the weld process variables. The weld joints of AA6063 and AA7075 alloys were fabricated with varying traversing speed (30-45 mm/min), rotational speed (1000–1200 rpm) and axial force (4 –6 kN).

2. METHODS

HSS tool with hexagonal pin of 5 mm pin diameter and 15 mm shoulder diameter was used for making butt joints. To analyse the wear behaviour of each joint, wear test, hardness test and microstructural analysis were carried out. For wear tests, 16 mm diameter circular pieces were cut at weld nugget. The wear tests were carried out using rotary drum abrasion resistance tester. Microhardness values across the weld zone were measured using Wilson Wolpert micro Vickers Hardness Tester. AA6063 and AA7075 aluminium plates with 150×50×6 mm is used as base metals to make butt weld joints. In this process, AA6063 plate is placed in advancing side whereas AA7075 plate is placed in retreating side. Butt weld joints were fabricated by varying traversing speed revolving speed, and axial force. In Taguchi technique, to evaluate the performance level of process variables, objective functions are converted into signal to noise (S/N) ratio.

3. RESULTS AND DISCUSSIONS

Frictional heat generation during welding is directly proportional to tool rotational speed Cooling rate during welding is directly proportional to tool traversing speed and downward axial force and heat input to leading side. To attain a good bonding at stir zone. whenever 6000 series alloys are involved, Mg_2S_i precipitates are formed (R.

A. Kumar et, al,. 2017). Temperature at stir zone is based on heat generation during welding. These precipitates get grow and dissolved at insufficient heat input and reprecipitated at sufficient heat input De-pending upon the heat input variation, percentage of precipitate growth, dissolution and reprecipitation are varied.

4. CONCLUSION

In this investigation, wear behaviour of friction stir welded AA7075 and AA6063 aluminium alloys are studied. The welding parameters with respect to wear characteristics are optimized using Taguchi L9 orthogonal array. The welded joints fabricated with 1100 rpm rotating speed, 30 mm/min traversing speed and 6 kN axial force exhibits higher wear resistance. The tool rotating speed contributes extensively with the percentage of 65.39 on wear characteristics.

5. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal

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Evaluation of PEEK to PEEK friction welded joint properties (ID: T086)

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Abstract: Poly(ether ether ketone) (PEEK) is a semicrystalline organic polymer. It has widely been used as high-performance engineering plastic owing to its high melting point, excellent mechanical strength, and outstanding chemical resistance. Therefore, PEEK and its composites have shown lots of applications in aerospace and medical fields. However, its application is redistricted due to poor strength at the mechanically joint components. Thus, this scope leads us to study an alternative method of joint process that will lead to finda new joining process for PEEK based materials. In this study, a solid state joining process was conducted to join two PEEK rods by friction welding process. Here, we optimized the parameters such as, forge load, friction load, and forge time of friction welding that have moreinfluence on tensile stress and hardness of the material after friction welding process. It has been found that the forge load had highest influence and forge time had least influence on tensile strength. Their optimal values were calculated after considering the trend in hardness values by statistical analysis using Minitab software. After the optimal values, the above parameter showed negative effect on the high tensile stress due to the change in crystallinity of the friction welding processed PEEK as confirmed by X-ray diffraction, microstructural and thermal analyses.

Keywords*:* Friction Welding Process; PAEK; Statistical analysis, XRD; Roughness

1. INTRODUCTION

Poly(ether ether ketone) (PEEK) belongs tosemicrystalline organic polymer called poly(aryl ether ketone) (PAEK), has high melting point, high strength, and excellent chemical resistance [1].The PEEK composites have shown good mechanical and tribological properties [2].However, application of PEEKin engineering filed is hindered by its poor mechanical strength at joint components. Friction welding of dissimilar polymer materials has been an attractive emerging technique for engineering applications in last few years [3]. Therefore, present aimed to adopt thefriction welding process as an alternative method of joining process for PEEK for engineering applications.

2. METHODOLOGY

In this study, a solid state joining process was conducted to join two PEEK rods by friction welding process. Here, we optimized the parameters such as, forge load, friction load, and forge time of friction welding that have moreinfluence on tensile stress and hardness of the material after friction welding process.

3. RESULTS AND DISCUSSION

Forgeload had more influence in tensile strength compared to hardness. The tensile strength of the welded PEEK is lesser than PEEK rod due to the influence of the temperature evolved by friction during welding. The friction or temperature further alters crystallinity of friction welding processed joint part of the PEEK compared with virgin PEEK rod.

4. CONCLUSION

Considering tensile strength and hardness of the friction welding processed PEEK, the optimal valuesof forgeload, friction load, and friction time are set as 100N, 450N, and 8s, respectively.

5. ACKNOWLEDGEMENT

Authors acknowledge Machine Shop, Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur for providing the facility of friction welding process.

5. DECLARATION

Authors declare that the present work has not been presented elsewhereor not being consideration for presentation in any journal.

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Prediction of suitable heat treatment for H13 tool steels by application of thermal shock fatigue cycle (ID: T083)

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Abstract: The present study investigates the as-received, heat treated, and heat treated and nitrogen treated H13 tool steels subjected to a thermal shock gradient similar to the actual industrial applications. The thermal shock gradients were created by using an in-house built thermal shock fatigue cyclic (TSFC) treatment machine. Effect of TSFC treatments at 1000 and 2000 thermal shock cycles in hot and molten metal chambers was noticed. All the TSFC treated samples were analysed by hardness, X-ray diffraction, microscopy and magnetic tests. The interesting changes in hardness, distorted crystal structure, and crack initiation were found to be different for differently treated H13 tool steel specimens. The molten Al was more prone to stick to the surface of AR as well as HN steel compared to the hardened H13 steel specimens, which would delay the crack initiation. The wear resistance properties of the hardened H13 steel specimens have shown higher compared to AR and HN after TSFC treatment. The loss in magnetic properties was significant for the heat treated hardened, and nitrogen treated samples compared to as-received H13 tool steel specimens. Therefore, the present thermal fatigue cycles 1000 and 2000 for 30 s at 670ºC would worthy to predict the proper heat treatment method in order to design the parameters as well as life of die-casting components and to help in economical production of casting.

Keywords: manufacturing; die-casting; hot work; residual strain; hardening

1. INTRODUCTION

The H13 or hot-worked die steel been used as die in hot-forging, die-casting, hot-extruding, and so on since last few decades [1]. Pressure die-casting process has widely been used in industry due to its low cost, high quality, and short lead-time. However, high temperature and pressure deteriorate the quality of tool or die and thus, increase the cost of castings significantly by replacing the mould components repeatedly. Thus, the role of surface treatments is crucial to protect the hot work steel from early thermal fatigue crack formation and/or propagation [2]. Hence, present study aimed to develop a proper simulated thermal gradient to predict the mould or tool material properties through their structural, mechanical and magnetic properties.

2. METHODOLOGY

In this study, the as-received H13 steel along with its with its differently heat treatments, one is heat treated by hardening and another is hardening followed by nitrogen treated, were subjected to two different simulated thermal shock fatigue cyclic (TSFC) conditions, which are generally exerted to the die or mould components in actual industrial cyclic heating applications.

3. RESULTS AND DISCUSSION

Results showed that the significant changes in hardness, crystal structure distortion, crack initiation, wear and magnetic properties due to the imposed cyclic thermal gradients exerted by TSFC treatments at 670 ºC for 1000 and 2000 thermal shock cycles in hot chamber as well as immersion in molten Al-metal were observed.

4. CONCLUSION

This study predicts that the hardened H13 steel samples would delay the crack initiation in hot air chamber as well as in molten metal and hence, would increase the life of tool or die-casting components. Therefore, the present thermal fatigue cycle numbers 1000 and 2000 for 30 s cycle time at 670 ºC would worthy to predict the life of die-casting components and to help in economical production of casting.

5. ACKNOWLEDGEMENT

Authors acknowledge Department of Mechanical Engineering, Nanotechnology and Research Centre (NRC), Physics and Nanotechnology, SRM Institute of Science and Technology, Kattankulathur.

6. DECELERATION

Authors declare that the present work has not been presented elsewhere or not being consideration for presentation in any journal.

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Correlating the stress state with morphological and tribological properties of thin coatings (ID: T018)

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Abstract: The wear resistance of mechanical parts of irrigation pumps can be improved by deposition of hard ceramic coatings. Friction tests were carried out on AMSLER machine using thin coatings of $Al_2O_3 – 40TiO_2$ (AMDRY 6250) powder deposited by atmospheric plasma spray (APS) on steel samples obtained by cutting an irrigation pump sleeve. The tests on AMSLER machine of coated samples with various thickness were realized in dry conditions, low and high loads and constant speed, the span of the test being one hour. Before and after the wear tests, the microstructure of the coatings was analysed by optical microscopy (OM) and scanning electron microscopy (SEM). The composition of the coatings was determined by energy dispersive X-ray spectroscopy (EDS). A theoretical model for stress computation in coatings was employed, the input data being taken from the previous experimental results on AMDRY 6250 coatings of three different thicknesses. The correlation of theoretical and experimental results indicated that the proper choose of the coating thickness play an important role in the position of maximum equivalent stress with respect to the bound interface between the ceramic coating and the substrate.

Keywords: *coatings; optimum thickness; stress state; $Al_2O_3 – 40TiO_2$; AMSLER machine*

1. INTRODUCTION

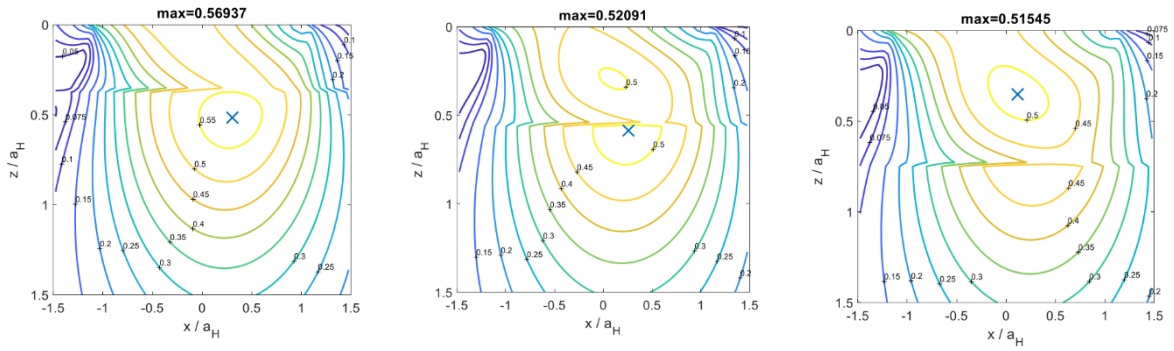
Atmospheric plasma spray (APS) deposition of coatings is a versatile thermal process, as it allows deposition of various powders in a wide range of thickness and porosity values. The resistance of the coatings at mechanical and thermal stress, and in corrosive environment depends on the quality of both the substrate and coating material, on deposition method and parameter, but can be influenced by the position of the maximum Von Mises stress. The aim of the paper is to correlate the results of dry friction tests, carried out on AMSLER machine at constant speed and light and heavy loads, with the position of the maximum Von Mises stress.

2. METHODOLOGY

According to the methodology described in Paleu et al. [1] and Paleu Cîrlan et al. [2], mean friction coefficients were determined from tribological tests, these values being inputs for the multilayer materials contact mechanics computer program [3]. The proposed algorithm was applied to calculation of stresses in the coated body, aiming to find the magnitude and position of the maximum equivalent von Mises stress in the sliding contact between a homogeneous spherical indenter and a coated half-space. In order to provide design recommendations, two loading levels, three coating thicknesses and three elastic moduli mismatches between the coating and the substrate were considered in the set of simulations.

3. RESULTS AND DISCUSSION

The results show that, even the friction tests predict favourable results for a coating of a certain thickness, the position of the maximum Von Mises stress may influence the coating resistance to wear (Figure 1).



(a) (b) ©

Figure 1: Maximum Von Mises stress for AMDRY 6250 coating on steel substrate for various coating thickness, (a) 55.56 µm, (b) 87.89 µm, and (c) 116.58 µm.

4. CONCLUSION

The magnitude of the maximum von Mises stress may indicate propensity to plastic yield if the yield stress of the elastic material is surpassed, whereas location in the vicinity of the interface between the coating and the substrate may favour crack nucleation. To completely validate the obtained results, further long-lasting tribological tests are planned.

5. DECLARATION

The work has not been presented elsewhereor not being consideration for presentation in any journal.

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Influence of powder feed rate on the slurry abrasive wear behavior of Co-Cr alloys deposited on SS 316L material (ID: T027)

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Abstract: Co-Cr alloys (Stellite 6) are commonly deposited as hard-faced materials for improved wear resistance and higher hardness. In this work, Co-Cr alloy has been deposited using plasma transferred arc (PTA) welding process on SS 316L substrate material. Effect of powder feed rate on slurry abrasive behavior of the Stellite 6 layer has been observed using mechanical and metallurgical characterizations. Slurry abrasive wear test and microhardness test were conducted in order to investigate influence of deposited material. Microstructural characterization of Stellite 6 deposited on SS 316L substrate were carried out. Depending upon the powder feed rate, the deposition efficiency has been calculated and compared with other process parameters to study the effect on tribological behavior of Stellite 6. Mechanical and metallurgical investigations confirm that 8 - 12 gm/min can be used for the said material combination since it has showed the excellent deposition efficiency and mechanical performance.

Keywords: SS316L, Stellite 6, PTAW, Slurry abrasive wear, Metallurgical characterization.

1. INTRODUCTION

There are many different materials used as hardfacing materials, Stellite 6 is one among them. These materials have good corrosion and wear resistance under varying environmental conditions in industries such as nuclear power plant, mining, petroleum, etc. (Gurumoorthy et al., 2013). SS 316L material is used as substrate material for various industrial components like engineering valves, pressure valves, pipelines, etc. in industrial sectors such as oil, petroleum, chemicals, fertilizers (Mandal et al., 2015). Amongst these components, engineering valves are usually exposed to slurry conditions in chemical and petroleum plants which demand higher slurry abrasive wear resistance and hardness at the exposed surface. However, process parameters such as current, powder feed rate, oscillation speed plays an important role to achieve improved mechanical properties (Mandal et al., 2015; Balasubramanian et al., 2009).

2. METHODOLOGY

Plasma transferred arc (PTA) welding process is used as hardfacing technique having minimal dilution and higher deposition rates in order to deposit advanced grade materials to increase hardness and wear resistance. Slurry abrasive wear test and microhardness test were conducted in order to investigate influence of deposited material. Microstructural characterization of Stellite 6 deposited on SS 316L substrate were carried out to understand the effect of powder feed rate on the overlaid surface. X-ray powder diffraction (XRD) is used for phase identification where as optical microscopy is carried to observe microstructure of Co-Cr based coated material.

3. RESULTS AND DISCUSSION

Powder feed rate plays an important role in deciding the better metallurgical bond between substrate and coated material. One of the important findings in this paper supported by the previous researchers is the decreased dilution with increased powder feed rate. Upon mechanical and metallurgical characterization, it is observed that, 8 -12 gm/min is the optimum range which can be used for better deposition efficiency and mechanical performance.

4. CONCLUSION

Mechanical and metallurgical investigations confirm that 8 - 12 gm/min can be used for the said material combination since it has showed the excellent deposition efficiency and mechanical performance.

5. ACKNOWLEDGEMENT

Authors are thankful to M/S KOSO India Pvt. Ltd., Nashik, Maharashtra, India, for providing good quality machine, materials and testing facilities to perform necessary experimental work.

6. DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Understanding the wear behavior of polymer coated steel surfaces in presence of commercial greases (ID: T084)

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Abstract: The current work investigated the lubricating performance of two commercial greases. The base oils in Grease 1 were mineral oil and Grease 2 had polyalphaolefin oil. Anti-wear and extreme pressure tests of the greases were conducted using a four ball tribometer according to ASTM 4172 and ASTM 2783 standards. To further analyse the wear behavior of the greases, in the presence of polymer coating, wear tests were carried out using a pin-on-disc tribometer according to ASTM G 99 at a normal load of 160N and angular velocity of 400 and 1600 RPM. Additionally, industrial grade sand was mixed to both greases on a weight percentage basis. A single layer of the grease, now mixed with sand, was applied on the disc and wear tests were conducted for 3600s with a load of 160N and angular velocity of 400 and 1600 RPM. From the anti-wear test results, it was concluded that Grease 2 performed better than Grease 1 as the coefficient of friction values were lower for Grease2. From the results obtained from the pin-on-disc tests, it was observed that at an angular velocity of 400 RPM, the coefficient of friction values obtained for Grease 2 were lower as compared to Grease 1. However at an angular velocity of 1600 RPM, it was observed that both greases showed similar values for average coefficient of friction. The surfaces of the steel balls used in extreme pressure tests were analysed using SEM, 3D profilometer and Raman spectrograph. The polymer coated pins used in pin-on-disc tests were analysed using 3D profilometer. It was concluded that due to the presence of ZDDP in Grease 2, it performed better than Grease 1.

1. INTRODUCTION

This study initially investigates the tribological properties of two commercial grease containing molybdenum di sulphide and ZDDP additives. Additionally the study was extended to understand the wear of polymer coated steel surfaces. These types of polymer coatings are generally used in automotive industries. The results will be helpful for automobile industries in understanding the tribological properties of the greases and the wear behavior of the polymer pins in the presence of the greases.

2. METHODOLOGY

Two test rigs were used to analyse and study the lubricating performance of the two greases. The anti-wear and extreme pressure tests were performed using a four ball tribometer. Anti-wear tests were carried out under a load of 392N, for a duration of 60 minutes at a temperature of 75 ℃. The extreme pressure tests of the greases were conducted by applying loads – 500 N, 630 N, 800 N, 1000 N, 1260 N, 1600 N and 2000 N. The top ball rotated at 1750 rpm and the test duration was 10 seconds at ambient temperature. Wear tests, in the presence of polymer coating were carried out using a pin-on-disc tribometer according to ASTM G 99 at a normal load of 160N and angular velocity of 400 and 1600 RPM. They were two sets of wear tests conducted-without sand, with added sand acting as impurities. A 3D profilometer was used to measure the surface roughness of the wear scar on the lower balls after the tribo tests using the four ball tribo meter and the pin surfaces used in pin on disc. A scanning electron microscope (SEM) was used to understand the severity of the wear occurred during the four ball tests.

3. RESULTS AND DISCUSSION

From the anti-wear test results, it was concluded that Grease 2 performed better than Grease 1 as the coefficient of friction values were lower for Grease2. From the results obtained from the pin-on-disc tests, it was observed that at an angular velocity of 400 RPM, the coefficient of friction values obtained for Grease 2 were lower as compared to Grease 1. However at an angular velocity of 1600 RPM, it was observed that both greases showed similar values for average coefficient of friction.

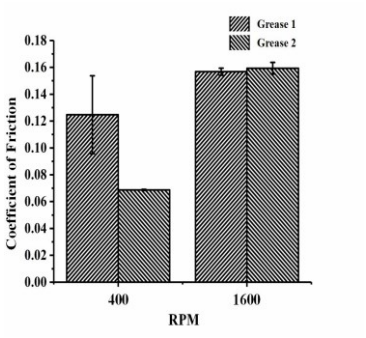

Figure 1.3.1: Comparison of CoF

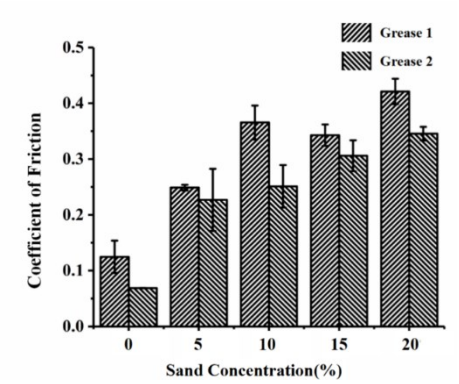

Figure 1.3.2: Comparison of CoF values without sand values without sand

Analysis from 3D profilometer and SEM concluded that Grease 2 had better lubricating characteristics of the two greases. On further characterizing the greases it was observed that Grease 2 contained additives of phosphates and zinc while Grease 1 contained molybdenum and sulphur additives, indicating that the greases containing compounds of sulphur or molybdenum might exhibit better tribological properties than the greases containing compounds of phosphates or zinc.

4. CONCLUSION

From the complete analysis of the obtained results, it was concluded that Grease 2 is better grease than Grease 1.

5. ACKNOWLEDGEMENT

The authors are grateful to Rane NSK Steering Systems, Guduvanchery, Tamil Nadu, for providing financial support to carry out the work.

6. DECLERATION

This work has not been presented elsewhere or not being consideration for presentation in any journal.

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Study of tribological properties of multilayer Ti/TiN coating (ID: T096)

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Abstract. Ti/TiN multilayer coating was deposited by unbalanced reactive pulsed d.c. magnetron sputtering system.. The characterization of the coating was done by XRD, SEM, and EDAX. The coating had NaCl type of structure and XRD results showed the preferential crystallographic orientation of TiN was along [111] direction. The tribological properties, wear and coefficient of friction of the nanostructured coating was evaluated under reciprocating sliding conditions using paraffin oil as a lubricant. Although, there was no significant decrease in coefficient of friction at different loads and temperature, a significant reduction in wear loss was detected at 100 °C temperature. Finally, the resulting wear tracks were characterized for their morphology, roughness and elemental composition trough SEM, EDAX, AFM, and XPS.

Keywords: Ti/TiN multilayers, Wear, Nanolayered multilayer coatings, Reciprocating sliding contact

1 INTRODUCTION

Tribological problems due to friction and wear are one of the major concerns of the industries. The cutting tools, automobile, and aircraft industries require solution related to these tribological problems. The multifunctional thin film physical vapour deposition (PVD) coatings have been used in industries widely to provide unique solutions to the problems arising from friction and wear. Today, we can design novel coatings in the form of nanocomposite and multilayer arrangements, which are tailored to meet the desirable properties [1-3]. In this work, the tribological behavior of Ti/TiN multilayered coating has been studied in the lubricated environment at 30 and 100 °C, respectively. Paraffin oil was used as a lubricant, as it is the most used and studied lubricant for industrial applications.

2 METHODOLOGY

Ti/TiN coating was deposited on 100Cr6 steel and silicon substrates. Reactive unbalanced magnetron sputtering equipped with four targets was used, and the targets were powered by pulsed DC power sources. All the cathodes were equipped with 6-inch titanium targets. A Ti interlayer was deposited on the substrates for better adhesion of the coatings. Reciprocating sliding tests were conducted to investigate the tribological properties of the multilayer coating. 10 mm diameter hardened 100Cr6 steel ball was used to slide against the coated substrates under lubricated and non-lubricated conditions. The normal load used was 2 and 7N corresponding to 0.5 and 1 GPa of Hertzian contact stress, respectively. Sliding frequency of 5 Hz and a stroke of 2 mm was given to the reciprocating arm. The tests were conducted at 30 and 100 °C for 18000 cycles.

3 RESULTS AND DISCUSSION

Figure. 1 shows the variation of the average coefficient of friction at different loads and temperatures for lubricated and unlubricated conditions. The coefficient of friction was slightly higher when tested at 100 °C than the one tested at 30 °C. However, the average coefficient of friction at 7N load is about 10% lower as compared to 2N load at both the temperatures. A similar kind of behaviour was also observed when the coating was tested in unlubricated condition (Figure. 1). This small difference can occur due to deformation of surface asperities at higher load. During sliding the peak of the surface asperities get sheared and thereby reduces the surface roughness to some extent [4]. In unlubricated conditions the percentage reduction in COF was more than that of lubricated conditions, as in the former the COF solely depends on surface asperities while the latter lubricant also plays a significant role in reducing the COF.

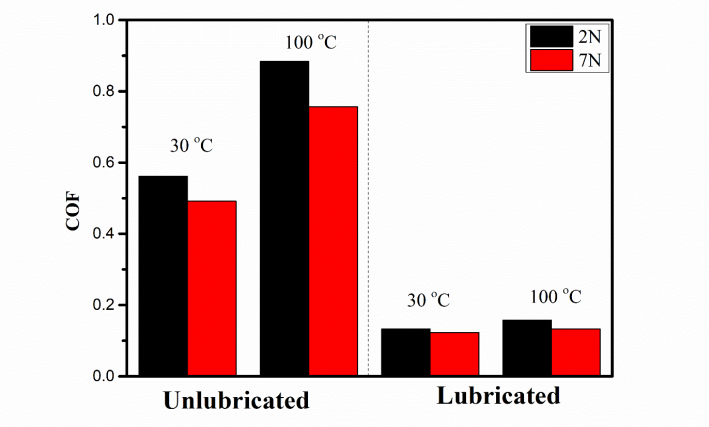

Figure 1: COF graph under different conditions

The wear obtained at 100 °C is considerably lower than wear at 30 °C because of some tribo-chemical reaction might have influenced the wear surface, which would have formed a tribo-film and protected the surface from getting worn out.

4 CONCLUSION

Following conclusions were drawn:

1. The COF did not change much in boundary lubrication condition. However, the COF decreased at higher load because of shearing of surface asperities at higher load.
2. A significant reduction in wear was observed when tested in lubricated conditions at a higher temperature.
3. The Raman results showed the formation of TiO2 phase, and no peaks of TiC phase were found.
4. The rutile phase of TiO2 being the most stable phase, increased the wear resistance at higher temperature.

5 DECLARATION

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Molykote – anti friction lubrication coating process establishment on solenoid armature & it tribo performance (ID: T030)

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Abstract: Molykote Anti-Friction Coatings typically contain MoS2 (molybdenum disulfide), graphite or PTFE lubricating solids. Depending on Lubrication need, precise formulations can be engineered with these or other lubricating solids to provide customized options that meet exact requirements. Product selection depends on service requirements, the desired coating method and specific advantages for different applications. From selecting the right formulation for the application needs to be identifying the proper coating methods that can rely on Molykote experts. 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 that than other application because of roughness value to be maintained. Mean time, there is a requirement of only specific portion of the component to be coated that leads to masking of the part before coating. In order to meet the roughness requirement of the component, there are different trails carried to evaluate the options related to the base preparations of surface, masking and coating parameters.

Keywords: Molykote, Surface Roughness, Spray paint

Reciprocating sliding behaviour of solid lubricantcoating over modified titanium alloy surfaces (ID: T067)

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Abstract: Tribological behaviour of contacting surfaces rigid sphere with its flat plate under the influence of normal and tangential loading (shear traction) is analysed using FEA model the surfaces being coated on flat plate as substrate by Titanium Alloy, Aluminium Alloy Molybdenum Disulfide. The elastic perfectly plastic contact is assumed on the flat model. the Results obtain from the software are used in the understanding by the tribological Behaviour of the coatings with respect to substrate .the finite element model facilitates to Evaluating the surface variables like contact stress distribution at the surface and surface level, contact pressure, shear stress and displacement .the finite element solution is validated Through the hertz solution and on the successful verification

Diamond like carbon coating on Y-TZP for dental implant (ID: T087)

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Abstract: Background: Zirconia can be used as alternative to titanium implant. Thus, the aim of the experiment to obtain thin film Coating on the Y-TZP achieve surface roughness required for osseointegration. **Material and Method:** Y-TZP material was divided into three groups with different post sintering (polishing and sandblasting) process which was coated with Rf sputtering to obtain thin film coating. Parameters opted in this process was power 200 W and duration of 90min at room temperature. The coated material was further tested by Raman spectroscopy, X-RD, 3-D surface roughness. **Results**: The results confirm the thin film coating on the material by Raman Spectroscopy the calculation by ID/IG Varying 0.54 to 0.8. The X-RD reveal the presence of tetragonal phase of Y-TZP. Polished Y-TZP measured the least surface roughness with range of 0.058 to 0.0397 µm which was not suitable for osseointegration the implant. **Conclusion**: To achieve the clinical success of dental Y-TZP implants and whether the osseointegration of Y-TZP is compared to that of titanium, the standard implant material.

Keywords: Thin films, Y-TZP, Implants, Rf Sputtering, Surface Roughness.

Wear, scratch and corrosion resistance of aluminide coating prepared on Ferritic Martensitic steel (ID: T055)

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Abstract: The present work aims to study the wear, scratch and corrosion resistance of aluminide layer prepared on Ferritic-Martensitic Steel (RAFMS) by Hot-dip aluminizing (HDA), subsequent diffusion annealing and oxidation processes. Dry sliding wear, scratch and corrosion resistance properties of these coatings were measured for the HDA, oxidized HDA and uncoated RAFMS at room temperature using standard test tools, respectively. The experimental results revealed that the wear, scratch and corrosion resistance of oxidized HDA samples are superior compared to other samples at all test conditions. Keywords: Sliding wear, Scratch, Corrosion, Tritium permeation barrier and Hot dip aluminizing.

Influence of mechanical properties of coating and substrate on wear performance of h-DLC or TiN- coated AISI 5140 steel (ID: T011)

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Abstract: In order to improve the wear characteristics of AISI 5140 steel, H-DLC and TiN thin films were deposited by using magnetron sputtering technique.The wear resistance,hardness of the coatings andsubstrates were evaluated. The results revealed that,various wear patterns are noticedin both coatings. In tribological tests, noticed thedominant wear mechanisms of TiN coatings are tribochemical wear, substrate material removaland wear debris.Nevertheless, the H-DLC coating experiences wear due to ploughing action,theminor patches of the thin film removed from the base material and no measurable wear was found by SEM observations. Hence, the durability of component is improved compared with substrate and other coatings.

Keywords: Hydrogenated diamond like carbon (H-DLC),Titanium nitride (TiN), Pin-on disc tribometer (POD), wear

Medico-Tribological investigation of pulsed plasma nitrided austenitic stainless steel (ID: T009)

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Abstract: Austenitic stainless-steel grade AISI 304 is one of the most commonly used surgical stainless steel. The surface of the material was modified using pulsed-plasma nitriding treatment under different experimental conditions derived from statistical design of experiments. In-vitro Bacterial sensitivity of pulsed plasma nitrided stainless steel grade 304 was studied using Bacillus Subtilis, a gram-positive bacterium. The specimens were investigated for their mechanical, tribological and micro-biological properties correlating the process parameters like gas ratios, process temperature under constant process duration and pressure. Bacterial sensitivity tests were conducted on specimens incubated for durations up to 48 hours. Tests indicate that nitriding has a positive effect on micro hardness, bacterial adhesion and wear loss under dry unlubricated pin on disc tests compared to virgin material. The materials were investigated using micro Vickers, optical microscope, tactile roughness gauge and LED-CCD optical micrometer. Enhanced surface hardness and improved wear resistance was observed in specimens nitrided at higher temperatures.

Wear behaviour of AA6061 processed by equal channel angular pressing (ID: T046)

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Abstract: Aluminum 6061 alloy is used in aircraft and marine fittings, camera lens mounts, bike frames and structural applications due to the its excellent joining characteristics, good acceptance of applied coatings, combine relatively high strength and good workability, corrosion resistant. Indeed, wear resistance is one of the most vital properties that critically influence the efficient functioning of the devices and components. There are several processes have been formulated for the production of high strength aluminum. But for the production of ultra-fine-grained material through severe plastic deformation, ECAP serves as a promising technique than any other metal forming process like cold working, forging, machining, etc., Though ECAP improves mechanical properties it is important to investigate their wear resistance since ECAP involves significant grain refinement which in turn plays vital role on frictional properties. Therefore, a research work has been formulated in order to examine the effect of ECAP on wear properties of Al-6061 alloy. ECAP was carried using a die with angle ' '= 90° and corner angle 'Ψ' = 20° through route A up to four passes. The effect of different passes of ECAP on the wear properties have been studied using Pin-on-disc dry wear testing for three different loads at a constant sliding speed 750 RPM and distance of 5 kms. ECAP processed AA6061 is good in wear resistance than as-received (unECAPed) AA6061.

Keywords: AA6061, SPD, ECAP, Mechanical Properties, Wear Study

The effect of deep cryogenic treatments on the microstructure and wear behaviour of 3.6-C 2.8-Si ductile cast iron subjected to austempering (ID: T082)

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Abstract: The mechanical properties of ductile cast iron can be greatly enhanced by austempering heat treatment. Excellent properties of Austempered Ductile Iron (ADI) is given by its unique microstructure which consists of graphite nodules, bainitic ferrite and retained austenite. In this work, the influence of austempering and subsequent cryogenic treatment on the microstructural changes and wear properties ductile cast iron has been explored. The ADI samples were produced by different austempering heat treatments carried out at 390℃ and 290℃ for various durations in KNO3-NaNO3 salt bath and were cooled to room temperature in the open air. These samples were subjected to cryogenic treatment in liquid nitrogen followed by bringing the samples back to ambient temperature. Wear tests, Hardness tests, micro structural studies and XRD characterization were done on the samples. Both wear and hardness test results indicate that the cryogenic treatment on ADI does improve its properties. A 39 % and 35% improvement in hardness and wear resistance was observed respectively for the 390℃ austempered-cryotreated samples. The enhancement in wear resistance can be attributed to increased hardness attained from the transformation of retained austenite into martensite during cryogenic treatment.

Keywords: Austempered Ductile Iron (ADI), Cryogenic Treatment, microstructure, wear behaviour, XRD characterization

Influence of countersurface roughness on two-body abrasive wear of Hastelloy C-276 in dry sliding conditions (ID: T101)

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Anstract: Alloy C-276 finds application in a wide range of process industries. This is due to the excellent resistance to corrosion it exhibits to a variety of environments encountered in chemical processing and allied industries, which calls for a need of study in tribological properties. The requirement of enhanced tribological properties has influenced the use of advanced surface roughness techniques for metals and alloys. In the present work, the two body abrasive wear behaviour of Hastelloy C-276, Nickel-Molybdenum-Chromium based superalloy, was studied and compared under various parameters. The dry sliding wear behaviour of C-276 was slid against a counter surface of various grit sized paper. A constant sliding speed of 0.2 m/s was provided along with a sliding distance 100 m. The contact pressure was varied from 0.5 MPa to 3 MPa. The countersurface grit size was varied from 80 to 320. It was observed that wear rate improved for counter surface grit size of 320 when compared to that with 80. The SEM, EDS and EBSD of the worn out pin surfaces were analysed.

Transitions in two-body microscale abrasive wear of Hastelloy C-22 superalloy (ID: T102)

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Anstract: Hastelloy C22 is a nickel-based alloy with high nickel (56%), chromium (22%), and molybdenum (13%) based superalloy. The C-22 is a great alternative to super austenitic stainless steels and can withstand extremely aggressive media. This suggest the potential usage of alloy in in piping and tubing carrying aggressive chemical-slurry media where it can be prone to two body abrasive wear. In this work, the two-body abrasive wear behaviour of haste alloy C22 is explored with micro- SiC particles as the abrasive media. The experimental studies were conducted by varying the contact pressures experienced at the particle substrate interface. The two-body abrasive wear mechanism and the transitions of the same including third body abrasion due to produced debris were studied. The results show that the contact pressure has direct dependence on the two-body abrasive wear behaviour of the alloy. Moreover, the transitions were found to be influence by sliding distance as well as the contact pressure. Onset of third body abrasion can reduce the friction and wear of the interacting surfaces. The studies and the findings are expected to give insights into exploring the possibilities of haste alloy C22 in applications dealing with scenarios like two body-three body abrasion.

Keywords: Hastelloy C22, Two body abrasion, Micro-scale wear

Micro tribological properties of Ti-6Al-4V in comparison to Ti-6Al-4V shot-blasted (ID: T104)

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Abstract: Shot blasting technique is a surface hardening method that can improve the surface properties of titanium alloys. Ti-6Al-4V(as-received) was used to study their surface properties in comparison to shot blasted Ti-6Al-4V. Shot blasting technique was instigated by blasting Aluminium Oxide (Al2O3) Grits of mesh size 80 on the Ti-6Al-4V surface with a constant pressure of 0.6Mpa. The 3D -surface topography of the shot-blasted sample shows substantial surface deformation and increased surface roughness in comparison to the as-received sample. Further, the specimens were tested using a reciprocating tribometer tester, where the steel balls were reciprocated on the specimen surface at a frequency of 5 Hz under different loading conditions. The surface characteristics were examined thoroughly by a set of different machines and techniques, namely optical profilometer, Scanning electron microscope (SEM), and Electron probe micro analyser (EPMA). The results exhibited an increase in wear resistance by ~87% which was caused due to reduced sliding contact area, increas ed surface roughness, and increased surface hardness. The results conclude that shot blasting technique can improve the tribological properties of Titanium alloys

Tribo – Measurements

New multi-sensing nanotribology test with electrical contact resistance and friction measurement (ID: T060)

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Abstract: Nano-/micro-scale tribology enables the onset of wear to be studied in detail and correlations with friction forces investigated to aid the design of surfaces with improved wear resistance. Reciprocating contacts occur in a wide variety of practical wear situations including hip joints and electrical contacts. In optimising materials for improved durability in these contacts it is important that the contact conditions can be reproduced. A capability for rapid high-cycle linear reciprocating nano-scale wear tests has therefore been developed (NanoTriboTest) with automatic recording of friction loops, cumulative energy dissipation and electrical contact resistance. The design has high level of lateral rigidity providing the necessary stability to perform nano-wear tests for several hours, up to 35000 cycles and 300 m sliding distance. High cycle reciprocating nano-wear tests have been performed on multilayer DLC coatings, and biomedical alloys Ti6Al4V and 316L stainless steel. Stainless steel exhibited a ductile response throughout the load range but an abrupt transition to higher friction and fracture-dominated wear occurred on Ti6Al4V. Improved detection of the onset of wear and the subsequent failure mechanisms was achieved by a multi-sensing approach where changes to electrical contact resistance were shown to correlate with friction. Nano-wear tests of noble metal-noble metal contacts showed much longer endurance than gold vs. steel contacts although occasional isolated failures were observed in 35000 cycle tests.

Keywords: micro-wear, biomaterials, electrical contact resistance, reciprocating nano-wear

1. INTRODUCTION

Deformation and wear begins at the asperities between contacting surfaces but the contact pressures acting on these are not well known in a typical macro-scale tribological test with multi-asperity contact. The simplified contact conditions in single asperity tribological tests with much lower forces and sharper probes provide an alternative approach to study the onset of wear, its correlation with friction, and the influence of surface topography and mechanical properties.

As a new single-asperity test technique, an additional microtribology capability has been implemented in a modular commercial nanoindenter system (NanoTest Vantage) [1]. Table 1 (over) compares the typical conditions in the new capability for nano-scale reciprocating wear to other approaches for multi-pass sliding contacts (repetitive scratch and nano-fretting) with the same instrumentation. The loading head, load range (0-500 mN, for low load head) and capability for tangential (frictional) force and ECR measurement are common to all three. Typical AFM wear test conditions are shown for comparison.

Table 1 Typical test conditions in nano- and microtribological tests

	AFM wear	Repetitive nano-scratch	Nano-fretting	NanoTriboTest
Motion type	Reciprocating	Unidirectional	Reciprocating	Reciprocating
Sliding speed	0.001-0.25	0.001-0.1	0.01	1-10
Track length (mm)	0.001-0.1	0.01-1	0.02	1-10
Number of cycles	1-50	1-20	1000-200000	100-30000
Sliding distance (m)	0.000001-0.001	0.00001-0.01	0.01-0.1	0.1-300
Probe radius (µm)	0.02-1	5-25	10-200	25-5000

2. METHODOLOGY

The new nano-wear capability has been used for reciprocating tests on multilayer DLC coatings, and biomedical alloys Ti6Al4V and 316L stainless steel. Tests with integrated Electrical contact resistance measurement were performed on (i) multilayer electroplated sliding contacts (ii) bulk silver and gold alloys being developed as

sliding contact materials.

3. RESULTS AND DISCUSSION

In reciprocating nano-wear tests with diamond probes the biomedical alloys Ti6Al4V and 316L stainless steel showed markedly difference behaviour as a function of applied load. Stainless steel exhibited a ductile response throughout the load range. At higher loads on Ti6Al4V there was an abrupt transition to higher friction and fracture-dominated wear after ~20 cycles.

In reciprocating tests noble metal-noble metal contacts (Au-Au and Ag-Ag) showed much longer endurance than gold vs. steel contacts. Improved detection of the onset of wear and the subsequent failure mechanisms was possible by simultaneously monitoring friction and ECR. Changes in electrical contact resistance showed a complex correlation with changes to the measured friction, through changes in the electrically conductive contact area.

4. CONCLUSION

The stability to perform long duration reciprocating tests, up to 35000 cycle - 46 hr - tests, has been demonstrated. Integrating the capability for high cycle, long duration reciprocating nano-/micro-scale tests into a commercial instrument extends the versatility of the multi-functional test instrumentation.

5. ACKNOWLEDGEMENT

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6. DECLARATION*:*

The work has not been presented elsewhere or not being consideration for presentation in any journal.

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Optimization of parameters of single point cutting tool for turning operation (ID: T085)

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Abstract: In this study, optimization of machining parameters of a single point cutting tool is done for turning operation. The main aim of this study is to use the mathematical model for the force analysis of the turning operation and compare the data with the analytical results found. A carbide insert - Kyocera Carbide Turning Insert CNMA120404, Grade CJ215K was used on a simple cylindrical workpiece where the depth of cut and specific force (as per tool material) will be kept constant. Further ahead, various permutations were done by varying the feed rate, spindle speed, and cutting speed of the tool. Once the force was found by theoretical calculations, FEM modelling was done using ANSYS to compare the data and validate the results found i.e. cutting force and surface roughness. Further optimization was done by following the Taguchi Method and finding the S/N ratio of the final result found by following the-higher-the-better method. The values which were found were validated by using the Tool Life formula on all the experiments done by the Taguchi Method. Later on, it was concluded that to obtain minimum wear feed rate plays an important role, and to minimize the surface roughness, feed rate and depth of cut are the main controllable factors. The deviations found between the actual and predicted S/N ratio was found to insignificant. Parameter design and optimization with the Taguchi Method provides a simple, systematic, and efficient methodology for the machining parameters.

Keywords: Turning operation, Cutting force, Surface roughness, Taguchi Method, S/N ratio, Optimization.

Development of test method for evaluation of engine oils in different inclination angle with line contact in SRV test machine (ID: T093)

Saurabh Mishra, Rameshwar Chaudhary, Dr. Sarita Seth, Shanker Bhadhavath, Rajendra Mahapatra, Ajay Kumar Harinarain, Dr. Veena Bansal, Dr. Deepak Saxena
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Abstract: The automotive industry requires extensive long duration tests and field trials prior to introduction of engine lubricants for piston ring –cylinder liner assembly in the automobile market. These tests assess friction and wear performance of candidate oils to compare their tribological performance, and often put demands incurring high cost for lubricant oil evaluation. Typical screening methodology involved in sorting out the best lubricant for further large-scale tests relies on simple point contact geometry with horizontal position of model test rig in SRV without oil recirculation and replenishment at contact zone. In practical applications, multi-cylinder engines are tilted for balancing purposes and encounter angular shifts in position due to undulating profile of roads, which affects the overall tribological performance of lubricants in actual vehicle running conditions. Moreover, there is a continuous oil recirculation at the piston ring-cylinder liner contact in engines, which differs from the single oil drop static lubricated point contact test setup.

In this study, an attempt has been made to overcome the limitations of existing screening methodology by utilizing SRV test machine. Two candidate engine oil samples have been evaluated with oil recirculation setup using a peristaltic pump. Apart from this, line contact geometry incorporating cylinder on disc configuration was realized with the machine to better simulate the concentrated contact geometry. Tests were designed and conducted for four different inclination angles of test setup, besides horizontal. All operating parameters viz. temperature, frequency of oscillation, stroke length, time duration, oil flow rate and loads were selected to replicate the actual engine conditions. The results show variations in coefficient of friction with respect to varying chemistry of lubricating oils. The graphs of coefficient of friction also displayed marked differences in values when inclination angles were varied for same lubricating oil under investigation. Therefore, the test method developed is found to be suitable to evaluate performance of engine lubricants and is hence proposed to establish a better screening methodology than the existing one.

Keywords: SRV test machine, oil recirculation, inclination angle, line contact

Development of test method to detect gear failure using vibration and ferrography analysis (ID: T092)

Rameshwar Chaudhary, Shubham Saini, Rahul B. Meshram, Shanker Bhadhavath, Rajendra Mahapatra, Ajay Kumar Harinarain, Dr. Veena R Bansal, Dr. Deepak Saxena
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Abstract: The method of operation of machine till their failure and then repair them to make fit for further service can be very expensive in terms of lost output and machine breakdown. To overcome hazardous situation and reduced downtime of the machine, regular maintenance using condition monitoring techniques has been proved to be more economical and operationally satisfactory. Condition/health of rotating equipment/gear transmission equipment can be analyzed by measuring the parameters such as vibrations, sound, and temperature. Used oil analysis could also be indicative of an impending failure. The increasing trend towards predictive maintenance has led to the development of a vast number of machine condition monitoring techniques. Vibration analysis and used oil analysis are the two distinct and most readily used methods in determining mechanical failures in common components of industrial machinery such as gears and bearings. A correlation between the two techniques, i.e., vibration analysis and oil analysis concerning gear failure in FZG test rig have been explored in this experimental study. Three gear oils were tested in the FZG test rig till scuffing failure stage was attained (each stage time duration was 15 minutes at 900C). Vibration measurements were taken at each stage in 10th minutes of the machine in both X and Y direction using two channel probes vibration sensor. Only peak amplitude in both X and Y direction was reported using suitable software. Also, oil samples were taken at regular interval until failure stage for ferrographic wear debris analysis. It was observed from vibration analysis results that vibration trends depends on the oil viscometrics and additives present in oil. Also, it was observed that the vibration trend changes and gradually starts rising generally 3 stage prior to failure stage indicating the loading condition upto which the oil can operate safely for a longer period. This method of condition monitoring can be useful in diagnosis of onset of lubrication failure and /or gear faults and the wear modes of the gearbox resulting from constant overload conditions and cyclic load conditions of windmills or other machinery using industrial gear oil.

Keywords: Gear failure, condition monitoring, gear oil, vibration analysis

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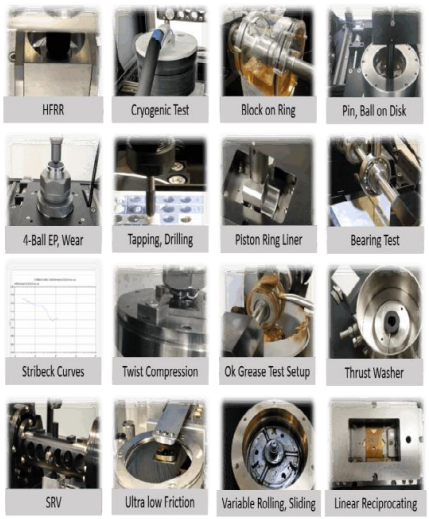

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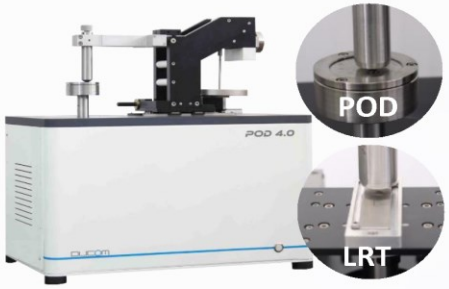

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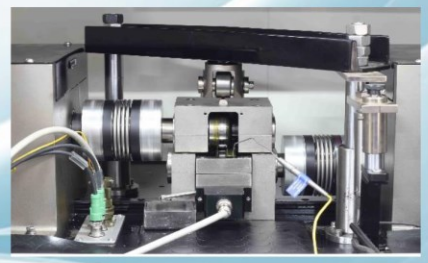

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