TSI

IndiaTrib-2024

(12th International Conference on Industrial Tribology)

On "Tribology for Sustainable Growth"

19-21 December, 2024

at

Fairfield By Marriott, Kolkata, India

Souvenir-cum-Abstract book

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TSI

Tribology Society of India

(Affiliated to the International Tribology Council, UK)

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व्यये कृते वर्धत एव नित्यं विद्याधनं सर्वधनप्रधानम्॥

"It cannot be stolen by a thief.

It cannot be taken away by a king.

It cannot be divided among siblings.

It does not cause load. It always increases when spent.

The wealth of education is the greatest of all wealth."

~The Vedas

Office of the President
International Tribology Council C/o Empa,
Überlandstrasse 129 8600 Dübendorf, Switzerland

Prof. em. Dr. Nicholas D. Spencer
President, ITC
www.itctribology.net

Message

December 1, 2024

To the attendees of IndiaTrib-2024, Kolkata

Dear Friends and Colleagues:

It is with great pleasure that, in the name of ITC, I welcome you to IndiaTrib-2024 in Kolkata, the "City of Joy".

The ITC exists to facilitate communication between tribologists worldwide, and this conference, with its many international participants, will be an excellent demonstration of this principle. We also are responsible for ensuring that international congresses (the World Tribology Congress, WTC) take place at regular intervals, and I remind you that the next WTC will take place in Rio de Janeiro, Brazil (20-25 September, 2026).

This conference happens in a period of crises: geopolitical and climatic. While we, as tribologists, can only hope that the politicians can solve the former, we hold some of the keys to the latter. Whether it be in the design of better lubricants to reduce CO2 emissions and lower energy consumption or the design of better tribological systems to improve the reliability of wind turbines, tribologists can play a very significant role in meeting net-zero and sustainability goals.

Despite our importance in solving some of these vital issues, our role as tribologists is often invisible. We have a responsibility to educate not only the public as to the criticality of tribology, but also a significant number of engineers (especially non-mechanical engineers). Tribology should form a part of all engineering curricula, and high-school teachers should incorporate tribological projects into their school programs. Tribology societies such as the TSI (to which I am honoured to belong, as a life member) have a responsibility to support such activities.

I do hope you find enrichment from the many presentations at the exciting conference that the organizers have planned. Please enjoy the conference and the days of intellectual stimulation in fascinating surroundings.

Sincerely,

Prof. Nicholas D. Spencer
President of the International Tribology Council

Message from Satish V. Kailas, President TSI

Meeting people in your field of research and interest is always important. Exchange of ideas with people whom one could forge lifelong interaction/collaboration, apart from becoming a friend happens during such conferences.

IndiaTrib-2024 is the biennial conference organized by the Tribology Society of India. IndiaTrib-24 is the event being held at Fairfield by Marriott Kolkata. The in-person event will take place from the 19th to the 21st of December, 2024. Several eminent speakers from academia and industry, and from India and abroad, are going to give talks during the conference. The talks will cover almost all aspects of tribology. More than 120 abstracts have been submitted for presentation during the conference. Given the importance of tribology in making development sustainable it is imperative that ideas are exchanged and new ideas generated. Being a multi-disciplinary field, listening to talks by others will help foster newer areas of research and development. An in-person meeting makes forging of newer ideas and relationships easier. Personally, attending these conferences and being an active participant has helped develop new ideas, collaboration and friends.

Do wish all the delegates a wonderful conference and chance to meet new people, generate new ideas and forge lasting relationships.

Prof. Satish V Kailas
President, Tribology Society of India
Professor, Department of Mechanical Engineering
Indian Institute of Science, Bangalore, India

Message from Senior Vice President, TSI

Indian industries face critical tribological challenges that undermine their efficiency, reliability, and cost-effectiveness. A key issue is the lack of effective control over the friction coefficient and the ingress of abrasive particles, leading to frequent equipment breakdowns, shorter component lifespans, and elevated maintenance expenses. Sectors like automotive, railways, manufacturing, mining, power generation, and agriculture are especially susceptible, given their dependence on machinery operating in challenging and variable environments.

While lubrication remains a widely used solution to manage friction and wear, its effectiveness often falls short due to poor lubricant selection, contamination by wear debris, and thermal degradation. These shortcomings not only increase energy consumption but also cause overheating and premature component failures. Additionally, humid climates prevalent across India contribute to corrosion, with the combined effects of wear and corrosion—known as tribocorrosion—accelerating material degradation. Industries such as oil and gas, marine, and construction are particularly impacted, facing structural failures and costly repairs as a result.

In response to these challenges, the focus is shifting toward sustainable and eco-friendly tribological practices. Smart sensors and IoT-enabled systems facilitate real-time monitoring of friction, wear, and lubrication, enabling industries to address problems proactively, optimize maintenance strategies, and reduce downtime. To harness these advancements effectively, training and skill development for operations and maintenance teams are essential.

Events such as **IndiaTrib-2024** serve as vital platforms for bridging gaps between academia and industry. By fostering collaboration and encouraging the exchange of ideas, these forums promote the development of tailored tribological solutions and drive advancements in research. By embracing these strategies, Indian industries can reduce operational costs, align with global sustainability standards, and ensure resilience in a dynamic industrial landscape. The combination of innovation, expertise, and collaboration is pivotal to overcoming tribological challenges effectively.

Prof. Harish Hirani
Senior Vice President, Tribology Society of India
Professor, Department of Mechanical Engineering,
IIT Delhi, India

Message from Vice President TSI

9th December 2024

Dear Fellow Tribologists

Tribology Society of India has a long tradition of organizing conferences to keep the practitioners in Tribology abreast of the latest developments in this domain for a very long time. It has organized several National and International conferences to draw attention to ongoing research and application work in this important subject since the year 1972.

Continuing in this endeavour is the organization of this IndiaTrib-2024 international conference at Fairfield by Marriott hotel during 19-21 December 2024 in Kolkata, India. The theme of the conference 'Tribology for Sustainable Growth' is quite apt and also very much in sync with the need for mankind to find solutions for mitigating the impending climate crisis owing to global warming leading to climate change. The solutions offered in this area such as improving energy efficiency and extending the life of components through application of Tribology is already well known and documented. The newer upcoming Tribo-interventions can add a lot of impetus to intensification of this global endeavour.

I am happy to note that there are several papers being presented at IndiaTrib-2024 related to the theme, and also covering the other aspects of this multi-disciplinary subject. I hope that this event will live up to your expectations of professional enrichment and offer ample opportunities to network and share your work with others working in newer and related areas.

I would like to personally welcome each one of you to this conference on behalf of the society and the organizing committee and hope that you have a pleasant stay in Kolkata.

With kind regards
Mr. Ajay Kumar Harinarain
Vice President, Tribology Society of India
Chief General Manager (AR & Projects)
Indian Oil R&D Centre, Faridabad

Message from the Desk of the Conference Chairman

Dear Delegates, Researchers, and Well-Wishers,

It is my great privilege to welcome you to IndiaTrib-2024 (12th International Conference on Industrial Tribology), organised by Tribology Society of India at Kolkata.

As we gather for this landmark event from 19 – 21 December 2024 at Kolkata, I am delighted to present this abstract book, a compilation of the exceptional research and innovations that form the cornerstone of our gathering.

This Abstract Book serves as a repository of knowledge, reflecting the diverse topics and cutting-edge advancements aligned with the theme of this conference, **"Tribology for Sustainable Growth"**. Each abstract represents the dedication, creativity, and hard work of researchers and practitioners striving to make significant contributions to their respective fields. I am confident that this Abstract Book will serve as a source of inspiration and a catalyst for meaningful discussions, collaborations, and innovations during and beyond the conference.

I take this opportunity to express my deepest gratitude to all authors for their valuable submissions, participants, sponsors, exhibitors, and the President TSI, Prof Satish V Kailas, Sr Vice President TSI, Prof Harish Hirani, Vice President TSI, Mr Ajay K Harinarain, Secretary TSI, Mr Rajendra Mahapatra, Treasurer TSI, Mr Rahul B Meshram & IndiaTrib-2024 Technical Convener, Dr Manjesh K Singh, TSI Office Staff, Mr Arun & TSI Executive Committee Members for their unwavering dedication and support.

I and sure this conference will also help to build strong inter-institutional networks and pave synergy among the research community and bridge the gaps between industry & academia.

I express my heartfelt gratitude to the Tribology Society of India for giving the opportunity of organizing IndiaTrib-2024 and providing full support for this event. Finally, I thank all the individuals who were directly or indirectly involved with IndiaTrib-2024.

Wishing you all a fruitful and enriching conference experience!

Warm greetings from the Organizing Committee of IndiaTrib-2024!

Dr. T Singh
Conference Chairman, IndiaTrib-2024
Director – Business Development
Siddharth Grease & Lubes Pvt. Ltd.

TRIBOLOGY SOCIETY OF INDIA
(Affiliated to International Tribology Council, U.K.)
Registered Office: R&D Centre – Indian Oil Corporation Limited, Sector – 13, Faridabad – 121 007 (Haryana), INDIA
Website: www.tribologyindia.org

Message from Secretary, Tribology Society of India

Dear TSI Members and IndiaTrib-2024 Delegates,

On behalf of the TSI Executive Committee and IndiaTrib-2024 Organising Committee, it gives me pleasure to extend a warm welcome to all of you to IndiaTrib-2024. This is the 12th edition of biennial international conference being held at Fairfield by Marriott hotel during 19th to 21st December 2024 in 'the city of joy', Kolkata. Keeping in view the current demand of mother earth, the theme of the conference 'Tribology for Sustainable Growth' is quite appropriate. This should provide great insights about this topic which has great relevance in these times when solutions for mitigating global warming and climate change are the need of the hour.

Ever since its inception, IndiaTrib (earlier known as ICIT) has been a flagship program of TSI in promoting the awareness and practice of Tribology in India and facilitating industry-academia interactions. Over two and a half days of the conference, we shall have an opportunity to interact with some of the finest minds in Tribology research education and practice. I am sure that the organizing committee of IndiaTrib-2024 will spare no efforts to live up to your expectations and ensure that this event is rewarding both scientifically and professionally to each one of you.

I would like to express my gratitude to the organizing committee members, Office bearers and EC members of TSI, Convenor of Technical Committee, Chairman of IndiaTrib-2024, and President TSI for their immense support and contribution. I hope the deliberations during the conference will provide insight for further research in your domain.

I thank you for your participation in IndiaTrib-2024 and sincerely hope that you will have a truly memorable experience and comfortable stay at Kolkata.

I once again welcome all of you to this grand event and wish the conference a resounding success.

Mr. Rajendra Mahapatra
Secretary, Tribology Society of India
General Manager (Tribology), R&D Centre,
Indian Oil Corporation Limited, Faridabad

Message from Technical Convener, IndiaTrib-2024

I am pleased to welcome you all to **IndiaTrib-2024: "*Tribology for Sustainable Growth*"**, in the vibrant city of Kolkata-the cultural capital of India. This event is a testament to our shared vision of advancing in the dynamic field of tribology. I extend my heartfelt thanks to the Tribology Society of India for their support in shaping this remarkable conference. I thank all the delegates for their enthusiastic participation. I also thank our generous sponsors, whose contributions have empowered us to convene together. IndiaTrib-2024 has drawn a gathering of academicians, researchers, and industry experts from India and across the globe. The diverse range of plenary, keynote, invited and contributed talks promises to provide insights into the challenges and opportunities to take tribology one more step closer to sustainability. From novel materials and advanced surface engineering techniques to computational tribology and eco-friendly lubricants, this conference covers almost all areas that hold importance to address tribological challenges.

The technical sessions aim to start meaningful discussions and pave the way for collaboration among the stakeholders of the tribology community. I thank the volunteers in organizing this conference, whose tireless efforts have laid the foundation of this mega event.

As we embark on this journey, I encourage all participants to actively engage, exchange ideas, and build lasting connections that will advance the cause of sustainable tribology. Let us together make IndiaTrib-2024 a pleasant experience.

Wishing everyone a joyful and memorable stay in the enchanting city of Kolkata, India.

Sincerely,
Dr. Manjesh K. Singh
Technical Convener, IndiaTrib-2024
Associate Professor
Department of Mechanical Engineering
Indian Institute of Technology Kanpur, India

ABSTRACTS

Tribo Behaviour of Agrowaste Based Sustainable Composites

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Abs.ID: P01

ABSTRACT

The need for lightweight in many engineering applications forced engineers to move to synthetic polymers and their composites in large quantities. Because of the difficulties in recycling and the resulting environmental harm, the widespread usage of synthetic polymers has presented serious environmental challenges. It is necessary to replace it with sustainable materials to minimize pollution and resource depletion at the earliest. India produces different agricultural products in large volumes, and the by-products generated during the process of cultivation and processing mostly go to landfill. This presentation discusses the possibilities of manufacturing value-added products from agricultural waste, such as coir and bagasse. Many parts in an automobile interior demand good wear resistance and are currently made of synthetic polymers such ABS, TPU, and PP. This project is focused towards identifying sustainable polymer composites with good wear resistance which will serve as an alternative to currently used synthetic polymers. Sustainable composites were manufactured using an advanced additive manufacturing process using treated agricultural waste and biopolymers in our centre. This presentation discusses about the tribo behaviour of composites made using 3D printing process and their suitability for value-added engineering applications.

Results from Electrification of Tribometers for EV Fluid Testing

Peter Lee, Carlos Sanchez and Andrew Velasquez

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Abs.ID: P02

ABSTRACT

Electric vehicles (EVs) continue to evolve and sales increase as the world pushes towards sustainability. This drives research to understand the unique environments in which fluids operate within the Electric Drive Units (EDUs) of EVs to improve durability and reduce frictional losses. Hence, test rigs are required that operate with electric current passing across the test parts and through the lubricant. Few electrified test rigs currently exist, with most being adaptions of rigs undertaken by academia and independent and National research labs.

This presentation describes modification of rigs to supply voltage across a tribological contact. Starting with a Rheometer and the Bruker UMT-3, new parts were designed, and lubricants tested. Seeing a noticeable difference in wear and friction SwRI partnered with PCS Instruments to develop a commercially available MTM. Work was undertaken in both the Author's and manufacturer's labs with the aim of bringing the MTM-ec to market as quickly as possible.

Results from this work indicate that the application of current causes a significant increase in wear scar versus non-electrified conditions. This results in increased traction values over non-electrified conditions. It was also noted that repeatability of traction curves and end of test wear reduced under electrified conditions.

On the Humidity Dependence of Highly Loaded Graphite Contacts

Martin Dienwiebel[1,2], Carina Morstein[2], Omar Zouina[2], Andreas Klemenz[1] and Michael Moseler[1,3]

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Abs.ID: P03

ABSTRACT

Graphite is a well-known solid lubricant that has been studied for decades. At low loads, graphite's lubricity depends on humidity. Classical models like e.g. the adsorption model explains this by molecular water films on graphite leading to defect passivation and easy sliding of counter bodies [1]. To explore the humidity dependence and validate the adsorption model for high loads (loads around 1GPa as typically found in rolling bearing elements), a commercial graphite solid lubricant was studied using micro tribometry [2]. Even at very high contact pressures, a high and low friction regime is observed - depending on humidity.

Transmission electron microscopy (TEM) and Electron Energy Loss spectroscopy (EELS) reveal transformation of the polycrystalline graphite lubricant into turbo stratic carbon after high but also after low load (50 MPa) sliding. Quantum molecular dynamics simulations relate high friction and wear to cold welding and shear-induced formation of turbo stratic carbon, while low friction originates in molecular water films on surfaces. The combined experiments and simulations lead to a novel, generalized adsorption model including turbo stratic carbon formation. In the second part of this talk, the findings are extended to CNT-based [3] and phenolic resin composite coatings.

[1] Savage, R. H. Graphite lubrication. J. Appl. Phys. 19, 1–10 (1948).

[2] C. Morstein, A. Klemenz, M. Dienwiebel, M. Moseler, Nature Comm. 13, 2022

[3] T. MacLucas, et al, ACS Applied Nano Materials 6, 1755-1769 (2023)

Evaluating the Stribeck Curve in the Boundary Lubrication Regime using a Force Controlled Tribometer

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ABSTRACT

Evaluating the Stribeck curve, particularly in the boundary lubrication regime, is key for designing lubricants. This becomes challenging when the velocity of sliding is very low. One other point to note is that many (almost all) of the tribological systems will experience sliding in the boundary lubrication regime, especially during starting and stopping of sliding in tribological pairs. One of the other factors that could influence the behavior of the interaction of asperities in a tribo-contact is the method under which the displacement is applied. Is the motion applied under a force-controlled method or a displacement-controlled method. In a force-controlled system the motion is initiated by the application of a force which will result in the motion. And, in a displacement-controlled system the motion is initiated by the application of a known displacement resulting in a frictional force. Studies were conducted using a newly developed tribometer at different temperatures for various lubricants, with and without additives. The tribometer picks up the differences in the frictional response with a very fine resolution of velocity. A "rectangular plot" is drawn to visually differentiate the energy dissipation. Noise and vibration due to the tribo-contact can be picked up in this tribo-meter. The tribo-meter has also been used to evaluate chocolates and soaps. Results from these experiments are presented in this talk.

Indian Lubricants Industry – Sustainability by Integrating Circular Economy

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Abs.ID: P05

ABSTRACT

The Indian lubricants industry is championing sustainability by integrating circular economy principles, achieving regulatory excellence, and fostering innovation. By meeting Extended Producer Responsibility (EPR) targets through CPCB-registered units and leveraging re-refined base oils and recycled materials, it addresses environmental challenges while setting compliance benchmarks. Key initiatives include the launch of hydraulic and gear oils by IOC, HPC, and BPC, the development of eco-friendly lubricants meeting global standards, and the adoption of recyclable packaging. The industry's net-zero roadmap spans biofuels, green hydrogen, and energy-efficient lubricants, powered by renewable energy adoption. Strategic partnerships with Honda and Sun Mobility for battery swapping, coupled with digital transformations like automated condition monitoring, are driving operational excellence and customer satisfaction. Embracing future-ready fuel solutions such as hydrogen blends, biodiesel and advanced battery technologies, the lubricants industry leads the transition to greener energy, building a sustainable future.

Impact Mechanics of Contacts: Genesis of Friction

M. S. Bobji, Uzair Iqbal, Gautam Revankar A and Kasula Vineeth kumar

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Abs.ID: K01

ABSTRACT

When two nominally flat, rough surfaces come into contact and slide past each other, asperities experience impact loading. Understanding the mechanics of asperity impacts is crucial for determining the energy loss due to friction. This study focuses on the elastic and elastoplastic impacts of a ball with a flat surface, a problem with applications ranging from sports to lubricant design.

At small scales, impacts are primarily elastic and dominated by adhesive van der Waals forces. By modelling these adhesive forces as body forces rather than surface forces, we investigate the impact of two spherical asperities using a finite element framework. Our findings reveal that impact energy can be converted into vibrational energy within the body, leading to energy dissipation. Adhesion-induced elastic instabilities influence the extent of this energy conversion.

Both plasticity and elasticity play significant roles at microscales, particularly in metals. We experimentally study elastoplastic impacts using high-speed camera techniques. Revisiting various impact models, we demonstrate the importance of including elastic strain energy in the total impact energy to accurately determine the restitution coefficient.

Insights into the Mechanics of Rough Contacts

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Abs.ID: K02

ABSTRACT

All surface around us are rough. This roughness affects how two contacting bodies interact. For hard material, roughness limits the area of intimate atomic contact to a small area confined to the protrusions on rough interfaces. Soft contact can deform to conform, but this requires elastic which can strongly affect adhesive interactions. In the last two decades, analytic modes and numerical calculations have helped us gain insights into the mechanical processes at contacting rough interfaces, yielding a consistent view and analytic expressions for the contact of hard interfaces and (very) soft interfaces. This talk will review these developments, with a focus on how roughness affects adhesive interactions. For hard interfaces, adhesion is largely dominated by a small area surrounding individual asperity contacts. For soft interfaces that conform, adhesion is governed by a balance between the intrinsic work of adhesion and the energy required for elastic deformation. Different structural features of the rough topography influence adhesion in these two limits. No consistent theory exists for solids with an elastic modulus in an intermediate range between the two limits.

Exotic Tribology – Coffee to Catheters, and Bitumen Binders

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Abs.ID: K03

ABSTRACT

The application of tribology has branched out into numerous novel fields such as food and beverages, cosmetics, asphalt, etc. However, these applications only form a tiny fraction of the overall tribology pie, which has its lion's share taken by engine and machine components. In the current work, the authors showcase the impediments encountered during the development of tribological test methodologies for a few such exotic applications. An apt example would be the case of food and beverages, or cosmetics. In both these cases, the idea is to apply tribology to understand and correlate the frictional response of the tribo system to certain sensory attributes of the sample. A complete contrasting application is that of asphalt or bitumen, which is typically used as a raw material for laying of pavements. One of the aims here is to decrease the process temperature in order to save energy as well as to avoid unnecessary thermal ageing of asphalt. Regardless of the application, the authors believe that an increase in the efficiency and lifetime, be it during operation or the production process, would lead to energy saving, which could in turn contribute positively towards the overall goal of attaining sustainability.

Tribology Related Issues in Missile and Artillery Systems

Manish Roy

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ABSTRACT

Missile systems are extremely complex engineering excellence. Over the last few decades, there has been significant development in missile technologies and artillery systems in India. Many parts of a missile are subjected to various forms of mechanical degradations. As missile systems are used once, tribology related issues of these systems have not received focused attention. In this presentation, tribology issues relevant to important parts of missiles such as jet vanes, exhaust nozzles, actuators etc and large caliber gas gun will be covered. Jet vanes are made from different materials depending on the type of missile. Jet vanes of surface-to-surface short range ballistic missile were found to fail because of generation of high friction. An MCrAlY coating dispersed with h-BN was applied on the jet vanes using air plasma spray (APS) technique which led to a significant improvement of the performance of these components. Nose tip of hypersonic missile are subjected to hypersonic conditions. Examination of several candidate materials under hypersonic conditions indicates relevance and importance of carbon-carbon composites. Application of $MoSi_2$ coating further enhanced it performance in hypersonic condition. Various exhaust nozzles of missiles are made from carbon-carbon composites are subjected to erosive, impact abrasion and even sliding wear. Barrels of large caliber guns are also exposed to various forms of mechanical degradation. Investigation in all these components carried out in 'Defence Metallurgical Research Laboratory' and suggested remedies will be presented in details.

Lubrication Capabilities of Cycloaliphatic Esters

G D Thakre, Neha Sharma and Anjan Ray

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Abs.ID: K05

ABSTRACT

The customizable properties of esters make them a cornerstone of synthetic lubricant formulations, mainly where durability, efficiency, and environmental considerations are paramount. The present work attempts to study the impact of molecular structural variations (developed by generating homocyclic and heterocyclic moieties at the molecular backbone of long-chain esters) on lubrication behaviour under different contact conditions. The products were synthesized consisting of a homocyclic or heterocyclic ring generated at the olefinic site of long-chain esters derived from plant-based oils. The tribological performance behaviour was undertaken for the cyclic nucleus, keeping the molecular backbone the same. The study revealed that the long-chain esters containing heterocyclic rings in their backbone (Triangle esters EE – Epoxy Ester and TE – Thiirane Ester) demonstrated notable improvement in anti-friction and anti-wear behaviour due to slower diffusion of the SAMs of EE and TE than LE over the substrate owing to their stronger affinity to the surface. The Van der Waals forces showed high values for TE and EE blends, and the surface tension of the synthesized lubricants correlated well with the results of the obtained tribo-performance.

A Practical Approach to the Optimization of Spur Gears

Harish Hirani, Fellow ASME,

Sr. Vice President, Tribology Society of India
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Abs.ID: K06

ABSTRACT

Gear tribology is vital for efficient power transmission. Therefore, focusing on elasto-hydrodynamic lubrication (EHL), tooth contact dynamics, and gear lubrication and wear behavior become essential for ensuring gear system performance and durability. However, researchers often isolate these aspects, leaving practical design considerations underexplored.

Effective EHL implementation must consider pressure-dependent lubricant viscosity, elastic deformation, and surface roughness effects. Surface imperfections like asperities and dents can impair lubrication, emphasizing the need for precise EHL application to maintain reliability. Realistic modeling of surface roughness and corresponding corrections reduces pressure peaks, mitigating wear and improving efficiency. Advances in lubricants, including organic nanoparticles, enhance gear performance by forming protective tribofilms, reducing friction, and improving load distribution. These nanoparticles also maintain thermal stability, extending gear lifespan under extreme conditions.

Failure modes such as micropitting, pitting, and scuffing stem from insufficient lubrication and material fatigue. Addressing these requires multi-objective optimization to balance weight, durability, and cost. Advanced mathematical modeling and tools like MATLAB enable iterative refinement of gear configurations, optimizing critical parameters. In the present research, case studies validate aforementioned approach, demonstrating its potential to enhance gear system efficiency and reliability under demanding conditions have been detailed.

Facilitating Indian Industrial Endeavour Towards Sustainability & Net Zero

Ajay Kumar Harinarain

Chief General Manager (Automotive Research & Projects), Indian Oil Corporation Ltd, R&D Centre, Sector 13, Faridabad-121007.

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Abs.ID: I01

ABSTRACT

Every sector of Industry globally is in the process of trying and implementing various approaches to become more sustainable in their businesses. Depending upon their business's environmental impact and the approaches being adopted to reduce the same, many of the global majors have announced their net zero targets and the strategies they propose to adopt to achieve the same. These steps primarily involve reduction of their Scope 1 and Scope 2 emissions by a large extent. The regulatory interventions are expected to become stricter by the day in the future as mankind rushes to contain the global warming to less than the 1.5^0C threshold – this message is quickly becoming clearer - Come clean and reduce your environmental impact, or else perish.

It is a well-known fact that a combination of several steps/measures taken in tandem will enable achievement of the net zero targets. Some of these steps currently under implementation include increasing natural carbon sinks such as natural green cover for removing the CO2 being generated or use artificial means such as carbon capture and underground storage (CCUS). The use of renewable energy sources such as wind, solar etc. to reduce the impact of fossil-based ones on the environment is also on the rise. Electric vehicles to replace the fossil fuel dependent IC Engine vehicles also facilitate significant reduction in emissions with the increasing use of renewable energy. The work on increasing the use of zero carbon technologies such as Hydrogen as a transportation fuel or even as an agent for replacing coke in metal and industrial processing has gathered pace, with green hydrogen being increasingly produced using renewable energy sources. While all these methods proposed above require significant technology upgradation over the coming years, there are several well-known methodologies that can be readily implemented to move towards sustainability and achieving the Net Zero targets.

These include improvement of Energy efficiency of the industrial equipment focusing of improvements in both its thermal as well as mechanical efficiency. The use of Energy efficient, long life and low wear lubricating oils and greases contribute significantly towards facilitating the reduction in GHG emissions throughout the life cycle of the equipment. Through careful analysis and studies, it is still possible to achieve distinct improvements in Energy efficiency of industrial equipment such as the Engines, gear transmissions, hydraulic systems, compressors, earth moving machinery by use of improved High performance lubricant grades. These lubricant grades offer additional benefits of equipment life extension as well as increased oil drain intervals. These all combine to work towards reduction of the impact on the environment. Some case studies of success stories in the application of High-performance Energy efficient long life lubricating oils and greases will be discussed in this presentation.

Adhesion Control at the Interface of the Two Complementary Rough Surfaces of the Elastomer (PDMS)

Susheel Kumar[1], Krishnacharya Khare[2], Manjesh Kumar Singh[1*]

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Abs.ID: I02

ABSTRACT

Adhesion control at the interface of two surfaces is crucial in many applications. Examples are the design of micro and nanodevices such as microfluidic devices, triboelectric nanogenerator, biochips, and electronic sensors. The main idea of this study is to control adhesion by the modification of the surface topography of the elastomer (PDMS). Adhesion was measured at the interface of two complementary (interfaces of the same roughness) rough surfaces of the elastomer (PDMS). The rough surfaces of the elastomer (PDMS) were produced against the sandpapers of various grit numbers. Adhesion measurements were performed using the wedge test. The relation between adhesion and roughness of the elastomer (PDMS) will be presented and discussed.

Designing Greases with Enhanced Lubricity and Environmental Responsibility

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Abs.ID: I03

ABSTRACT

The commercial greases are primarily petroleum- and mineral oil-based formulations relying on harmful chemicals, thickeners, and additives. These greases pose environmental risks both during their use and after disposal. Although some eco-friendly alternatives have been explored, a viable solution is still needed. This study aims to explore the naturally occurring materials and develop environmentally friendly greases. The natural materials used are soybean oil as the base, organo-montmorillonite as a thickener, and calcium carbonate nanoparticles, along with biopolymers like gum acacia (GA) and guar gum (GG) as additives. The developed greases were analyzed for essential properties such as consistency, thixotropy, and rheology, and compared to a standard commercial grease to validate their lubricating characteristics. A detailed investigation of the microstructures was conducted to elucidate the underlying mechanisms. Generally, the new formulations showed performance comparable to commercial options, with the concentration of nanoparticles significantly affecting grease behaviour. The GG-based greases demonstrated improved anti-wear properties (≈ 22% enhancement) and reduced friction (≈ 42% enhancement) across all concentrations. Key factors influencing performance included nanoparticle distribution and agglomeration. Models were proposed to clarify grease structure, supported by Transmission Electron Microscopy (TEM) explorations, highlighting the interactions among ingredients as crucial to grease properties.

The Role of Carbides and Retained Austenite in Mitigating White Etching Areas Formation in Bearing Steel

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Abs.ID: I04

ABSTRACT

Despite more than two decades of research in white etching areas (WEAs), WEAs formation is persisting in wind turbine gearbox bearings and resulting in a serious reduction in designed life of the bearings (L_{10} life) by up to 90%. There are various driving forces that contribute to the WEAs formation among which diffusible hydrogen is considered one of the root causes. The detrimental effect of hydrogen on such microstructure degradation can be minimized by introducing hydrogen traps in the microstructure, thereby reducing the hydrogen mobility inside the matrix. In this work, the role of size and volume fraction of carbides, and retained austenite (RA) against WEAs formation tendency in bearing steel is studied. Bearing ball samples with two different carbide sizes and RA contents were chosen for this study. The experiments were carried out in the dynamic load pin-on-disc (PoD) tribometer in using polyalphaolephin and real time hydrogenating oils. The outcomes of the study showed that reducing the size of carbides improved their stability against plastic deformation leading to the stagnation of WEAs formation. Further, stabilizing RA in the microstructure proved to be beneficial in reducing hydrogen permeation and degradation of microstructure in a high hydrogen atmosphere under dynamic loading conditions.

Tribology and Sustainable Mobility- An Industry Perspective

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Abs.ID: I05

ABSTRACT

This brief talk would bring to focus the increasing relevance of future fuels, like the renewable e-fuels, green fuels, low carbon and zero carbon fuels in the transportation and mobility domain. These alternatives are slowly and steadily replacing the conventional fuels and be used for powering the internal combustion engines as well as marine and jet engines. This transition is important to ensure the carbon neutrality promise for our future generations. The new generation fuels also attempt to keep the harmful pollutants under control and eventually bring a decline in the net greenhouse gas emissions from the mobility sector. Biodiesel present tribological challenges with respect to corrosion, moisture ingress, material compatibility as well as the durability of engine components. Hydrogen as a fuel for ICE engines also present unique challenges with respect to material compatibility due to hydrogen diffusion, presence of high moisture, trace sulphur contaminants, and due to the absence of 'lubricating' carbon in these engines which can challenge the tribo-environment. Similar challenges exist with compressed biogas fuels for the natural gas engines derived from the processing of organic wastes and feedstock. This talk aims to bring these topics into relevance and help generate interest for further research with the industry, academic and the research fraternity.

Tribological of SiC Ceramics: Role of h-BN Reinforcement, Humidity and Temperature

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Abs.ID: I06

ABSTRACT

The escalating need for sustainable self-lubricating ceramic components in tribological contacts has catalyzed significant advancements in material development, enabling performance under extreme humidity and temperature conditions. The present study investigates the feasibility of achieving a wide range of dry sliding friction coefficients (influenced by varying humidity andtemperature) and erosive wear rates (affected by varying impingement angles and temperatures) in hot-pressed SiC-hBN ceramic composites with varying (0-10 vol%) h-BN reinforcement The material removal mechanism study exhibited a transition from (i) fracture-dominated wear in monolithic SiC to hydroxylative and oxidative wear in SiC-hBN composites in sliding conditions, and (ii) significant SiC grain pull-out in monolithic SiC to surface deformation and formation of aprotective borosilicate phase in SiC-hBN composites in erosive conditions. The relation of composition, mechanical properties and wear properties of SiC-hBN composites is highlighted.

Prospects And Future Directions of Advanced Lubricants

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ABSTRACT

To attain energy efficiency and environmental sustainability, need for new lubricants are in demand. The performance of industrial lubricants will be impacted by various weather conditions, such as a hot, dry, and dusty afternoon or a chilly, foggy morning. Future industrial lubricant research will concentrate on working under such harsh operating circumstances.

Conventional hydrocarbon-based lubricants have several issues like biodegradability, spillage and limited reserves, similarly, synthetic alternatives have compatibility issues with tribosystems.

Ionic liquids, nanolubricants and biolubricants have emerged as new lubricant alternatives. Ionic liquids have high thermal stability and negligible volatility. Nanolubricants are the name given to the nanofluids with nanoparticles dispersed any lubricating oil. The nanomaterials inclusion to oils significantly enhances the tribological characteristics and other physiochemical properties of the base oil. Biolubricants are tree origin and exhibit superior lubrication properties over lubricants conventionally being used. Ionic liquids are salts in solid state and they are known for their unique properties. Certain ionic liquids act as excellent lubricant having some of the properties better than any conventional lubricants known. In this oration, prospects of Ionic liquids, nanolubricants and biolubricants that emerged as new lubricant alternatives have been discussed.

Innovations in Plasma Spraying

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ABSTRACT

As graphene penetrates into industries, it is essential to mass produce high quality graphene sheets. New discoveries face formidable challenges in the marketplace due to the lack of proficient protocols to produce graphene on a commercial scale while maintaining its quality. Here, we present a conspicuous protocol for ultrafast exfoliation of graphite into high quality graphene on the sub-kilogram scale without the use of any intercalants, chemicals, or solvent. We show that graphite can be exfoliated using a plasma spray technique with high single-layer selectivity (~85%) at a very high production rate (48 g/h). This is possible because of the inherent characteristics of the protocol which provides sudden thermal shock followed by two-stage shear. The exfoliated graphene shows almost no basal defect (I_d/I_g: 0) and possesses high quality (C/O ratio: 21.2, sp^2 %:~95%), an indication of negligible structural deterioration. The results were reproducible indicating the adeptness of the protocol. We provided several proofs-of-concept of plasma spray exfoliated graphene to demonstrate its utility in applications such as mechanical reinforcements; frictionless, transparent conductive coatings; and energy storage devices.

Assessment of Energy Consumption, Friction & Wear Losses vis-à-vis CO_2 Emission in the Heavy Earth Moving Machines - A Case Study from A Mega Indian Open Cast Coal Mine

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ABSTRACT

In modern surface mining, the heavy earth moving machines (HEMM) in use play a pivotal role in mining operations. It has been observed that many assemblies used in HEMM experience primary wear due to abrasion and adhesion in the hazardous atmosphere in a mine. For the first time, the estimation of quantum of losses due to friction & wear losses in HEMM in use in the largest mine of India (Gevra mine of South Eastern Coalfields Limited) have been carried out and will be described in this paper. This paper covers a case study from a mega surface mine with the assessment of annual energy consumed, friction & wear losses with impact of its CO_2 emissions as calculated for HEMM. This study has a huge significance with the increasing scrutiny of the mining operations and pressure on the mining companies to reduce their CO_2 emissions to contribute towards achieving the net zero targets for the company as well as for the country.

The systematic application of tribology has a huge potential to facilitate reduction of the friction losses & insidious wear experienced, thus striving for achieving increased operational efficiencies and reduction of CO_2 emissions being generated from the mining operations on such a large scale. Some of the steps used include the repair of worn parts with the extensive use of coating technology facilitating the turning the otherwise 'scraps' assemblies into usable ones generating huge 'savings' from avoidance of replacement of the parts. other steps include the use of energy efficient lubricants in HEMM which offer extended life of lubricated components as well as enhanced oil drain intervals. The total energy loss was estimated to be 103 PJ during a year in this mega mine. The total loss in terms of friction & wear comes out to be 431 Cr during the same period Strategic maintenance planning of HEMM considering the criticality of this equipment will also be discussed. Thus, economy of operations from the efficiency improvements and life enhancements & benefits of emission reduction as an outcome can be achieved by following these strategies in a coal mine.

Nanotribology of 2D Materials using Atomic Force Microscopy

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ABSTRACT

Friction and wear of engineering components result in enormous energy losses, reliability issues, and environmental problems. Two-dimensional (2D) materials are being rigorously studied to address these challenges. 2D materials are single or few-layered structures with atomic-scale thickness, possessing extraordinary electronic, mechanical, and tribological properties. 2D materials have a crystal lattice structure with weakly bonded interlayer interactions, resulting in low friction between the layers. Even a single layer of 2D material can reduce friction efficiently due to its inertness and atomically smooth nature. A better understanding of 2D materials-based solid lubricant films using atomic force microscopy (AFM) can enable the rational design of more environmentally friendly and energy-efficient solid lubricant coatings.

I'll discuss recent investigations of nanotribology of 2D materials where we have applied 2D materials-based coatings on silica glass surfaces to prevent scratch and indentation-induced damage to glass surfaces. In particular, we demonstrate the self-generation of lubricious graphene-based tribochemical films from aqueous graphene dispersion on silica glass surfaces, drastically reducing friction and scratch-induced surface damage under severe loading conditions. In addition, our results reveal that super-lubricious and highly scratch-resistant glass surfaces can also be realized using a few layers of graphene films deposited using the transfer method.

For large-area 2D material film deposition, controlled deposition of 2D monolayers of WS_2 via chemical vapor deposition (CVD) on glass surfaces is demonstrated. Our investigation reveals that the nanotribological properties of WS_2 monolayer, considered an excellent solid lubricant, are highly sensitive to the role of atomic defects, aging, and morphology of the monolayer as well as shear-induced phase transitions.

The results of our study provide possible strategies for optimizing the tribological properties of 2D material films for their potential tribological applications.

Effect of Tool-Tip Rolling Motion in Metal Cutting

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Abs.ID: I11

ABSTRACT

The tribological characteristics of the tool-chip interface play a critical role in metal cutting. Severe plastic deformation, stagnation zone, stick-slip motion, and built-up-edge formation are the commonly observed phenomena in metal cutting. Cutting fluid or surface coating is not very effective in many situations. To mitigate this problem, a roller/ball is mounted at the tool-tip to introduce the rolling motion at the interface. Interestingly, slow rolling motion effectively disrupts the sliding contact and significantly reduces power consumption. The effect of rolling motion is analyzed using a digital image correlation technique followed by Electron Backscatter Diffraction (EBSD) analysis. The findings show that fluid-like non-laminar flow is suppressed significantly with the introduction of rolling motion. Additionally, rolling motion eliminates the shear banded flow in the retardation region present just ahead of the tool-tip. As a result, material flow accelerates within the retardation region, strain reduces within the chip, defect eliminates from the slid surface, and plastic flow becomes approximately laminar. Additionally, rolling motion can facilitate the direct injection of cutting fluid at the tool-chip interface. This study demonstrates how a sluggish rolling motion drastically alters the deformation characteristics of severe sliding contact and offers substantial tribological benefits.

Development of Ag-Doped CrAlN as Hard Solid Lubricant Coating for High Performance Cutting Application

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Abs.ID: I12

ABSTRACT

In recent times, stricter global environmental regulations have increased the demand for dry or near-dry machining in modern industries. While advanced hard coatings on cutting tools have proven a viable technological alternative over decades, they still fall short of promoting environment-friendly dry machining due to insufficient lubricating properties of hard coatings. Therefore, it is essential to effectively combine solid lubrication with hardness and wear resistance of the coating material for cutting tool applications. A current research work undertaken at IIT Bhilai developed a novel CrAlN-based hard coating incorporating Ag as a soft metallic phase using closed-field unbalanced magnetron sputtering. Ag content in the CrAlN phase was systematically varied (2–16 at.%), with the CrAlNAg9 composition (8.6 at.% Ag) demonstrating the best balance of mechanical and tribological properties.

Tribological tests demonstrated CrAlNAg9's low friction coefficient (μ = 0.16 at room temperature, 0.26 at 600°C) and superior wear resistance compared to reference CrAlN. Performance evaluations in milling and turning showed significant reductions in cutting forces, up to 16% and 7%, respectively, and improved surface finish, attributed to its anti-friction and anti-sticking properties. CrAlNAg9 also outperformed commercially available TiAlN coatings, making it a viable alternative for dry machining.

HFC-E Fluid Evaluation with Axial Piston Pump and Bent Axis Motor

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Abs.ID: I13

ABSTRACT

HFC fluids, commonly known as water glycol-based fire-resistant hydraulic fluid, are the most widely used among water-containing fire-resistant fluids. HFC-E fluids (water polymer solution) are the latest addition in this category, but the water content is limited to approximately 20%.

The properties of the fluid and the bench tests can be used for screening a fluid but are incapable of demonstrating the behavior towards each component and the hydraulic system in the field.

HFC-E fluid was tested with a hydraulic system close to agriculture equipment, which consists of an axial piston pump, bent axis motor, and a flywheel for loading. The fluid properties, system performance and efficiency, and components of the pump and motor are evaluated to estimate the capability of the fluid to perform and protect the components in an environment close to real-world application.

The test results are compared with the test results of a standard mineral oil-based anti-wear hydraulic fluid. It is found that the HFC-E fluids cannot be used as direct replacements of mineral oil-based fluids but are better than the conventional HFC fluids. For a one-to-one replacement with mineral oil fluids, HFC-E fluids can be used for applications where the operating conditions are derated and the hydraulicsystem follows certain design parameters.

Experimental and Simulation Rolling Sliding Fatigue Study of Rail Wheel Contact

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Abs.ID: I14

ABSTRACT

Rail systems are being designed with the objective for higher speeds and large load carrying capacity. This is very relevant for current rail technology in India. As axial load and running speed keep increasing with increasing heavy traffic and the running speed frequently varies after braking or turning on the railway track, resulting in slide-to-roll ratio (SRR). These factors, like axial load, rail speed, and SRR directly affect the rolling contact fatigue (RCF) life of the rail. Microstructural aspects like ferrite content, inclusions and surface finishing (like surface roughness) also affect factors other than operational conditions like load, speed and SRR. Investigations have been done to evaluate the cyclic plastic deformation response at the subsurface during rolling contact fatigue (RCF) under the conditions of pure rolling and rolling-sliding. A three-dimensional (3D) finite element simulation of Rolling-sliding tests is modelled to determine the state of stress in the contact zone with fully lubricated and dry conditions. Simulation results indicate that the slip-to-roll ratio (SRR)has an immense effect on the cyclic plastic deformation evolution at the subsurface during RCF. Also, surface and subsurface evolution are assessed after completion of rolling contact fatigue (RCF) tests on a Twin Disc RCF test rig (Phoenix TE74s). Lubricated, dry and mixed (dry condition followed by lubrication) conditioned twin-disc RCF tests are conducted.

Machine Learning Based Fault Identification in Journal Bearing

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Abs.ID: I15

ABSTRACT

Journal or plain bearings consist of a shaft or journal that rotates freely in a supporting metal sleeve or shell. There are no rolling elements in these bearings. They are extensively used in applications such as IC engines, centrifugal pumps, etc. where high speeds are the key requirement. The major problem that usually arises in journal bearings is a failure due to corrosion and looseness while mounting the bearing or due to continuous use, which results in economic loss and creates major safety risks in an industry. Thus, it is necessary to provide a suitable condition-monitoring technique to detect and diagnose failures and achieve cost savings for the industry. This paper presents the fault diagnosis method based on vibration analysis. An experimental setup is developed to diagnose faults in journal bearings such as holes, notch, looseness, etc. Experimental data is then collected for healthy & unhealthy bearings rotating at 12 Hz, 14 Hz and 16 Hz, using FFT analyser. Further, these experimental data were trained using Artificial Neural Networks (ANN) and Decision Tree (DT) and tested to predict the test-bearing health status based on statistical features that influence the faults most. The accuracy of Artificial Neural Networks (ANN) and Decision Tree (DT) was observed to be 91.47% and 96.12% respectively. It is concluded that machine learning algorithms are an efficient tool for identifying journal-bearing defects.

Development of Synthetic Barrier Fluid for Pressurized Seals with Correct Viscosity Configuration

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Abs.ID: C001

ABSTRACT

Mechanical seals operate with a thin liquid film between the faces. The fluid must have properties which allow the faces to operate under the application conditions and provide adequate lubrication. This is a function of the lubricity of the fluid, the viscosity under operating conditions, and the presence of additives or other contamination. The barrier or buffer fluid must also provide good lubrication for the specific face material combination in the application. Selecting the correct barrier or buffer fluid is a critical step in specifying a sealing system. It is easy to consider a barrier or buffer fluid only in terms of its lubricating properties; however, the fluid serves a number of other functions and must possess certain characteristics for successful use in mechanical seals. Viscosity is one of the most important properties of a good barrier fluid and is representative of lubricity. The fluid should be viscous enough to separate surfaces and prevent wear without restricting seal movement or heat transfer. Any liquid will have changes in its fluid properties as a function of its temperature.

The most desirable viscosity is between 2 and 32 cSt and this case study is about development of ISO VG 10 fluid as per requirement of customer for resolution of the problem with frequent breakdown seal and leakage, where ISO VG 17 imported Barrier fluid was under use. The loss of barrier fluid pressure can result in a reversal of hydraulic loads on the inboard seal hardware. If the seal hardware is not properly retained and reverse pressure capabilities for the rotating seal ring, the seal faces can blow open and unseat the stationary seal face. Pressure reversals on mixer seals is a common failure mode in industry.

Effect of Abrasive Particle Size and Hardness on Slurry Abrasion Behaviourof Weld-Deposited Steels

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Abs.ID: C002

ABSTRACT

Hardfaced steels are used for increasing wear resistance of industrial components under slurry abrasion situations in mining and mineral processing industries. Abrasive particle size and hardness are important factors influencing slurry abrasion of steels. The present work reports the effect of abrasive particle size and hardness on four weld-deposited steels with different hardness and varying carbon and chromium. The abrasive particles with different hardness; limestone, iron ore, and silica sand particles and with different particle sizes; 450-600 µm, 300-450 µm, 250-300 µm, 212-250 µm and 150-212 µm were used for slurry abrasion testing. The abrasive wear loss was found to be a function of H_a/H_s, the ratio of abrasive particle hardness (H_a) and surface hardness of steels (H_s) and decreased with an increase in hardness of weld deposited steels irrespective of abrasive particles; although the magnitude of decrease was different in each case. The slurry abrasion mass loss was highest for coarsest abrasive particle for all the abrasives; which was 1.35-2.67 times than that exhibited by finer abrasive particles. Slurry abrasion mass loss (q) showed power law relation with abrasive particle size (d) expressed as $q = k\, d^n$, where kis constant and particle size exponents (n) were in the range of 0.492-0.88.

Evolution of Surface Roughness and Correlation with Friction using in-situ Profilometry

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Abs.ID: C003

ABSTRACT

Friction, wear and scuffing of a starved tribological contact is often related to the changes in surface topography and chemistry of tribofilms. Though the starting lubrication regime, typically a fixed lambda ratio i.e., film thickness to composite surface roughness is well-defined, the changing surface topography poses challenges to quantity and understand the transitions. In this study a 3D interferometer integrated with tribometer on UniTest platform captured the evolving surface topography. Friction, surface roughness and wear evolution were recorded as a function of time. Lubricants with different anti-wear property were tested under linear reciprocation motion. The tests were intermittently stopped, ball and disc imaged and testing continued without disturbing the configuration. Under some conditions of load and temperature, failure of the lubricant film was observed with significant changes in surface topography. The transitions in friction and wear would be connected with the surface roughness to obtain new insights into lubricant behaviour.

Tribo Analytics for Sustainability using Alternate Energy Source

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Abs.ID: C004

ABSTRACT

Data analytics are gaining due weight day by day because of its unique characteristics of application in diverse fields of engineering. In the present paper, application of data analytics is shown in tribology area for sustainability which is badly needed to achieve future existence. Alternative energy source has come into the picture because of the fact that sustainability can be achieved more significantly by using it. Sustainability cannot be measured directly and hence it has been attempted to show significant improvement of any one of the three components of sustainability with a view to claiming the overall enhancement of sustainability. Four components of tribo analytics have been proposed and analyzed in details considering the real life experimentaldata. The industrial engine is driven by the CNG fuel and the used lubricating oils have been diagnosed experimentally. In the deterministic step, analytical ferrography facilitates to obtain theimages of the wear particles. Subsequently, fractal dimensions of the wear particles have been computed. In the third step, a predictive model has been developed using artificial neural network.In this step, regression coefficient of the experimental as well as predicted values are shown. In the final stage, a decision making model has been developed for prescribing the suggestion for implementation purpose. The important findings from the comparative studies of tribo analytics application reveal that the early maintenance action is needed for the CNG engine with a view to enhancing their performance in line with that of diesel engine.

Tribological Interaction Studies of Engine Oil Additives and their Combinations

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Abs.ID: C005

ABSTRACT

Modern engine oil formulations usually contain many kinds of additives, such as detergents, dispersants, antioxidants, viscosity improvers, anti-wear (AW) and friction modifiers at different dosages to obtain the desired physico-chemical and performance characteristics. These additives give numerous benefits including increasing the durability of components by reducing wear, fuel efficiency by minimizing the coefficient of friction between the surfaces, increasing the oil drain interval etc. The combinations of additives may interact with each other and exhibit antagonistic or synergistic effects in tribological performance compared to the individual additives. In this work, the effect of such interactions between two key additives (AW and dispersant) in engine oil with respect to tribological performance under boundary lubrication is studied. The test samples comprised of combinations of primary and secondary zinc dialkyl dithiophosphate (ZDDP) and polymeric dispersant additives in base oils and the tribological testing was carried out employing ball-on-disc test rig (SRV) and four-ball tester. This study provides a better understanding of the frictional properties of primary and secondary ZDDP, polymeric dispersant and its combinations with ZDDP when formulated with Group-I and Group-II base oils.

Tribological Interaction Studies of Metalworking Additives and their Combinations

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Abs.ID: C006

ABSTRACT

Previously a comprehensive study was done on tribological interactions of metalworking additives with respect to their anti-wear, anti-friction and extreme pressure characteristics when one or more additives in a base oil were studied. Two tribological equipment, viz., four-ball tester and SRV tester were used to assess the performance of different additive chemistries, which are typically used in formulating neat cutting oils. The following additive chemistries were utilized for this study: natural ester, sulfurized ester, chlorinated paraffin, phosphate ester, and sulfurized olefin. Three different dosages of these chemistries were initially mixed with a mineral-based oil and subsequently evaluated for their tribological performance. The most effective additive dosage (in percentage) from individual additive chemistry was selected for further investigation of the combination of two additives. Tribological testing of formulations involved the measurement of weld load, wear scar diameter and coefficient of friction at different test conditions. Several combinations of additives in the experiments enhanced tribological performance indicating synergism, while antagonistic effects of some combinations were observed. In this present paper, an effort has been made to validate the above findings using Microtap equipment.

Dry Sliding Performance of Thermomechanically Treated Structural Steel

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Abs.ID: C007

ABSTRACT

Carbon Manganese steel is thermo-mechanically treated using the Gleeble® 3800 thermomechanical simulator at 950°C and strain rates of 0.1, 0.01 and 10 s^{-1}. After the treatment, mechanical properties and microstructural features studied and correlates with untreated specimen. The work presented in this study discusses the dry sliding performance of all the specimens studied using the pin on disc apparatus and wear mechanism. Results shows that thermo-mechanically treated specimens gives the more resistance against the loss of materials due to the dry sliding as compared to the untreated specimens. This is attributed to the better hardness attainment and microstructural refinements. Wear mechanism of material damage are discussed for all thermo-mechanically treated specimens and untreated specimen.

Carbon Nanostructures: Structural Features and Tribological Characteristics

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Abs.ID: C008

ABSTRACT

Tribology plays a crucial role in improvement of performance and overall efficiency of machineries and thus to enhance the usability period of these systems. Many materials are reported which can effectively improve the performance of mechanical systems by reducing friction and wear of tribopairs. Nanolubricants are one of the currently growing materials which can effectively be used for the same purpose. But the application of these nanolubricants for any system is constrained by limited dispersibility and stability of fluids. In this study, novel nanofluids incorporating carbon nanostructures were developed, and their properties were investigated. In the present experimental investigations, the carbon nanostructures were synthesized using novel methods that are cost-effective and offer improved yield. The synthesized materials were fully characterized using different nano-characterization techniques, e.g. TEM, FESEM, DLS, Raman, XRD, UV-V is absorption spectrometer and FT-IR spectrometer. The results are well correlated with the reported literatures and support the formation of materials. The nanolubricants based on these synthesized materials were developed and their primary tribological characteristics study was done. The inclusion of the carbon nanostructure on tribological characteristics show strong dependence on structural features and dispersion stability of nanolubricant.

High Temperature Friction and Wear of Nimonic C263

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Abs.ID: C009

ABSTRACT

Turbines generate about 20% of the world's electricity and transport about a million people every hour globally. Turbine blade is a critical component in the hot path section of the gas turbine that undergoes deterioration due to high temperature erosion and fretting wear. In this study, UniTest 750 with pin and disc made of C 263 was tested in fretting at room temperature, 300°C, 500°C, 700°C and 900°C. At each test temperature the total number of sliding cycles and load were fixed at 25,000 and 100 N, respectively. Friction coefficient decreased exponentially as the temperature increased to 900°C. Wear coefficient decreased linearly with an increase in temperature. Lowest friction and wear were recorded at 900°C. Elemental composition analysis of worn surfaces showed an exponential increase in concentration of oxygen as a function of temperature. It was only at 900°C that we observed a layer rich in chromium oxide, using the XRD. Interestingly, there were no traces of Ni or Cr in the wear debris generated at 900°C. This wear mechanism is comparable to our field wear study of combustor parts and transient piece in gas turbines.

Tribological Behaviour under High Vacuum: Introducing the Ducom Vacuum Tribometer VT 3.0

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Abs.ID: C010

ABSTRACT

As the demand for advanced materials in cutting-edge applications like semiconductors, space exploration, and aviation continues to rise, understanding material performance under vacuum conditions is becoming increasingly crucial. Conventional Tribometers often fall short in accurately analysing material behaviour under such specialized environments. This study introduces the Ducom Vacuum Tribometer VT 3.0—a modular benchtop tribometer equipped with a compact vacuum chamber, capable of achieving vacuum levels down to 10^{-7} Torr, specifically designed for precise evaluation of tribological properties under both unidirectional and bidirectional test conditions. The results underscore the essential role of a controlled vacuum environment in accurately assessing friction and wear mechanisms, offering valuable insights into material performance. Consequently, the vacuum tribological testing methods introduced in this study could significantly enhance the accuracy and efficiency of screening advanced materials for high-performance applications.

Electrified Tribology: Revolutionizing EV Lubricant Testing

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Abs.ID: C011

ABSTRACT

As electric mobility advances, the need for lubricants that withstand the extreme conditions of EV powertrains is critical. EV lubricants face challenges like high starting torques, elevated speeds, and unpredictable electrical currents, complicating traditional testing methods. This study introduces the DUCOM POD 4.0 Tribometer with an integrated E-Module, designed to evaluate EV lubricants under electrified conditions. Using this advanced tribometer, the impact of DC current discharges on 100Cr6 bearing steel contacts was examined under dry and ATF oil-lubricated conditions, following ASTM G99. Results reveal that electric current significantly increases wear, driven by accelerated oxidation from elevated contact temperatures and reduced fluid film thickness. These findings highlight the urgent need for innovative solutions to protect EV bearings and extend vehicle lifespan. The electrified tribological testing methods presented offer a breakthrough in developing electric and hybrid vehicle lubricants, setting new industry standards for reliability and efficiency.

Enhancing the Performance of Concentrated Tribo-Contacts: Investigating the Tribo-Performance of Nano Grease Lubricated Textured Concentrated Contacts

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Abs.ID: C012

ABSTRACT

Grease lubricated textured contacts significantly impact the tribo-performance of concentrated tribo-contacts. In tribology, the study of friction, wear, and lubrication in mechanical systems, tribo-performance directly influences energy efficiency. Textured contact surfaces offer a promising solution for energy-efficient tribology by reducing friction and wear in tribo-contacts. The incorporation of nano particle blended oil/grease further enhances the performance, resulting in even lower friction and wear. Advanced lubrication technologies like minimum quantity lubrication, boundary lubrication, and nano oils, when combined with textured contacts, further improve tribo-performance and energy efficiency.

This study investigates the tribo-performance of nano grease lubricated textured concentrated contacts in comparison to conventional contacts, regardless of operating parameters. The results demonstrate reductions in friction coefficient at the nano-grease lubricated textured contacts compared to conventional contacts. Additionally, reciprocating balls in textured contacts exhibit lower wear when lubricated with nano grease compared to conventional contacts. The presence of nano grease also enhances the load carrying capacity of textured point and line contacts. However, it is worth noting that the lubricated textured point contacts show relatively higher electrical contact resistance compared to conventional contacts with nano grease, indicating superior lubricating oil film formation at the textured contacts. These findings suggest that utilizing nano grease lubrication in textured concentrated contacts can significantly improve their performance and efficiency.

A Review of Tribological Properties of Bearings with Nano-Lubricant

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Abs.ID: C013

ABSTRACT

Lubrication plays a vital role in engineering, with lubricants typically consisting of base oils (either mineral or synthetic) and various additives that enhance their tribological properties. As industrialization has progressed, the demand for lubricants has risen, leading to concerns about the depletion and biodegradability of mineral and synthetic base stocks. To address environmental issues and reduce pollution, researchers are exploring alternatives to mineral oil, including the use ofvegetable oil as a lubricant. Vegetable oils offer advantages such as being non-toxic, biodegradable, and environmentally friendly, with good lubricity. However, they face challenges like oxidation and reduced performance at low temperatures. To improve the tribological performance of lubricants, blends of different lubricants have been investigated, showing better or comparable properties to traditional lubricants. Nanoparticles have been explored as additives to modify the flow behavior of base fluids, particularly in lubrication, leading to the development of nano-lubricants - new lubricants created by dispersing nanoparticles in base oils. Nanomaterials are increasingly used in tribological applications due to their ability to reduce wear and friction. This is achieved through mechanisms such as the colloidal effect, rolling effect, small-size effect, protective film formation, and third body effect. The addition of nanoparticles like Al_2O_3, TiO_2, SiO_2, BN, CuO, and Graphene to lubricants has shown promising results in improving their performance.

Tribological Behaviour of rGO-Based Polymeric Coating

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Abs.ID: C014

ABSTRACT

The exceptional mechanical and lubricating properties of reduced Graphene oxide (rGO), along with the water-repellent nature of superhydrophobic surfaces, offer great potential for developing the advanced protective coatings for harsh environments. In the present study hybrid coating was developed with rGO-PTFE as filler materials into a polymer matrix, followed by the microstructural and micro-hardness characterization and wettability characteristics. Then the tribological behaviour of fabricated (rGO)-based polymeric superhydrophobic coatings was carried out. The results show that, with increasing the content of rGO, the coefficient of friction significantly falls, whereas the wear resistance is remarkably improved. Also, it is observed that the higher rGO concentrations in the presence of PTFE ensure better retention of the super hydrophobicity characteristics of the coating. At the same time, it was found that an optimal concentration of rGO existed beyond which the mechanical integrity of the coating could become compromised. The results highlight some interesting insights which reveals the potential of rGO-based superhydrophobic coatings in tailoring frictional properties with high durability, hence having great implications for industries related to aerospace and marine engineering. Further studies are focused on the optimization of the rGO content for the long-term stability of these coatings to be used in the specific application.

Influence of Texture Surface and Electro-Rheological (ER) Lubricant on the Performance of Two-Lobe Slot-Entry Hybrid Journal Bearing

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Abs.ID: C015

ABSTRACT

This paper investigates the performance of two-lobe slot-entry hybrid journal bearings lubricatedwith electro-rheological (ER) fluids, which are modeled using the Bingham model of non - Newtonian fluid flow. Surface texturing, a technique that has shown great potential in enhancing tribological components' performance, is applied in this study to fluid film bearings. The research focuses on the theoretical analysis of ER fluid lubrication combined with textured bearings, aiming to improve the performance characteristics of these systems. The Continuous Bingham model is employed to derive a modified Reynolds equation, which is then solved using the Finite Element Method (FEM) to obtain the static and dynamic characteristics of the textured ER-lubricated two- lobe slot-entry hybrid journal bearing. The findings demonstrate that ER fluid lubrication in two-lobe textured slot-entry journal bearings increase film stiffness by an order of 44.81% and stabilityby an order of 21.76%, compared to non-textured circular bearings with Newtonian fluids.

"Crystalline Calcite-the EP Load Carrier" in Calcium Sulfonate Greases

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Abs.ID: C016

ABSTRACT

Calcium sulfonate greases are special grease thickeners exhibit inherent load carrying capacity owing to the ingredient "calcite". Unique properties of Calcium sulfonate greases such as high dropping points, load carrying capacity, etc are dependent on the transformation of amorphous calcium carbonate to crystalline calcite form. Author's laboratory recently developed calcium sulfonate calcium complex greases (CaSCaC) with minimum amount of calcium sulfonate. Effect of crystalline "calcite" on the properties of on the greases - calcium sulfonate, calcium sulfonate calcium complex, calcium sulfonate calcium complex with added calcium carbonate and lithium EP greases with calcium carbonate is presented. Physico-chemical properties, SEM analysis, FTIR, ED-XRD and FE9 rig test studies were carried out and results on above mentioned greases were compared to understand the structure- property relationship. Rheological and tribological studies were carried out to understand effect of calcite and calcium carbonate on the frictional, load carrying, and grease life performances.

IIoT – Enabled Laser Particle Analyzer for Predictive Maintenance

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Abs.ID: C017

ABSTRACT

Contamination is a leading cause of equipment failure. Oil particle analysis helps identify and monitor contaminants in lubricated systems. Using an LED-based particle counter, we can assess anomalies in Viscosity Index, Moisture Content, TAN, TBN, Contamination Level, Particle Count, etc. Data is transmitted securely from sensors to a cloud-based platform using industrial protocols like Modbus, CAN bus, TCP/IP, etc. Raw data is processed in real-time using algorithms tailored to oil analysis and predictive maintenance, thereby generating real-time insights to empower proactive maintenance decisions, directly addressing the challenge scenario. This paper explores how IIoT enables advanced particle analysis technology and its potential to increase connected devices' operational efficiency and visibility.

Process Parameter Optimization of Trochoidal Toolpath in Hybrid-Electrochemical Magneto Rheological (H-ECMR) Finishing

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Abs.ID: C018

ABSTRACT

Hybrid-Electrochemical Magnetorheological (H-ECMR) Finishing process is an advanced surface finishing technique that produces surface roughness (R_a) up to a few nanometers, which is required for the implants. This study considers duplex stainless steel (DSS), a biomaterial constituting ferrite and austenite in equal proportion, as the workpiece. DSS is widely used for its high corrosion resistance compared with other grades of stainless-steel biomaterials. Furthermore, optimization of the process parameters for the trochoidal, a high-speed finishing toolpath, is carried out to achieve optimum surface roughness parameters during H-ECMR finishing. The surface roughness parameters (i.e., average Surface roughness (R_a), Kurtosis (R_{ku}), and Skewness (R_{sk})) are attained from the integration of the Design of Experiment (DOE), Response Surface Methodology (RSM), and Machine Learning Genetic Algorithm (ML-GA). DOE is utilized to plan the experiments based on Central Composite Design (CCD) using input process parameters of the H-ECMR finishing process. The regression equation is developed with the RSM, and its optimization study is performed with ML-GA. This paper aims to analyze the impact of the process parameters for the H-ECMR finishing process on different surface roughness parameters.

Investigation of the Impact of Biodiesel Dilution on the Oxidation and Tribological Properties of Engine Oil, and its Mitigation

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Abs.ID: C019

ABSTRACT

The aim to achieve carbon neutrality has paved the way for alternate fuels for internal combustion engines. Biodiesel is one such fuel which is being extensively studied for compression ignition engine applications. However, its reduced oxidation stability has an adverse impact on the oxidation and tribological properties of engine oil. In this study the oxidation and tribological properties of tractor engine oil (API CH-4) were investigated at different biodiesel dilution (5%, 10%, 15%, and 20%) using PDSC, and SRV tribometer (Ball on Disk set up). Tribological studies revealed a decrease in COF for different levels of biodiesel dilution in fresh oil. On oxidizing the biodiesel diluted oils using IP48 instrument, the tribology studies of the oxidized oils showed a significant increase in COF, proportional to biodiesel content in oil. To mitigate these effects of biodiesel dilution, three components (Antioxidant, TBN Booster, Friction Modifier) and their combination were studied on a 10% biodiesel diluted tractor engine oil. Antioxidant although delayed the oxidation but did not show any tribological advantage, Friction Modifier however showed a reduction in COF. A top treat of Antioxidant and Friction Modifier in a CH-4 engine oil is necessary for biodiesel fueled engines for smooth engine operation.

Effect of Base Oil Blend Viscosity (BOV) on Various Physical and Chemical Properties of Heavy-Duty Diesel Engine Oils

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Abs.ID: C020

ABSTRACT

Base oil blend viscosity, which is popularly known as BOV, has significant contribution in various physical and chemical properties of finished engine oils. In this research, three diesel engine oils of same API Specification (API CI-4 performance level) and same SAE grade (SAE 20W-40) are formulated with three different BOVs at 100 degree C with adjustment of Viscosity Modifier (VM) dosages. API Group II base oils (150N and 500N) are used in all engine oils. These oils are then analyzed for most critical characteristics of engine oil such as low temperature flowability, oxidation stability, deposit formation tendency and anti-wear characteristics. This study consists of analysis of 25 nos. of different parameters at the laboratory level for each engine oil. Complete study was carried out with two different API CI-4 additive chemistries. It is observed that, lower BOV can improve the flowability of engine oils which in turn start ability of engines, but it adversely impacts engine oil oxidation stability, deposit formation tendency and wear characteristics. Hence, Base oil blend viscosity (BOV) should be optimized for improved performance of engine oils and longer life of engines.

Artificial Intelligence Based Lubricant Formulation Prediction Software

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Abs.ID: C021

ABSTRACT

Lubricants are manufactured by blending of base oils and additives, whose composition is formulated based on end application. Over the years, Lubricant's specifications have been upgraded to meet improved performance of various Equipment manufacture's, environmentand customer requirement.

The requirement of multi grade oils have expanded from 15W40/20W40 to 0w20/ 5w30/10W30/0W16, etc. are being produced to meet stringent OEM / International specifications.

Receipt of base oils from multiple sources like CPCL, HPCL, BPCL, ADNOC, SAUDI ARAMCO and EXXON MOBIL, results in variation of base oil properties due to various operational conditions. Our R&D has formulated compositions with the typical values of base oil properties available at the time of development. However, base oil properties are prone to variation as stated above due to which R&D formulation for base oil composition cannot be adopted directly.

Even Mathematical or statistical models are not available to understand the correlation between base oil, additive properties and lubricant specification. Hence, Artificial Neural Networks which is data driven technology that combines statistical analysis and forecasting techniques can be possible approach. Using ANN, software can be developed to predict Lubricant Formulation based on properties of base oils, additives and specification of lubricant.

This AI tool allows one to speed up formulation development also as the number of test blendsand the amount of testing can be significantly reduced.

Tribological Characteristics of Meso-Scale Air Bearing with Texture

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Abs.ID: C022

ABSTRACT

The miniaturization trend in technology has driven innovation in all aspects of design, including bearings. In this realm, meso-scale air bearings offer a unique solution for supporting high-speed, low friction rotation in miniature systems. The applications of meso-scale bearings are hard disc drive, laser scanner, miniature motor and spindle, dentist drill, etc. Researchers are actively seeking methods to improve the performance of meso-scale air bearings. One promising approach involves surface texturing in the bearing.

In this paper, the bearing with texture is printed in steel using metal 3D printer. The experimental set up is developed to measure the friction. Post test wear is measured. The parametric study on texture parameters and position is presented. The comparison between plane and textured bearing is presented. The partial texturing is beneficial in hydrodynamic zone at higher loading. Abrasive wear is dominated in plane bearing and adhesive wear in textured bearing.

Development of Fuel-Efficient Crankcase Engine Oil for Heavy Duty Applications

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Abs.ID: C023

ABSTRACT

Indian government legislation of emission norms rapidly shifted from BS IV to BS VI to protect environment from air pollution and applicable from April 2020. Presently most of heavy duty and light duty commercial vehicles running on road belongs to BS-III & BS-IV emission norms. These older vehicles are contributing more to air pollution but an important part of the economy and perform a wide variety of revenue services which is reflected in the large range of vehicle sizes and operational characteristics. The complexity of this vehicle category presents a challenge in reducing emissions and fuel consumption. In these old vehicles, the only way to overcome problems is to develop low viscosity engine oil deployed with friction modifiers. However, it is difficult to improve the performance, reliability and cost-effectiveness of engine oil formulation for existing old vehicles. The most challenging target of these vehicles is to achieve fuel efficiency along with engine durability by using low viscosity lubricants. This study investigates the tribological behaviours of low viscosity multi-grade SAE 10W-30 engine oil and reference engine oil of monograde SAE-30 and SAE-40 using SRV test rigs, Rolling-disk machine and Weld load. Developed low viscosity engine oil was better in friction properties and elasto-hydrodynamic (EHD) film thickness at high operating temperature which is equivalent to oil temperature in running diesel engine. A multigrade engine oil has an advantage over monograde oil is to keep viscosity at optimum level within a certain temperature range and avoid faster oil thickening as temperature decreases. In engine oil, friction modifiers are deployed to improve fuel economy by reducing friction and performed experimentally by SRV test. The effect on torque was also evaluated on the lubricants by friction torque test (FTT). The average change in the torque (%) greatly enhanced (~7% to ~9%) with the developed fuel-efficient crankcase engine oil with respect to reference monograde oil SAE-30 and SAE-40. The findings of the experimental studies will be presented in the conference.

A Smart Cloud-Based Monitoring and Fault Detecting System for Identifying Surface Defects Rolling Element Bearing

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Abs.ID: C024

ABSTRACT

Bearings are considered to be one of the crucial parts of rotating machines from a maintenance perspective. Vibration analysis gives early intimations of machine failure. Therefore, mostly vibration-based fault diagnosis is used to monitor the condition of bearing's health. In this work, a cloud-based Data Acquisition System is developed to identify surface defects at ball-bearing raceways. The vibration data from an experimental setup in time domain is captured by a wireless sensor and saved on AWS cloud. The digital twin rotor-bearing model is simulated in ANSYS. After Signal processing the simulated data is fed to Decision Tree (DT) algorithm. The simulated data is used to train the algorithm, whereas the data acquired from the developed cloud-based Data Acquisition System is used for testing. It can be concluded that the defects are characterized by Ball Pass Frequency at the inner race and Outer Raceway (BPFO and BPFI) as indicated in the literature available. As the intensity of the defect increases, there is an increase in vibration amplitude at signature frequencies. The developed web application is capable of identifying bearing defects with an average accuracy of 92 %.

Low Pressure Nitrogen Treatment of Sisal Fiber to Improve Tribo-Performance of Composites

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Abs.ID: C025

ABSTRACT

The increasing interest in environmentally friendly lightweight materials driven by concerns regarding environmental degradation, urbanization and sustainability has brought natural fibers such as sisal fiber (SF) into the spotlight as reinforcement choices. Industries have steered clear of conventional chemical treatments due to their adverse environmental effects and high costs. To enhance the surface properties of the fibers and their compatibility with other materials a low-pressure plasma modification process using nitrogen gas was conducted for half an hour at 120 W power. The SF was then combined with epoxy resin at a consistent weight fraction of 30wt% for tribological testing following ASTM standards. Abrasive wear and friction tests were carried out on unmodified and treated composite specimens at varying sliding velocities (1-3 m/s), sliding distances (1000-3000m) and loads (10-40 N). Treated composites exhibited a significant reduction in S.W.R by 40.28%, 45.45%, 50.16% and 53.04% in comparison to untreated SFREC. The coefficient of friction (COF) of treated composites decreased by 11.0 %, 18.42 %, 22.85 % and 28.87 % at loads ranging from 10 to 40 N when compared to untreated SFREC at a sliding velocity of 3 m/s and a sliding distance of 3000 m.

Comparative Analysis of Spiral Bevel Gears Manufactured by Continuous Indexing Face Hobbing and Single-Indexing Face Milling

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Abs.ID: C026

ABSTRACT

Spiral bevel gears are vital components in the power transmission systems of heavy-duty trucks, with their performance significantly impacted by the manufacturing process. This paper presents a comprehensive comparative analysis of spiral bevel gears manufactured using continuous indexing face hobbing and single-indexing face milling techniques. In continuous indexing, the gear teeth are cut one after the other using a single cutter head, whereas in the single-indexing method, one slot is cut at a time. The study explores primary differences in friction-induced heat generation. Face-milled gear pairs were designed and verified according to AGMA standards using the powertrain analysis software KISSsoft and compared with existing gears manufactured by face hobbing. To assess real- time performance, the gears were subjected to a cross-country trial, followed by a strip examination. Additionally, the heat generated by the gears during operation was evaluated using an axle test rig. By integrating theoretical modeling with empirical testing, this paper provides an in-depth examination of the tribological performance of gears produced by these two manufacturing methods. The results offer critical insights into the advantages and limitations of face hobbing versus face milling, informing the selection of optimal manufacturing techniques. Ultimately, this research contributes to the understanding of how these processes influence gear performance, offering guidance for enhancing durability and efficiency in demanding heavy-duty truck applications.

Development and Evaluation of New Synergistic Approach for Fuel Efficient Low Viscosity Gasoline Engine Oils

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Abs.ID: C027

ABSTRACT

Automobile original equipment manufacturers, government, and end consumers are always looking for improved fuel efficiency and extended oil drain period without compromising engine durability and power. Auto OEMs are demanding low viscosity engine oils to achieve fuel economy with high performance engine and durability for meeting CAFÉ emission norms. Fuel economy can be improved by adopting innovative approaches in engine design and using appropriate low viscosity engine oil with friction reduction chemistry. This concept is already established worldwide, and many OEMs are following the same footprint for achieving the targets.

In this paper, authors have developed three different candidate oils by using different base oils and friction modifying agents with suitable performance package meeting ILSAC GF5/SN SAE 0W-20 credentials. This study includes physicochemical tests, lab performance tests (low temperature fluidity, High Temperature High Shear Viscosity, Noack evaporation loss, oxidation test, deposit forming tendency through TEOST), and tribological performance tests i.e., SRV and MTM. The transit dynamometer engine test bench is used for friction torque studies. Out of three candidates based on the friction torque performance best candidate oil was selected for the fuel economy testing on chassis dynamometer using the Modified Indian Driving Cycle. Selected candidate oil performance in terms of improvement in fuel economy and reasons thereof are discussed in the current publication.

Evaluation of Static and Dynamic Coefficient of Friction During Dry Sliding Contacts Between Al6061 and SS304 Material at Variable Speeds

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Abs.ID: C028

ABSTRACT

The present tribological investigation aims to replicate the practical aspects of the extrusion process. Estimating the static and dynamic coefficients of friction (COF) between the pairing materials is crucial, as these values help in calculating the forces required during extrusion process. For this study, Al6061 sample was selected for extrusion, and SS304 was used for the mandrel in the dynamic extrusion setup.

To accurately mimic the real application scenario, pin (Al6061) and plate (SS304) samples were carefully chosen to create Hertzian line contact on a linear reciprocating tribometer. Calculations were performed to determine the contact stresses generated in the actual application. The load and length of the contact line were then adjusted to match this stress range for experimental purposes, with varying sliding speeds.

The results indicate that at very low sliding speeds (0.002-0.004 m/s), both static and dynamic COFs fall within a relatively narrow range of 0.4-0.49. However, when the speed exceeds 0.010 m/s, a significant disparity between the static and dynamic COF emerges. The static COF increases substantially, ranging from 0.74 to 0.81, while the dynamic COF remains comparatively lower, fluctuating between 0.45 and 0.54.

Futuristic Lubricants for Advanced E-Vehicles

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Abs.ID: C029

ABSTRACT

The Global drive for improved energy efficiency and lower CO_2 emissions are the main motives for emergence of E-mobility. Growth of electric vehicles (EVs) has continued since its introduction in early 19th century and has grown substantially thereafter. Significant growth in EVsis expected in future and beyond 2030. Electric vehicles require specialized lubricants which are different from conventional lubricants mainly due to the addition of new hardware technology including e-motor, invertor, battery and new materials (copper windings, elastomers, plastic and other materials). Any lubricant when used in an advanced powertrain electric vehicle specifically where lubricant encounter the e-motor must deliver unique performance attributes including optimal electrical/thermal management/ material compatibility apart from the traditional performance features such as extreme pressure/ friction performance, oxidation, and wear control. Understanding the requirements of electrical, heat transfer and corrosion resistance, oxidation resistance and tribological properties was outlined in this study. In the current study, we have also evaluated a series of candidates ranging from conventional GL4/GL5, manual transmission oils and dedicated e-fluids for physio-chemical, performance, and tribo properties. Our current study emphasized that the additives chemistry played a significant role in delivering required performance in electric vehicle lubricants.

Development and Field Validation of New Generation Low Mist Type Neat Cutting Oil for Gear Hobbing Application

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Abs.ID: C030

ABSTRACT

Gear hobbing is a machining process in which gear cutting is done by a multipoint cutting tool called gear hob on rotating gear blank. In this severe metal cutting process, both tool and workpiece are in relative rotational motion and profile is formed on gear blank by the equally spaced several cutting edges around the gear hob and cutting the gear blank in a single operation.

This paper describes the development of new generation neat cutting oil for gear hobbing application which provides excellent lubricity & antiwear property, enhanced tool life & surface finishing, enhanced sump life due to excellent thermo-oxidation stability, excellent foam control & excellent air release property, low volatility & superior antimisting characteristics for improved working environment.

The paper also deliberates field validation of developed candidate for gear hobbing application in auto ancillary industries. Field studies not only established its performance but also validated its excellent antimisting characteristics indicating good correlation between laboratory and field data.

The Rolling Contact Fatigue Behaviour of Transmission Lubricants

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Abs.ID: C031

ABSTRACT

In strongly loaded, non-conformal contacts like gears and rolling element bearings, a specific kind of fatigue known as rolling contact fatigue can develop. Mainly, it is a failure mechanism linked to cyclic loading that repeatedly occurs, producing high local Hertzian pressures that cause significant surface or subsurface stress as well as local plastic deformation. Crack initiation and propagation follow from this. This can occasionally lead to the abrupt and frequently catastrophic mechanical failure of the contacting parts. The right lubricant selection can influence this failure mode to some extent, both in terms of the chemical and physical characteristics of the films that form at the surface.

This research demonstrates that the quality of base oil plays a significant role in rolling contact fatigue resistance, even with lubricants of the same viscosity grade and physical properties. The RCF L_{10} life mostly depends on the composition of the lubricant (a combination of additive and base oil), which also results in a significant variation in friction performance, especially in the mixed lubrication regime.

The statistical L_{10} life based on multiple tests is presented in the form of a Weibull distribution, along with a detailed discussion of the statistical significance of the fatigue life of the selected lubricants.

Tribological Behaviour of Various Base Fluids used in Neat Cutting Oils

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ABSTRACT

Metal Working Fluids find huge applications in numerous industries for manufacturing applications such as grinding, drilling, cutting etc. Neat cutting oils are particularly designed for improving the longevity of the machinery and tools & help in reducing their wear and tear. The major function of neat cutting oil is anti-wear properties, substantially for increased machine life along with achieving and retaining superior surface finish of work piece. Increasing demand for neat cutting oils in various machining applications is expected to expand the neat cutting oil market across the globe. Technological up-gradation in the tools and equipment used in various industries like automobile, aerospace, construction and electrical, marine, rail and power, telecommunication and healthcare are assumed to raise the demand for the neat cutting oil market in immediate future. Composition of neat cutting oil usually depends on the type of process being followed. Neat cutting oil is generally produced from petroleum, natural or synthetic oils using various types of additives. Time to time, there is a constant change in the composition of these products due to oscillating regulations and formulations along with the pressure from regulatory environmental authorities across the world.

This present study is intended to examine the tribological behavior of mineral oil, vegetable oil, and synthetic esters as base fluids in neat cutting oils, focusing on key performance metrics: lubricity through anti wear properties, mist generation, evaporation loss, and environmental impact. Synthetic esters exhibited the highest lubricity with high thermal stability and expected to significantly reduce tool wear, improving surface finish of work piece. Vegetable oils provided comparable lubricity with the added advantage of being biodegradable and environment friendly. Both synthetic esters and vegetable oils will show lower mist generation and evaporation loss as compared to mineral oils, contributing to a cleaner working environment and reduced fluid consumption. Environmentally, vegetable oils and synthetic esters are expected to perform better than mineral oils, offering eco-friendly alternatives aligned with modern sustainability goals. This study emphasizes the increasing preference for synthetic esters and vegetable oils in immediate future and next-generation machining operations where performance and environmental considerations are crucial, along with economic efficiency and cost-effectiveness. In this work, the wetting phenomena of the three base fluids used in the neat cutting oils influencing the lubricity are explained by determining the Spreading Parameter and Surface Free Energy through measuring Surface Tension and Contact Angles. The information obtained from the study will be useful in considering right selection of base fluid suitable for end cutting application.

Lubrication Management – Key to Plant Reliability

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ABSTRACT

In steel industry, lubricants play a vital role to keep the equipment in running and healthy condition. Lubrication requirement of steel industry is very challenging as the operating condition of machineries are very harsh with respect to load, temperature, dust, and water ingress.

Lubrication costs typically consume between 3%-5% of the total maintenance budget. While lube costs appear low as a percentage of the overall budget, their impact on every other maintenance item is significant if lubes are not effectively employed. Six Rs of lubrication - The right lubricant, In the right amount, At the right time, At the right place, With the right method and right people to lubricate are essential to the successful performance of any equipment.

Right Product & Quality: If the lubricant is not correct & fit for purpose, it may result in failure. Right Quality of Lubricant needs to be ensured through,

- Lubricant Condition Monitoring
- Contamination Control
- Proper Sealing

Right Place: If the lube is not in the equipment, it cannot lubricate. Lubricant must reach to the right place for lubrication.

Right Time: All equipment have a frequency of lubrication. This may be schedule to change oil, time between regreasing frequencies, schedule of drip or pressure supply for total loss systems.

Right Amount: Equipment needs a certain volume of lube to protect moving parts. This volume is determined by OEM's or by existing user practices.

Right Method: There are several ways to get lube into equipment.

• Manual application (grease gun / oil can/ pump)

• Centralized lubrication systems (high pressure, timer operated grease pumps & measuring valves; recirculation oil systems; level operated oil top up systems; open gear spray systems, etc.

• Semi automated systems (single point lubricators; drip feeders, etc.)

• Is the system fit for purpose? Is it working correctly & in good condition? Does it meet OEM requirements?

Right People: The competence of the people performing lubrication can greatly affect the outcome.

Present paper discusses some of the case studies from Tata Steel highlighting the above points.

Screening and Performance Evaluation of UTTO (Universal Tractor Transmission Oil)using LVFA Test Rig and Bench Top Tribometer

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ABSTRACT

The Low Velocity Friction Apparatus (LVFA) test rig is a versatile rotary tribometer with axial loading, capable of evaluating shudder, endurance, friction, and wear performance in wet clutches using 'clutch plate-friction plate' area contacts at low velocity (up-to 1.5 m/s). This study screened and evaluated Universal Tractor Transmission Oils (UTTO) using the LVFA, a Mini Traction Machine (MTM), and an SRV Tribometer to assess their effectiveness and durability under conditions relevant to agricultural machinery. Wet clutches, which operate in lubricated environments, offer smoother engagement and longer lifespans, albeit with lower efficiency compared to dry clutches. The SRV and MTM rigs are well-documented and widely accepted industrial benchtop tribometers. Screening tests on the SRV and MTM machines were conducted to select oil samples based on their expected endurance and anti-shudder performance. A correlation was established between the SRV, MTM, and LVFA tests, resulting in a comprehensive methodology for evaluating oils in clutches and brakes.

Long duration LVFA endurance/durability tests were successfully conducted on three commercial brake fluids according to JASO M349 standards. The results indicated distinct variations in the frictional performance of the three oils. While clutch frictional characteristics appeared similar among the oils at lower temperatures, they diverged significantly as test temperatures increased. Notably, Oil A demonstrated superior performance compared to Oil B, which, in turn, outperformed Oil C at elevated temperatures. Consistently, in endurance testing, Oil A exhibited the highest performance, followed by Oil B and then Oil C. Results from the MTM test showed similar outcomes for all three oils. Frictional characteristics derived from the SRV test revealed maximum friction for Oil A, followed by Oil B, with Oil C exhibiting the lowest friction coefficient. Moving forward, this established test methodology holds promise for future evaluations of lubricant products and clutch performances.

Synergistic Tribological Effects of Cold Rolling and Heat Treatment on Inconel-718 at Room and High Temperature

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Abs.ID: C035

ABSTRACT

Inconel-718, a nickel-based superalloy, finds application in nuclear power plants, aircraft engines, gas and steam turbines at both low and high temperatures due to their higher mechanical strength, good fatigue life and corrosive resistance. Inconel-718 is a heat-treatable alloy, and its strength is mainly contributed by the γ', γ'' and δ-phases present in it. We aim to study the tribological behaviour of this superalloy after cold-rolling and cold-rolling followed by aging. We have carried out studies at room and high (450°C) temperature. Our study focuses on the systematic study of microstructural changes under different cold rolling reduction percentages with isothermal aging and their effect on the wear behaviour of Inconel-718. The cold-rolling with isothermal aging treatment improves the micro-hardness of the alloy through the combined effect of work-hardening and precipitation of γ', γ'' and δ-phases. Post- tribological test characterization of wear tracks was done using non-contact 3D optical profilometry, scanning electron microscopy along with energy-dispersive X-ray spectroscopy. The results indicate that the cold rolling helps in enhancing the wear resistance of as-cast Inconel-718 alloy. Wear tracks on specimens were further analysed to elucidate the wear mechanism.

Study of Adhesion Behaviour of the PDMS Elastomer Against Borosilicate Glass-Slide by Varying the Curing Conditions

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Abs.ID: C036

ABSTRACT

As technology advances and devices miniaturize, controlling the adhesion behaviour of PDMS elastomer becomes critical. Adhesion or stiction is also a significant cause of failures in MEMS and NEMS devices. Examples of PDMS elastomer-based MEMS and NEMS devices include microfluidic devices, triboelectric nanogenerators, biochips, and electronic sensors. Interfacial adhesion can be managed through chemical surface treatments, altering surface textures, and modifying the mechanical properties of materials. This research aims to tune adhesion by altering the mechanical properties (modulus and hardness) of PDMS elastomers through changes in curing conditions, specifically curing-temperature, and curing-time. We used the wedge test to determine the adhesion between the PDMS elastomers and the borosilicate glass slide. This approach creates the wedge by inserting a glass coverslip at the interface. We measure the equilibrium crack length between the elastomer and glass-slide and from there, we estimate the work of adhesion. We see a considerable drop in the work of adhesion and an increase in equilibrium crack length when the PDMS elastomer's curing-temperature and curing-time rise.

Study of fracture mechanics behavior and mechanism of hydrogen embrittlement in nickel using molecular dynamics simulation

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Abs.ID: C037

ABSTRACT

Molecular dynamics (MD) simulations were employed to investigate the effects of hydrogen embrittlement on the deformation and failure behaviour of nanoscale monocrystalline nickel with elliptical notches. This study provides atomic-scale insights into how hydrogen influences mechanical properties and fracture mechanisms. Tensile tests were conducted at varying hydrogen concentrations and temperatures using LAMMPS for simulations, Ovito for visualization, and Python/MATLAB for data analysis. Key findings reveal that hydrogen significantly reduces the tensile strength and ductility of nickel, facilitating premature failure. Stress-strain analysis demonstrated a marked reduction in yield stress and ultimate tensile strength with increasing hydrogen concentration and temperature. Dislocation dynamics, including Shockley partials and perfect dislocations, highlighted the role of hydrogen in enhancing dislocation mobility and promoting crack initiation at the notch tip. The elliptical notch geometry was found to amplify stress concentrations at the semi-major axis, leading to accelerated crack propagation in hydrogen-charged specimens. These results underscore the synergistic effects of hydrogen embrittlement, temperature, and notch geometry on the mechanical properties and fracture mechanisms in nickel.

Experimental Investigation into Abrasive Wear Behaviour of Terminalia Chebula Particulate Reinforced Epoxy Composite

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Abs.ID: C038

ABSTRACT

Particulate fillers are used in tribological applications to enhance friction and wear of polymericmaterials. High cost of particulate fillers sometimes restricts their use. However, low-cost particulate fillers obtained from bio-waste, industrial waste and constructional waste can be used if research out successfully in polymer-based composite for tribological applications. Themain objective of this study is to investigate the mechanical and abrasive wear properties of Terminalia Chebula seed particulate (a bio waste) reinforced epoxy composite. The characterization of Terminalia Chebula seed particulate was carried out using SEM, FTIR, EDX and XRD. Mechanical characterization and abrasive wear study of fabricated composites(0, 10, 20, 30 and 40 wt.%) was performed under dry sliding condition on a pin on disc machinewith various operating parameters. The experimental results shown that mechanical and abrasive wear property of neat epoxy has increased significantly by TCP filler reinforcement. The surface morphology of worn and fractured surfaces was carried out by SEM to find out thefailure mechanism.

Solid Particles Erosive Study of 1.1 C Bainitic Alloy Steel

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Abs.ID: C039

ABSTRACT

Erosive behaviour of 1.1 C bainitic alloy steel against alumina was analysed in the present research work. As cast 1.1 wt% carbon alloy steel was austenitized at 900°C followed by austempering at 250°C for 24 hours for bainitic transformation. Microstructure/phases were characterized by optical microscopy, Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD). Modulus of elasticity and hardness were measured by micro hardness tester. Erosion tests were performed at impact angles of 15°, 30°, 60° and 90° with velocities of 40, 60 and 90 m/s to determine Steady State Erosion Rate (SSER), and velocity exponent(n).

The velocity exponent was obtained using erosion power law model ($E=k*v^n$), which concluded an average value of 2.594 indicating ductile erosive behaviour. The SSER was highest at 60° impact angle for impact velocities of 60-90 m/s and at 90° impact angle for 40m/s, whereas it was lowest at 90° impact angle for impact velocities of 60-90 m/s and at 15° impact angle for 40m/s. SEM analysis revealed that lower impact angles and lower impact velocities responded micro-ploughing and micro-crack formation, while at higher impact angles and higher impact velocities large cracks, pits and significant craters with embedded alumina fragments.

Tribological Properties of Protic Ionic Liquid and Deep Eutectic Solvents for Steel/Steel and Steel/Ceramic Contacts under Boundary Lubrication

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Abs.ID: C040

ABSTRACT

Dry machining is widely recognized as one of the most environmentally friendly approaches aimed at minimizing the use of mineral-based lubricants. The disadvantages of dry machining involve higher contact temperatures and stresses, which result in increased friction and wear. As a result, there is a need for more sustainable lubricants to promote environmentally friendly alternatives. Ionic liquids (ILs) and their family, deep eutectic solvents (DESs), are non-volatile, non-flammable, recyclable, and environmentally friendly fluids, making them well-suited for a range of applications, including lubricants. The purpose of this study is to examine the impact of ILs and DESs on the tribological properties of different contact pairs, such as steel-steel and steel-ceramic. Tribological properties were measured by a reciprocating ball-on-plate tribometer at room temperature. The morphologies of wear tracks were analyzed with a field emission scanning electron microscope (FE-SEM). It was observed that the coefficients of friction and wear for the bearing steel disk decreased when using the as- synthesized lubricants compared to the commercial base oil. The predicted mechanism for reducing friction and wear involves the formation of an adsorption layer, which is influenced by the alkyl chain length and the strong hydrogen bonding network of ILs and DESs lubricants.

Efficient MATLAB Implementation of FEM for Fluid Film Bearing System

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ABSTRACT

This paper aims at improving the performance of Finite Element Method (FEM) computations in fluid film bearing system, focusing on an efficient MATLAB implementation. The simulation of fluid film bearing system often requires incorporation of surface topography micro-features such as micro-dimples and micro-grooves. The inclusion of these features necessitates the use of a very large mesh size, making global matrix computation exceedingly time-consuming with standard FEM algorithms. The research presented in this paper focuses on the development of an alternative method that optimizes global matrix computations, significantly reducing computational time and memory usage. By analyzing the performance bottlenecks in traditional FEM approaches, we propose an alternative method that ensures sustained high performance for very large mesh size. The result is an efficient and scalable solution for high-resolution modeling of complex fluid film bearing system.

An Energy Dissipation Approach to Study the Tribological Behaviour of Chocolate During Mastication Using a Pendulum Tribometer

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Abs.ID: C042

ABSTRACT

In food perception and palatability, characteristics such as texture and swallowability are key to consumer satisfaction. These characteristics are influenced by the friction experienced during mastication. Designing the food texture is essential to enhance its quality, and assessing the food based on tribological behaviour provides insights into its quality. The present study reveals the frictional behaviour of chocolate during mouth interaction. A pendulum tribometer, utilizing the energy dissipation method, calculates friction during mouth-chocolate interaction by calculating the energy dissipation per cycle. A non-contact rotary encoder captures the pendulum's angular position over time, with the oscillation amplitude reduction indicating energy loss in the system. A no-load test was conducted to neglect the effects of system damping. Test specimens were obtained from four commercially available bars of chocolate. The average coefficient of friction, which varies from 0.02 to 0.28, provides a clear distinction among the chocolates. The amplitude vs. time plot uses colour variations per cycle to indicate the coefficient of friction. The colour intensity reflects the average friction coefficient per cycle. The present methodology closely replicates the mouth-chocolate interaction and aids the food industry in distinguishing food perception based on frictional properties.

Tactile Friction under Boundary Lubrication: Reduction in Fingertip Friction using Surfactants

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Abs.ID: C043

ABSTRACT

Tactile exploration involves dynamic interactions between fingertips and object surfaces, governed by both normal and frictional forces. To understand these interactions, the friction between a patterned, deformable soft substrate and a rigid substrate under boundary lubrication by human fingers was investigated. This study has potential applications in areas like tactile sensing, haptic devices, prosthetics and design of textiles and FMCG goods. Using a custom-built strain gauge sensor, both normal and frictional forces were measured simultaneously and independently for various lubricating solutions applied to the fingertip interacting with a glass substrate. The results demonstrate a significant reduction in friction upon introducing a surfactant acting as a lubricant as compared to dry contact. Solutions containing surfactants, like Sodium Dodecyl Sulfate (SDS), exhibit efficient boundary lubrication, achieving Coefficient of Friction (COF) values as low as 0.2 at high concentrations. Notably, COF exhibits an asymptotic behavior beyond the surfactant's critical micellar concentration, suggesting saturation of the interface. Further, the COF-time profile changes its nature as the bulk concentration increases and experiments indicate that the adsorption of surfactant molecules onto the surfaces is the cause for this.

Effect of Local Cyclic Stresses due to Predetermined Cracks on Rolling Contactfatigue Behaviors of AISI 52100 TH Bearing Steel

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Abs.ID: C044

ABSTRACT

AISI 52100 steel is a deep hardening alloy used for aircraft bearings or other high stressed parts. This steel has the necessary qualities to tolerate high cycle, high stress fatigue in a hardened formbecause of its high hardness, high strength, and high cleanliness. Even though there are many individual and combination external factors like tensile stresses, short heavy loads, dynamics or vibration, electrical currents, corrosion, lubricant, mixed friction and slip that may influence premature fatigue failure accelerated in bearings. This article investigates an extensive analysis on premature bearing failures based on pure rolling contact with local cyclic stresses due to predetermined cracks under mixed lubrication conditions in AISI 52100 through hardened material for wind turbine applications. The variable-sized pit forms that occurred directly nearthe dent mark on tested cylindrical samples are mostly caused by the different applied load conditions and the number of dents. The L_{10} Weibull life varies depending on the number of notches and lubrication conditions observed. In the subsurface of the samples under examination,the white/dark etching cracks were precisely located beneath the dents. A more detailed analysis based on observed results with input parameters begins to conclude this current investigation from an industrial perspective.

On the Triboelectric Energy Harvesting Performance of Fibrous Structures

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Abs.ID: C045

ABSTRACT

The present era is majorly facing the problem of energy crisis. Conversion of abundantly availablewasted mechanical energy into its electrical counterpart has surfaced as an effective solution for powering small electronic gadgets. As fibrous structures are being used in apparel sector as well as in numerous technical applications, such materials can be an appropriate candidate for triboelectric energy harvesting from various mechanical energy sources. Among several textile structures, we have explored the nonwoven structure particularly in this work. Anisotropic fibrous web was manufactured employing carding process followed by mechanical bonding to provide structural integrity to the web structure. Finally, the triboelectric energy harvesting performance of such structures was studied, considering polyethylene terephthalate as the second surface. Such a type of fibrous structure has few unique properties which may be beneficial from triboelectric energy harvesting perspective. Moreover, material and process parameters can be easily tailored to prepare different structures of this form. In this work, the influence of different structures of fibrous assembly on their triboelectric energy harvesting performance has been explored. Further, such fibrous material was tested for real-time energy harvesting applications.

Synthesis, Characterization and Tribological Studies of Molybdenum Sulfide as a Dry Lubricant

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Abs.ID: C046

ABSTRACT

The dynamic elements of machineries need lubrication to decrease its wear properties. Mostly, the semi solid lubricants such as grease and oils are used until now which is a promising candidate but needs refilling after a certain time and has its own cons. It has become a critical job to refill the grease very often and decreasing efficiency with time makes it less efficient.

The current report studies the formation of MoS_2 nanomaterial flowering its way towards dry lubrication and describes a better synthesis (hydrothermal method) as well as coating process without the use of any binders. The Coefficient of friction (COF) of the material was analyzed and the structural as well as tribological aspects are studied. It reveals the promising nature of MoS_2 as a dry lubricant by varying the working conditions.

Nanoscale Frictional Characteristics of Titania Nanorod Patterned Surfaces

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Abs.ID: C047

ABSTRACT

Biological species such as snakes, fish and certain insects control friction and drag intelligentially via textured surfaces. Such nature inspired nanoscale surface texturing is a useful tool to control the tribological properties for various engineering applications involving sliding contacts. However, an in-depth understanding of nanoscale tribological behavior is needed to optimize the surface texture for achieving desired frictional properties. In this work,nanotextured surfaces with tilted titania nanorods (TiNRs) were developed using the glancingangle deposition (GLAD) technique. These surfaces exhibited stick-slip friction as well as frictional anisotropy for different sliding directions. An Atomic Force Microscopy (AFM) based approach was deployed to study the frictional behavior, and the resulting anisotropy was measured and analyzed quantitatively. The frictional behavior varied significantly in different sliding directions as per the orientation of the TiNRs. In one direction, the 'stick-slip' phenomenon was prominent; in contrast, it was reduced significantly when the nano-textured surface was rotated at different angles with respect to the sliding direction of the AFM cantilever. Overall, the textured surface and AFM-based frictional measurement provide a fundamental understanding of influence of surface texturing on friction at the microscopic level.

Adhesive Contact of Elastic Asperities using Body-Force Formulation

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Abs.ID: C048

ABSTRACT

Adhesion significantly influences the tribological behaviour of surfaces in contact. The interaction of asperities between sliding elastic bodies in the presence of adhesion and the associated energy loss is an important concern in studies regarding the origin of friction.

Traditional analytical models for asperity interaction often rely on assumptions of small deformation, surface force approximation, and specific geometries. Similarly, most computational methods also assume surface force approximation to reduce computational costs. However, this assumption frequently fails at the nanoscale, where large deformation and strong adhesion are present. The present study employs van der Waals adhesion as a body force within an in-house developed large deformation finite element code to study the adhesive contact between asperities. The research examines variations in contact area, pull-off force, and contact stresses under both normal and shear loading of a spherical asperity.

Additionally, normal and oblique impact studies investigate energy dissipation caused by adhesion-induced instabilities. A parametric study of varying material properties, geometry, and interaction parameters is conducted to enhance the understanding of contact phenomena in the presence of adhesion. This study aims to overcome some of the challenges in understanding the fundamental problem of asperity-asperity interaction and consequently help in developing a better understanding of dry friction for materials undergoing elastic deformation.

Employment of Cohesive Zone Modelling to Study the Interfacial Delamination in Coated Hip Implants using FEM

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Abs.ID: C049

ABSTRACT

Hip implants are prone to severe wear, which leads to premature failures, affecting their longevity. These failures can be mitigated by applying coatings on the cup-head tribo-pair, which can improve the wear resistance, corrosion resistance and bio-compatibility of the prostheses and thereby increasing the lifespan of the hip implants. Although, coatings have shown the potential to improve the tribological and tribo-corrosive performance of hip implants, there are some underlying failures which must be addressed to get the best utilization of coatings in hip implant tribo-pair. Particularly, interfacial delamination is a known failure mode where a thin coating-substrate system subjected to hip implant indentation loading conditions fails due to strain mismatch. Investigation of delamination of coatings using experiments is a time-consuming and expensive process which can be replaced by using computational finite element methods. In this study, a bilinear cohesive zone model with prescribed cohesive strength and energy is applied to simulate the initiation and evolution of the delamination. The effects of the coating thickness on the indentation response are evaluated. At a critical value of the coating thickness, the resistance to interfacial delamination reaches its minimum. Thus, this study helps to improve the durability of brittle thin coatings.

Oblique Collision of Sphere on a Flat Surface: Effect of Lubricant on the Coefficient of Restitution During Low Velocity Impact

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Abs.ID: C050

ABSTRACT

The collision between two bodies is a common phenomenon which takes place over length scales varying from nanometers to kilometres, such as in nanoparticle collisions to asteroid impacts. Coefficient of restitution is widely used to quantify the energy dissipation during impact of two bodies. The present work is an experimental study of the low-velocity oblique impact of a rigid ceramic spherical ball against a flat metal surface in dry and lubricated conditions. The velocities of the impacting ball during the impact phenomenon have been recorded with high-speed imaging and tracking of the ball by subsequent image processing. The coefficient of restitution obtained from the ratio of rebound velocity to the impact velocity has been used to quantify the fraction of the input energy recovered as rebound of the ball, and the fraction of the energy dissipated as plastic deformation of the target metal surface. The effect of the impacting angle on the normal and tangential coefficients of restitution has been studied. Results have shown that the presence of a thin lubricant film on the impacting surface affects the behaviour of the rebound of the ball owing to the reduction in friction between the impacting bodies.

Tribological Characteristics of Additively Manufactured H13 Tool Steel Against Alumina Ball under Dry Sliding Condition

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Abs.ID: C051

ABSTRACT

Industries, including automotive, aerospace and biomedical, have been holistically revolutionized with the emergence of additive manufacturing (AM), a viable process for manufacturing near-net-shaped parts and complex designs without additional machining. H13 tool steel (hot work tool steel) is widely used in making molds for hot forging application. Currently, H13 molds are produced not only by casting and machining but also by AM processes such as Laser powder bed fusion (LPBF). The microstructure of H13 hot work tool steel manufactured by LPBF has been evaluated in three conditions – as-printed (AP), direct tempered (DT), and quenched (Q) states. The as-printed specimens revealed two types of grains generated during the solidification process. These are heterogeneously distributed equiaxed and columnar grains. Carbides are supersaturated into martensitic matrix owing to a very high cooling rate in the LPBF process. The morphology and volume fraction of carbides are changed during heat treatment, directly influencing wear rate and mechanism. A dry sliding wear test using a ball-on-disc apparatus was performed on as-printed and heat-treated conditions along the transverse (XY plane) and parallel (YZ plane) to build direction. The results of this work allow to establish a correlation between the obtained microstructure and tribological performance of H13 tool steel under the tested conditions.

Polyol Esters of Undecylenic Estolides: Multifunctional Lubricant Additive

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Abs.ID: C052

ABSTRACT

Estolides, a class of oligomeric fatty acids, have been extensively studied in recent years due to their superior properties. Estolide from undecylenic acid, one of the castor oil derivatives, has been reported to have exceptional physicochemical and tribological properties but lacks oxidative stability and a lower viscosity index. Undecylenic estolides were further transformed into polyol esters using polyethylene glycol 600, neopentyl glycol, trimethylolpropane, and pentaerythritol to overcome these critical properties. The synthesized esters were characterized using FTIR & NMR. The physicochemical analysis concluded that all the synthesized esters have pour points as low as -51˚C and viscosity index as high as 174. Further, the study of polyol esters as additives in mineral oil established the potential of reducing the pour point, exceptional thickening, and viscosity index improvement. Moreover, the esters were evaluated for their ability to reduce friction, and wear and provide excellent load-carrying capacity. To gauge the stability of the esters at elevated temperatures, the thermo-oxidative stability was analyzed using TGA. Considering the ability to improve physiochemical properties, better oxidative stability, and capability to alter friction and wear characteristics, polyol esters of undecylenic can be used as renewable sourced multifunctional lubricant additives.

Wear Estimation of Steering Linkage Ball Joints under Real-Time Load Conditions using FEM

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Abs.ID: C053

ABSTRACT

Ball joints in steering linkage of automotive vehicles are exposed to dynamic loading during on-road driving conditions. Wear occurs in the ball joint tribo-pair due to vehicle loading conditions, design and improper pre-compression setting during assembly. This wear causes axial and radial play, thereby reducing its performance, subsequently leading to pull-out of the ball joint from the steering linkage, causing loss of steering which leads to accidents. The real-time loading conditions are tested using the prototype-level wear test rig. However, the experimental testing of ball joints involves enormous costs and time. The present study has developed a FEM wear prediction model for the commercial vehicle ball joint to predict the wear due to real-time loading conditions. Wear is determined using the contact pressure and slide track distance obtained between the tribo-pair. Extrapolation techniques are utilized to optimize and improve the accuracy of the FEM wear prediction model. Overall, the FEM model is validated with the experimental setup results up to 1 million cycles to match the magnitude of wear and wear scar profile.

A Variable Speed Traction Drive for Rotary Wing UAV Applications

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Abs.ID: C054

ABSTRACT

VTOL platforms with high payload capacity (100 kg+), whether manned or unmanned, are a high priority technology for our country. The technology development is headed in the direction of increasing the payload capacity, speed, range, and maintainability of UAVs. Utilization of high speed and high-power density speed reduction mechanism unlocks the design space for the VTOL capable UAV propulsion systems with high torque to weight ratio required to meet aggressive performance targets. The rotor speed (NR) for hover is higher than the cruise speed and this is usually achieved by varying the speed of the prime mover (motor or engine). Therefore, for a considerable period, the engine operates away from the maximum efficiency point. The variable speed transmission is a key enabling technology to overcome this disadvantage.

The traction drive transfers motion using pure rolling contact between a roller and the disk and the concept was first introduced in the year 1985. The variable speed ratio is achieved by moving the roller assembly radially along the disk using a leadscrew. The lubrication is achieved using a high friction coefficient experimental oil that is not commercially available. This work will present the efficiency analysis and results from preliminary testing of the 1st ever variable speed traction drive prototype.

Advancing Sustainability Through Green Tribology: Minimizing Environmental Impact in Industrial Applications

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Abs.ID: C055

ABSTRACT

Sustainable development is essential for preserving resources for future generations, and green tribology is a key component of this effort. Green tribology, a branch of tribology, focuses on improving technology while minimizing environmental and biological impacts. Its core principles include friction, wear, lubrication, and the production and treatment of materials and surfaces, particularly in the context of renewable energy sources. Green tribology is vital because it seeks to reduce environmental harm while enhancing the efficiency and reliability of machinery.

The main objective of green tribology is to make industrial processes more environmentally friendly by minimizing energy consumption and material loss in mechanical systems. This approach also emphasizes reducing the use of hazardous substances, cutting waste, and lowering emissions. Green tribology finds application in major sectors such as automotive, aerospace, manufacturing, wind and renewable energy, marine, railways, and energy generation.

Though relatively new, the concept of green tribology has its roots in earlier efforts to reduce environmental impact and improve efficiency across various industries. Today, it has evolved into a well-defined field dedicated to sustainable and eco-friendly practices in the science of friction, lubrication, and wear. As advancements in materials science and digital technologies continue, green tribology is poised to play an increasingly important role in promoting sustainable industrial practices.

Micro-Indentation Study of Poly-Ether-Ether-Ketone (PEEK) using Experimental and Finite Element Methods

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Abs.ID: C056

ABSTRACT

Micro-indentation is a technique used by researchers to study the mechanical properties of materials like elastic modulus and hardness. However, studying polymer surfaces remains challenging due to their unpredictable nature, chemical reactivity, and mechanical flexibility. Poly-ether-ether-ketone (PEEK) is a popular polymer in biomedical applications due to its reduced stress-shielding effects and its use in orthopaedic implants to enhance biofunctionality. This study focuses on investigating the micro-mechanical properties of PEEK using a Vickers indenter to analyze load-displacement curves. Initial application of a 2.5N load and subsequent collection of displacement data resulted in consistent alignment between experimental and finite element method (FEM) analyses across a range of higher loads (5N, 7.5N, and 10N). The 3D finite element model accurately simulates PEEK's mechanical behavior using an elastic-plastic material model, demonstrating its ability to predict micro-indentation levels by comparing experimental and simulated load-displacement curves. The experimental maximum penetration depth (h_{max}) was 0.0293 mm, and a numerical simulation yielded 0.0314 mm with a 6.66% error percentage. The study confirms the agreement between experimental and FE-derived values for elastic modulus (E) and hardness (H), offering valuable insights for optimizing PEEK's performance in biomedical applications, enhancing implant durability and functionality.

Optimization of PVD –Magnetron Sputtering Parameters of Zirconium Base Coating on Ti6Al4V

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Abs.ID: C057

ABSTRACT

Ti6Al4V alloys are extensively utilized for biomedical applications because of their outstanding biocompatibility. However, this alloy has poor tribological characteristics, which leads to aseptic loosening and implant failure. Thus, to enhance the tribological performance, different types of coatings were deposited on the surface. These coatings failed due to poor adhesion strength. Coating adhesion strength depends on the type of coating and coating process parameters. Thus, optimizing coating parameters is crucial for any kind of coating. This study involves the optimization of PVD - DC magnetron sputtering process parameters of zirconium base coating on Ti6Al4V alloy. Three process parameters, power, substrate temperature, and argon gas flow rate, were considered, and the experiments were designed by utilizing Taguchi's L9 orthogonal array. Multi-response attributes like coating thickness (CT), surface roughness (SR), and hardness (H) were optimized using grey relations and assignment of weight methods. Finally, the optimized coating parameters from these two methods were compared using various characterization techniques such as FESEM, EDX, AFM, and nanoindentation. The results indicated that the optimum coating parameters of 100 W - power, 10 sccm-argon flow, and RT (room temperature)– substrate temperature attained by the assignment of weight method produced a coating with excellent quality characteristics.

Performance of Positive Herringbone-Textured Sliding Surfaces: Experimental Hydrodynamic Assessment

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Abs.ID: C058

ABSTRACT

The Couette velocity in parallel sliding contacts creates a tiny pressure, which is eliminated by an external force, according to lubrication theory. Thus, an advanced, efficient lubrication method that can handle more loads must be developed. This can be achieved by adding textures that generate pressure.

This study compares positive deterministic herringbone patterns and untextured surfaces to assess the hydrodynamic efficiency of parallel sliding surfaces. On an annular disk, the herringbone patterns are arranged. Herringbone textures of the same size, density, and height are compared. Herringbone textures are tested on an in-house-developed setup. At first, textures are made stationary and tested on several parameters like bearing clearance, frictional torque, and recess pressure. Then the texture is mounted on a rotating surface and tested for the aforementioned parameters.

This study compares stationary textured, rotating textured, and untextured surfaces by altering rotational speed and applied loads. Upon evaluating bearing clearance, frictional torque, and recess pressure, the rotating textured herringbone surface yields superior results compared to the textured stationary herringbone surface and untextured surfaces.

Performance Evaluation of Conical Textured Two Lobe Hydrodynamic Journal Bearing with Newtonian Lubricant

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Abs.ID: C059

ABSTRACT

The objective of this research paper is to investigate the theoretical effect of conical textured and Newtonian lubricants on the performance of circular and two-lobe hydrodynamic journal bearings. The Power law model is used to represent the Newtonian behaviour of lubricating oil. A modified form of Reynolds' equation is solved using the finite element technique (FEM), which takes into consideration the relationship between shear stress and shear strain rate. The effect of fully textured on the bearing performance of a two-lobe hydrodynamic journal bearing can be observed for various offset factor values (1.0 and 1.1). Adding a conical texture to the bearing surface increases the direct fluid film stiffness coefficient ($\overline{S}_{11}$ and $\overline{S}_{22}$). Using a two-lobe bearing with offset factor δ = 1.1 enhances rotor direct fluid film stiffness coefficients ($\overline{S}_{11}, \overline{S}_{22}$), compared to a circular profile journal bearing configuration. The two-lobe journal bearing with offset factor (δ = 1.1) has the highest direct fluid film stiffness coefficients ($\overline{S}_{11}, \overline{S}_{22}$) compared to circular journal bearing designs. Lubricating a textured two-lobe journal bearing with Newtonian lubricant improves the value of by 37.58% and 47.52%, respectively, assuming a constant external load.

Tribological Studies on Sustainable Hydraulic Oils

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Abs.ID: C060

ABSTRACT

With ongoing concern due to usage of fossil fuels and lubricants a new paradigm shift is required to increase the proliferation of sustainable and environment friendly lubricants at mass level in industrial applications. In view of present context Bio hydraulic oils, derived from renewable feedstocks such as vegetable oils, present a promising solution for improving the tribological properties of lubricants while reducing their environmental impact.

This paper focuses on the development of sustainable bio hydraulic oils and their potential for enhancing tribological properties. Tribology, the science and engineering of friction, wear, and lubrication, plays a crucial role in the performance and durability of mechanical systems. By optimizing the tribological properties of lubricants, such as reducing friction and wear, the efficiency and lifespan of machinery can be improved. In order to accomplish this, we have formulated bio hydraulic oil using vegetable oil.

Vegetable oil with high viscosity index and great lubricity due to unsaturated fatty acids has the great potential to be used in hydraulic Oil application. However, these base oils have the limitation of being oxidative unstable, with poor thermal stability and thus rapid degradation of its properties on account of non-homogenous characteristics and natural composition which degrade in actual application as Hydraulic Oil.

The current research work thus encompasses improving the oxidative life of the hydraulic oil and thus retaining its properties as a hydraulic oil for the longer service life. The study elucidates the effect of vegetable oil on the thermal, oxidation and tribological properties. It also presents the improved antiwear characteristics which is required for the hydraulic oil.

Thus, the study emphasizes the importance of developing environmentally friendly lubricants to mitigate the adverse impacts of conventional petroleum-based oils. The use of bio hydraulic oils can contribute to a more sustainable future by simultaneously improving machinery performance and reducing environmental footprints.

Numerical Simulation of Two-Lobe Journal Bearing Operating with Magnetorheological Lubricant

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Abs.ID: C061

ABSTRACT

This article focuses on the numerical simulations of textured surface two-lobe journal bearing operating with Magnetorheological (MR) lubricant. A MR fluid consists fine magnetic particles suspended in a carrier fluid and is considered a smart lubricant. Reynold's equation models the flow of the MR lubricant in textured surface two-lobe journal bearing, where textures are provided as hemispherical, conical, and cylindrical shape micro-depressions oriented along the circumferential and axial directions. The Bingham plastic model defines the viscosity of the MR lubricant in terms of yielding stress, magnetic field, and shear-strain rate. The Reynolds equation is solved using the finite element method to obtain film pressure, frictional power loss, film stiffness, damping parameters, threshold speed, and trajectories of the journal. Numerical results show an enhancement in minimum film thickness, stiffness parameters, and threshold speed due to the synergistic use of MR lubricant and textured surface bearing.

Energy Conservation in Textile Sector: Go Green – Sustainability

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Abs.ID: C062

ABSTRACT

The textile sector, dominated by small and medium enterprises (SMEs), is highly energy-intensive, with power costs contributing 15-20% of production costs. Enhancing energy efficiency is crucial to addressing the rising energy consumption and maintaining global competitiveness. In textile spinning, where machinery operates at high speeds, reducing power consumption by minimizing friction and wear is essential. Bharat Petroleum Corporation Limited (BPCL) has developed energy efficient, a high-performance spindle oil formulated with advanced friction modifiers and anti-wear additives to address this need.

Field trials have shown a 1.9% reduction in power consumption in spinning mills using energy efficient spindle oil, contributing to an estimated annual savings of ₹12 lakh for an average textile plant. This oil not only enhances energy efficiency but also reduces equipment downtime, promotes operational sustainability, and helps in carbon footprint reduction. The energy-saving potential of this innovation is significant across the textile industry, offering both cost and environmental benefits. BPCL remains committed to driving sustainable energy practices in the sector through innovative lubrication solutions.

Ferrography Analysis – Expert Oil Examination to Diagnose Gear and Bearing Wear

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Abs.ID: C063

ABSTRACT

Adani Dahanu Thermal Power Station (ADTPS) is one of the best power generation plants 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 monitoring program as one of the key condition based maintenance management practices. Equipment are prioritized for close monitoring on basis of criticality index to ensure high plant availability by ascertaining health of equipment. 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** 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.

Multi-Scale Tribological Behavior of Fe-Based ($Fe_{63}Cr_9P_5B_{16}C_7$, at.%) Amorphous/ Nanocrystalline Coating

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Abs.ID: C064

ABSTRACT

Among various metallic glass systems, Fe-based ones have gained significant attention for surface protection of structural components in extreme environments. In this work, to investigate multi-scale tribological behavior, Fe-based ($Fe_{63}Cr_9B_{16}C_7P_5$, at. %) amorphous/ nanocrystalline coating (ANC) was produced using optimized plasma spraying parameters. To understand the individual effects of amorphicity and porosity on wear resistance, two melt spun ribbons were produced with no porosity having different amorphous content viz. (i) fully amorphous (FA-Rib) and (ii) partially amorphous (PA-Rib) structure with similar amorphicity as that of the coatings. Nanoscratch tests revealed that ANC and PA-Rib displayed better wear resistance compared to FA-Rib, ascribed to the presence of nano-sized intermetallics. However, the wear resistance measured on a single-splat of ANC was lower than PA-Rib which can attributed to the formation of larger grain size of crystalline phases in the coatings. Low load (nano-scale) scratch tests on a single-splat of coating under constant (2 and 5 mN) and ramped (0–5 mN) loading conditions revealed deformation occurred through plowing mechanism. Macro-scale dry sliding wear studied on a global basis at a constant applied load (10 N) revealed that dominating wear mechanism in coating was fatigue accompanied by abrasive and oxidative wear.

Design and Development of Novel Strain Wave Generating Bearing for Harmonic Drive for Higher Mechanical and Tribological Performance Requirements

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Abs.ID: C065

ABSTRACT

Rolling pin based non-circular strain wave generating bearing with self-lubricant containing and auto- feeding mechanism (Patented) is the improvement over conventional strain wave generating cam (SWGc). It consists of inner rim for lubricant storage, rolling pins for motion transfer and slotted cams for mounting of rolling pins. In the present invention bearing is non-circular i.e. rolling pin is mounted on oval periphery of inner rim but they are mounted on the circular slots. These slots are created on the periphery of inner rim making the rolling pins to roll on circular curve instead of oval, to avoid the loss of rolling motion which otherwise was obviously occurring due to non-circularity in the conventional SWG cam. Hence, in spite of bearing being non-circular, the effect of non-circularity has been reduced tremendously. Also, as the rolling pins roll in the circular slots it results reduction in unwanted noise, vibration and ripple which was prominent in the prior invention. Besides, present invention provides the scope of lubricant storage in the inner rim and feeding of it to the rolling pins through the groove by utilizing centrifugal force of bearing. Design, fabrication of conceptual non- circular bearing and its mechanical and tribological performances have been presented in the present article.

Tribological Behavior of Al Alloy for Durability in Dry FrictionConditions

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Abs.ID: C066

ABSTRACT

The study of materials and friction, particularly in the context of tribology, holds significant scientific and engineering importance. Understanding the tribological behavior of materials, such as the Al4032 alloy, is critical for optimizing performance in applications where contact between surfaces and relative motion occur, such as in motorsports and high-performance mechanical systems. Tribological analysis enables the investigation of key factors such as wear resistance, frictional behavior, and the ability to endure mechanical stress, especially under harsh conditions like high temperatures and the absence of lubrication.

In particular, the consistent coefficient of friction (COF) and controlled wear characteristics are essential for enhancing the longevity and efficiency of components, suchas engine parts and structural elements, where materials are subjected to repetitive mechanical interactions. The stabilization of the COF, observed through the stabilization of the real contact area between surfaces, suggests that maintaining predictable frictional behavior is vital for the reliable operation of such systems.

Moreover, the ability of a material to resist abrasive wear, as indicated by minimal penetration depth, directly correlates with its suitability for high-stress environments. In the case of the Al4032 alloy, the enhanced wear resistance translates to improved durability and performance stability over time. These insights are crucial for the selection and design of material combinations that meet specific mechanical and tribological demands, ultimately improving the efficiency and lifespan of mechanical systems in industries such as automotive,aerospace, and motorsports.

A Novel Approach to Conveyor Chain Lubrication: Synthetic Chain Conveyor Fluid

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Abs.ID: C067

ABSTRACT

The chain conveyor system plays a critical role in the bottling production plant, operating over a distance of 2-3 km within a shed. Conveyor system acts as a lifeline for production, without which everything in the plant would come to a grinding halt. For years, industrial soap has been used for lubrication and rust protection of the conveyor system, but it presents multiple issues including poor rust protection, hard water solubility challenges, and the formation of metal salts, which contribute to frequent conveyor chain breakage.

We identified the need for improvement and conducted a thorough evaluation of industrial soap performance through site visits and process analysis. After extensive testing, we developed a fully synthetic, water-soluble alternative with superior performance. The new product eliminates dust accumulation risks, reduces wear and tear, prevents rusting, and enhances lubrication, while also being more cost-effective. It operates at a lower concentration (2.5% vs. 10% for industrial soap), offering improved ease of handling, reduced inventory and monthly consumption, and better overall conveyor chain performance.

Key benefits include reduced chain breakage and noise during startup, superior rust protection, anti-foaming characteristics, and improved cleanliness of the chain. The new formulation exceeds performance requirements across all critical parameters.

Performance Analysis of Hydrodynamic Journal Bearing using Machine Learning

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Abs.ID: C068

ABSTRACT

Hydrodynamic journal bearings play a crucial role in many mechanical systems to rotate the industrial machineries. The bearings provide support and stability to rotating shafts under varying operational conditions. The bearings and their performance are influenced by various factors, which includes load,speed, lubrication, and material properties. Conventional methods of performance analysis often rely on experimental and computational approaches. As these approaches are time-consuming and resource-intensive, so machine learning (ML) techniques have emerged in recent time as a promising tool to enhance predictive capabilities and optimize the bearing performance. This paper presents a comprehensive analysis of hydrodynamic journal bearing performance using machine learning models. Various algorithms such as Artificial Neural Networks (ANN), K-Nearest Neighbour, Support Vector Machines (SVM), and Random Forest (RF) are employed to predict key performance indicators like load capacity, friction, and stability parameters. The results demonstrate that ML models can significantly improve prediction accuracy compared to conventional methods, offering real-time monitoring and fault diagnosis capabilities. The integration of machine learning with tribological data provides insights into optimizing bearing design and maintenance strategies. Advancements in ML algorithms and computational resources accelerate the application of data-driven approaches further in tribology, paving the way for smarter and more efficient bearing systems.

Machine Learning-Based Fault Diagnosis in Spur Gearboxes Under Combined Gear and Bearing Faults

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Abs.ID: C069

ABSTRACT

Gearboxes are critical subsystems in many rotating machinery applications, with gears and bearings serving as essential components in power transmission systems. When localized faults occur concurrently in rolling element bearings and gears, fault detection becomes increasingly challenging due to the overlapping fault signatures. This paper implements machine learning techniques for intelligent fault detection to detect faults in both bearings and gears under various operating conditions. Vibration data were collected from a single-stage spur gearbox in healthy, bearing fault and gear fault conditions. Features were extracted from the vibration signals and Principle Component Analysis (PCA) was used for feature reduction. Different Machine Learning Algorithms were trained using these features. Tree based ML classifier were found to be giving better classification accuracy for compound fault detection of bearing and gear faults.

An Investigation of the Transition from Non-Dissipative to Dissipative Sliding Behavior of a Graphene Nanoribbon on Agraphite Substrate

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Abs.ID: C070

ABSTRACT

We study the transition in the sliding behavior of edge-pulled graphene nanoribbons (GNRs). This transition is influenced by the strength of interlayer van der Waals (vdW) interactions between the stacked layers, as well as the length of the sliding ribbon. In contact mechanics, whenever instability (stick-slip) arises in the system, energy dissipation happens. Our discovery supports the idea that phononic dispersion is the primary mechanism of energy loss during quasi-static sliding, as instability causes the system to vibrate rapidly. We employed finite element modeling and molecular dynamics simulation to determine the stable sliding length of GNRs. We plotted this length against the strength of the van der Waals interaction. We observed that, for varying strengths of the van der Waals interaction, the dissipative length is simply a scale factor of the shear-lag length. Following Lyapunov's criteria for stability, we have also made an attempt to determine the parameter that characterizes the sliding behavior of finite-length GNRs. All results agree very well. This study is important from the material application point of view, because it will contribute to determining the coefficient of friction in a system that incorporates finite-size, two-dimensional materials for lubrication.

Friction and Wear Behaviour of Heat-Treated Ni-B-W Coatings

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Abs.ID: C071

ABSTRACT

The electroless coatings are used widely due to its excellent tribological and mechanical behaviours. The addition of hard particles with some base materials like nickel is widely and successfully used to improve the coating characteristics. The coating characteristics depend on coating composition, surface texture and phases present in the coatings. These features of any coated layer may not only be changed with coating composition, but these may also be altered through heat treatment. In the present study, Ni-B-W coatings are developed through chemical deposition method and heat treated at different temperatures within the range of 300°C to 600°C to understand the impact of heat treatment temperatures on tribological behaviour of the heat-treated Ni-B-W coatings. All the Ni-B-W coated surfaces are seen to possess nodular surface morphology resembling to cauliflower like morphology or broccoli like morphology. Initially, the coatings are seen to be stable at heat treatment temperature of 300°C and the presence of various crystalline phases are observed for the coatings heat treated above 350°C. The Ni-B-W coated surfaces are seen to become compact with heat treatment temperature till 400°C leading to reduction in friction coefficient value and wear rate. The same coated surfaces become slightly rougher in appearance leading to rise in friction coefficient and wear rate.

Reverse Pulse Plating of Ni-Co-P Coatings: The Influence of Cobalt on Microhardness and Wear Resistance

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Abs.ID: C072

ABSTRACT

Protecting vulnerable surfaces against wear and tear in a cost-effective manner has always remained one of the prime objectives of researchers. The present study investigates the effect of cobalt content on the mechanical and tribological properties of Ni-Co-P coatings deposited on mild steel using the reverse pulse plating technique. Coatings were prepared with varying cobalt concentrations (low, medium, and high) and samples were characterized for their microhardness and wear resistance under dry sliding conditions. Results demonstrate a significant increase in microhardness with increasing cobalt content. The enhancement of microhardness is primarily attributed to the formation of intermetallic compounds between nickel and cobalt within the coating matrix. Concurrently, the coefficient of friction and wear rate decreased with higher cobalt concentrations. The improved wear resistance is primarily due to the formation of a protective oxide layer on the coating surface during sliding, which acts as a barrier against abrasive wear. The findings suggest that the reverse pulse plating method can effectively tailor the mechanical and tribological properties of Ni-Co-P coatings by controlling the cobalt content. These coatings have potential applications in various industries requiring wear-resistant surfaces.

Tribological Behaviour of Additively Manufactured 17-4 PH Stainless Steel

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Abs.ID: C073

ABSTRACT

Stainless steel, 17-4 PH, also known as precipitation-hardening stainless steel, is a highly adaptable material that is frequently utilized in additive manufacturing because of its superior blend of strength, resistance to corrosion, processing simplicity, high strength, and toughness. Additive manufacturing builds up materials layer by layer, producing less waste and frequently enabling more intricate geometries. It provides the liberty to make components with tailored behaviour with ease. In the present study, 17-4 PH stainless steel samples are prepared to investigate the tribological behaviour. The tribological tests are carried out by varying the applied load within the range of 30N to 70N and varying sliding speed within the range of 0.4 m/s to 1 m/s. Tribological tests are also conducted for the conventional 17-4 PH specimens and the same is compared with that of the additively manufactured specimens. It is observed that the conventionally manufactured specimens possess higher friction coefficient than additively manufactured specimens. The conventionally manufactured specimens show higher wear rate with increased applied load and sliding speed, though applied load and sliding speed do not have much impact on the wear rate of the specimens developed through additive manufacturing method.

Flattening Contact Analysis of Carbon Nanotube (CNT) Reinforced Functionally Graded Matrix

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Abs.ID: C074

ABSTRACT

In industrial machines and machine elements, it is quite common to find contact between surfaces under various loading conditions. Interaction between such contacting surfaces during loading and subsequent unloading and the subsequent responses of the contact system are important in terms of the longevity and sustainability of the components. The present work studies flattening contact of a carbon nanotubes (CNT) reinforced functionally graded material (FGM) matrix nanocomposite (CNTR-FGMMC) using a finite element-based cylindrical contact model. It focuses on the effect of gradation parameter or index of the functionally graded matrix material. The FGM is treated as an elastically-graded material, where both the modulus of elasticity and tangent modulus vary while the yield strength remains constant. The finite element model has been tested for convergence and validity by comparison with established results from systems with lesser complexity. The flattening analysis is conducted by varying elastic inhomogeneity/gradation parameters while maintaining a constant wall thickness of CNTs. Stress and deformation behaviors, including contact force and contact area, throughout the loading and unloading phases as gradation parameters vary. Additionally, the analysis encompasses an examination of energy losses attributed to plasticity. The study reveals that the gradation parameter plays a significant role in contact behavior.

Tribological Behavior of Inconel 617 Superalloy at Room and High Temperatures

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ABSTRACT

Nickel-based superalloys have great applications at both low and high temperatures due to their excellent mechanical properties, good fatigue life, excellent wear resistance, and high resistance to oxidation and corrosion. Inconel 617 is one of the prominent alloys of this group, which is considered as a principal candidate material for aeroengine, and nuclear reactor application where friction and wear take place. A tribo-oxide layer normally formed on the surfaces during the low as well as high temperature friction and wear process, typically affects the tribological properties of materials. In this work, the friction and wear properties of Inconel 617 were studied. The sliding wear test was performed at 5N load for 30 min against Al_2O_3 ball at room temperature and 800°C. Morphology and chemical composition of the worn surfaces of the tribo-pair were investigated using a field emission scanning electron microscopy (FESEM), Raman spectroscopy and three dimensional (3D) profilometry. The tribological behavior of Inconel 617 was found to be significantly affected by the test temperatures. The result revealed that the coefficient of friction and wear rate were 0.6851, 1.9291 x 10^{-4} mm^3/Nm at room temperature and 0.2762, 1.3102 x 10^{-5} mm^3/Nm at 800°C respectively. It was observed that severe abrasive wear occurred at room temperature led to higher friction and wear, whereas at 800°C, oxides composite film comprising of Fe, Cr, Mo and Ni provided good lubrication effect, resulting reduced the friction and wear.

Effect of Aging Time on the Fretting Wear Behaviour of Selective Laser Melted (SLM), 15-5 PH Stainless Steel Against a Zirconia Ceramic Ball

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Abs.ID: C076

ABSTRACT

This study explores the effects of controlled aging and solution treatment on the fretting wear behaviour and microstructural evolution of Selective Laser Melted (SLM), 15-5 precipitation hardened (PH) stainless steel (ss) against a bearing zirconium dioxide ball. Addressing the inherent thermal inconsistencies in SLM processing, resulting in microstructural inhomogeneities and irregular mechanical properties, the research aims to optimize performance for critical applications. Two thermal processes were compared. One set of specimens were directly aged at controlled temperature of 480°C for durations ranging from 10 to 240 min. Another set of specimens were solution-treated at 1040ºC, followed by aging at the same temperature for same time durations as indicated in set 1. Microstructural characterization using SEM, EDS, EBSD, and TEM for set 2 showed that solution treatment followed by aging led to microstructural homogenization, reduced austenitic phase, and Cu, Nb-rich precipitate formation as compared to set 1. Analysis of the worn surface, using SEM, EDS, and Optical Profilometry, highlighted how precipitate distribution affected the coefficient of friction and surface interactions under Hertzian contact at loads of 2, 5, and 10 N. The analysis showed that abrasive, adhesive, and oxidative wear mechanisms, either independently or combined, significantly influenced wear responses. These findings underscore the importance of optimizing thermal treatments for enhanced performance in fretting wear applications.

Wear and Corrosion Behaviour of TiB_2 Reinforced Functionally Graded Aluminum Matrix Composites by Centrifugal Casting

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Abs.ID: C077

ABSTRACT

This study examines the effect of 2.5% TiB_2 addition on the tribological behaviour of functionally graded composite with a pure aluminum matrix, fabricated via centrifugal casting. The influences of casting speed on wear and friction against a rotating EN 31 disk was analyzed using 1000, 1100, and 1200 rpm with a graphite coated mild steel mold. Pin-on-disk tribometer was used to conduct wear test in dry condition at a disc speed of 160 rpm, applying normal loads of 10N to 40N for 10 minutes. Scanning electron microscopy (SEM) was employed to assess frictional effects on the pin's surface, and wear rates were calculated based on volume loss before and after testing.

The relationship between wear mechanisms, wear rates, and TiB_2 particle distribution was explored, correlating these with the microstructural analysis. The gradient distribution of TiB_2, affected by mold speed across the casting wall thickness, significantly enhanced the tribological properties of the Al-TiB_2 composite. Also, potentiodynamic polarization tests were done to evaluated corrosion resistance in a 3.5% NaCl solution. Results showed that the composites exhibited the low friction coefficient, wear volume, and corrosion current. TiB_2 reinforcement in aluminum matrix through centrifugal casting significantly improves the strength, friction, and wear resistance of the composites, making them promising candidates for automotive applications.

Sliding Wear Behavior of Various Microstructures Made from Indian Rail Steel

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Abs.ID: C078

ABSTRACT

This research explored the impact of microstructural variations on the sliding wear characteristics of Indian Rail steel, achieved through distinct heat treatment regimens: austenitization (960°C/30min) coupled with furnace cooling (pearlitic), water quenching (martensitic), austempering (400°C/1h, bainitic), and thermal treatments (800°C/45min, spheroidized; 400°C/24h, tempered martensitic). Sliding wear tests were conducted on a DUCOM1014 wear testing apparatus, utilizing a ball-on-disc setup to evaluate tribological properties. The wear tests revealed that microstructure profoundly affects wear resistance, despite consistent chemical composition. Notably, bainitic steel demonstrated superior wear resistance, attributed to its remarkable stability and capacity for plastic deformation without substantial cracking. Martensitic and tempered martensitic steels also exhibited impressive wear resistance, primarily due to their exceptional hardness and toughness. Conversely, pearlitic and spheroidized steels displayed diminished wear resistance, with pearlitic steel's balanced strength- ductility balance compromised by softer ferrite phases, and spheroidized steel's ductile nature leading to elevated wear rates. These findings emphasize the significant impact of microstructural engineeringon optimizing rail steel's tribological properties.

Effect of Lubrication on Aluminum Alloy (Al4032) for Different Surface Texture Geometries

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Abs.ID: C079

ABSTRACT

The tribological behavior of Al alloy used for pistons in internal combustion engines has been characterized after texturing in oscillating pin-on-disk experiments. Disks were prepared from Al alloy (piston) and textured for 10x15 mm areas, keeping the total dimpled area constant at 10%. Pins were prepared by cutting and machining the liner made of gray cast iron. Texturing was performed ina high-speed conventional micromachining setup for 65000 rpm and 1 mm/min feed rate with ball nose end mill cutters to obtain the semi-hemispherical shape of micro-dimples. Three types of textured surfaces were prepared with dimple depths of 15, 20 and 40 µm and dimple diameters of 90, 120 and 240 µm, respectively. Tribology tests of untextured and textured surfaces were performed at a fixed load, speed and temperature with three different lubricant (SAE 20W-40) volumes. Variations in friction for test surfaces were analyzed in mixed and boundary lubrication regimes. Overall textured surfaces improve the tribology behavior of Al alloy at all lubricating conditions. At a constant depth- to-diameter ratio, the results showed a significant dependence of the friction coefficient on the dimple diameter and lubrication. Textured surfaces with larger dimple diameters resulted in enhanced friction reduction at elevated lubrication.

High Temperature Wear Behaviour of Stellite 6 and Stellite 6 – TiC Metal Matrix Composite Coatings Fabricated via Additive Manufacturing

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Abs.ID: C080

ABSTRACT

Stellite 6 (Co-Cr-W-C) superalloy is widely known for its high hardness, excellent wear, and oxidation resistance properties, which frequently employ as hardfacing materials, typically operating at temperatures up to 600 ºC. Fabricating metal matrix composite (MMC) coatings may improve its high temperature attributes. In this study, the high-temperature sliding wear behavior has been investigated for additively manufactured Stellite 6 and Stellite 6 – TiC (10, 20, 30 vol.%) MMC coatings deposited on P91 steel. The addition of TiC particles has markedly enhanced the high-temperature wear behavior of the composite coatings, which correlated with the formation of a composite oxide layer at elevated temperatures. Interestingly, the wear volume loss of fabricated composite coatings decreased at elevated temperatures (150°C to 450 °C) and was the lowest in the case of Stellite 6 – 30 vol.% TiC composite coating. In contrast, at room temperature, no significant changes were noticed in wear loss. At 450 °C, wear volume loss of Stellite 6 – 30 vol% TiC was reduced by approximately 3 times compared to that of only Stellite 6 coating. The adhesive and oxidative wear mechanisms were predominated at 450 ºC, while primarily abrasive wear was pronounced at room temperature, though multiple mechanisms coexist concurrently.

Tribological Behavior of Al_2O_3-Based Bimodal Composites Prepared by Spark Plasma Sintering

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Abs.ID: C081

ABSTRACT

Bimodal thermal barrier composites of micro-Al_2O_3 matrix reinforced with nanometre sized 20 wt% ZrO_2 (AZ) and 4 wt% carbon nanotubes (CNTs), AZC were prepared by spark plasma sintering technique (SPS). The role of reinforcements and bimodality is evaluated in assessing tribological behaviour of Al_2O_3-ZrO_2-CNT based composites. The reinforced composites exhibited bimodal microstructure consisting of distinctive dense particles contact and uniform distribution of nanoparticles. Reinforcements led to an increased hardness from ~17.8 GPa (μ-Al_2O_3) to ~22.3 GPa (AZ) and ~22.7 GPa (AZC), which is attributed to the increased densification ~97.51% (AZ) and ~98.66% (AZC) and uniform distribution of second phase particles. Increased hardness and low Hertzian contact pressure (~1.58 GPa) generated lowest value of co-efficient of friction (0.51) and wear rate for AZC composite (~1.7 $\times 10^{-6}$ $mm^3N^{-1}m^{-1}$) than μ-Al2O3 (~3.2 $\times 10^{-6}$ $mm^3N^{-1}m^{-1}$). Increased wear resistance of AZ and AZC ~34.5% and ~40.1% than monolithic μ-Al_2O_3, is attributed to improved hardness ~22.3 GPa (AZ) and ~22.7 GPa (AZC). Further, higher aspect ratio of nano ZrO_2 and CNT, have contributed to lowering wear damage in AZ and AZC composites than that in μ-Al_2O_3. Material transfer between friction pair and generation of wear debris confirms occurrence of dominant abrasive wear mechanism for all three samples. Overall synergistic effect of bimodality and reinforcements improved mechanical property, and reduced wear damage, make bimodal AZC composite a potential material for wear and abrasive environment.

UHMWPE Based Composites for Artificial Hip Joint Applications

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Abs.ID: C082

ABSTRACT

Deterioration of hip and knee joints are the commonly growing joint related issues over the globe. Osteoarthritis, Rheumatoid arthritis, Posttraumatic arthritis, Osteonecrosis, Childhood hip disease and/or accidental damage etc. are reported to be some of the unavoidable causes for these issues. The only remedies of getting out of these issues are the complete replacement of these joints. The history of total hip arthroplasty (THA) explains the evolution of materials from ceramic on ceramic to metal on polyethylene for the replacement purpose. This study provides a brief review on the evolution of materials for the replacement surgery, together with emphasizing on the use of UHMWPE based composites for this application. In addition, the recent advances in this field in terms of materials and preparation techniques are also covered in this research.

Tribological Behavior of Polytetrafluoroethylene and Polyurethane Coatings in Various Environments for Hydrogen Infrastructure Applications

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ABSTRACT

The growing global population and increasing reliance on fossil fuels have raised concerns about their depletion and harmful emissions. Hydrogen, with its zero emissions post-combustion, presents a promising alternative energy source. However, the effect of hydrogen on the tribological behaviour of materials used in critical infrastructure remains understudied, particularly for sliding surfaces. This research investigates the tribological performance of polymer coatings in hydrogen environments. Polytetrafluoroethylene (PTFE) and polyurethane (PU) coatings were deposited on steel discs via spray coating, while 316L austenitic stainless steel pins were used as counter bodies in a custom-built pin-on-disc tribometer. The tribology tests were carried out in hydrogen, air, and argon environments at 2 bar pressure, with a pre-charge duration of three hours. The results showed that the PTFE coating exhibited the lowest coefficient of friction (COF) and same in the hydrogen and argon environments, compared to air whereas the PU coating demonstrated a higher COF in the hydrogen environment compared to both argon and air. Furthermore, SEM analysis revealed coating delamination from the steel surface. Transfer films were observed, indicating material transfer during the tests. Hydrogen absorption was measured using CHNS equipment. This study highlights the need for further investigation into material performance in hydrogen environments, especially concerning coating durability and tribological properties.

Advanced Multifunctional Nano Lubricants Utilizing Synergy Between Surface Functionalized Hexagonal Boron Nitride Nanoplatelets and Imidazolium Ionic liquid

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Abs.ID: C084

ABSTRACT

This study investigates the tribological and thermophysical characteristics of a new hybrid nanolubricant incorporating functionalized hexagonal boron nitride (fBN) nanoplatelets and imidazolium cation-based ionic liquid (IL) in a polyalphaolefin (PAO) base oil. Various nanolubricant formulations with 0.05 wt% and 0.1 wt% of BN nanoplatelets and 1 wt% ionic liquid were examined to evaluate the synergistic effects of surface functionalization and ionic liquid addition on the antifriction and antiwear properties of the PAO base oil. Thermal stability was assessed using thermogravimetric analysis (TGA) to determine the oxidation onset and decomposition temperatures of different formulations with varying nanoadditive concentrations. The antifriction performance was quantified by the reduction in the coefficient of friction (COF) compared to the neat lubricant. The most significant reduction in COF, 60.60%, was achieved with the formulation containing 0.1 wt% fBN + 1 wt% IL, followed closely by 0.1 wt% fBN and 0.1 wt% BN with reductions of 43.5% and 32.7%, respectively. Post-wear analysis of the wear scars was conducted using a 3D optical profiler, SEM micrographs, EDX elemental composition, and Raman spectra. The greatest reduction in wear depth was observed with PAO + 0.1% fBN+1%IL, showing a 46.12% reduction, followed by a 34.50% reduction with PAO + 0.1 % wt BN+1% wt IL. The morphologies of samples containing both ionic liquid and nanoplatelets exhibited significantly smoother surfaces with the absence of deep grooves and pits, attributed to the formation of a strongly bonded tribofilm resulting from chemical interactions between the ionic liquid-capped nanoplatelets and the metal substrate. Strong interfacial interactions also contributed to a notable increase in the thermal stability of the nanofluids, with the maximum shift in the oxidation onset temperature relative to neat PAO being 52°C, and the decomposition temperature increasing by 66°C. Due to their exceptional friction, wear, and thermal properties, these hybrid nanofluids are particularly suitable for applications in high-temperature and high-stress environments, such as automotive engines, aerospace components, thermal power plants, and advanced machining operations. Additionally, their high thermal conductivity and stability make them ideal for electronic cooling systems, including micro/nano-electromechanical systems (MEMS/NEMS), where effective heat dissipation is crucial.

Exploring the Tribological Effect of TiO_2 Nano-Additive in Oil-in-Water Emulsions for Forged Steel-Steel Contacts

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Abs.ID: C085

ABSTRACT

The article aims to explore the tribological behaviour of TiO_2 nano-additive oil-in-water emulsion. Tribological tests were conducted under a 70N load for 10 minutes using nanofluids prepared through a dual-step method at varying concentrations (wt.%) of 0.05, 0.1, 0.3, 0.5, and 1.0. The pin and disc materials used were IS 2062 E350 and 2% chromium-forged steel, respectively. Surface characterization of pin wear surface was performed through FESEM and a non-contact type profilometer. 0.1 wt.% nano-concentration showed excellent tribological efficacy with a 65% friction force reduction and better surface morphology than the conventional emulsion. The reasonably lower surface roughness (0.101 µm) was also detected. The nano-emulsion witnessed slightly higher wear than the without nanoparticle emulsion. The Wear Scar Diameter (WSD) increased due to the increment in nano-concentrations. The WSDs for base emulsion and optimised 0.1 wt.% nano-suspension are 1112 µm and 1684 µm, respectively. But, at the same time, the nano-suspension has a good polishing effect by reducing the surface roughness. The inflation in concentration increased the thermal conductivity and wettability. With the increased concentration in the base, the emulsion showed a minimal increase in viscosity. Hence, the nano-additive oil-in-water emulsion carries the potential to substitute conventional oil emulsions.

Synergistic Effects of rGO/MoS_2 Heterostructure and Phosphonium Ionic Liquid on the Tribological and Thermophysical Properties of Polyalphaolefin Based Hybrid Nanolubricants

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Abs.ID: C086

ABSTRACT

Graphene oxide (GO) and molybdenum disulfide (MoS_2) as nanoadditives in lubricants has garnered significant interest due to their potential to enhance tribological properties. In this study, we explore the combined effect of GO/MoS_2 nanoadditives on poly alpha olefin (PAO) base oils, with a particular focus on the inclusion of phosphonium-based ionic liquids (ILs). The addition of GO/MoS_2 into PAO lubricants is hypothesized to improve anti-wear and friction-reducing capabilities because the MoS_2 layers are connected by weak van der Waals forces and the atoms in the layers are connected by strong covalent bonds, this material is easy to slide between the layers when subjected to shear and obtains a low coefficient of friction. At the same time, the phosphonium-based IL acts as a synergistic component, enhancing the lubricating performance through ionic interactions. We systematically evaluate the thermal stability, tribological behavior, and rheological properties of the modified PAO oil. Results indicate significant improvements in wear resistance, friction reduction, and thermal performance, attributed to the layered structure and high surface activity of GO/MoS_2, coupled with the superior ionic conductivity and film-forming properties of the phosphonium-based IL. This study provides valuable insights into the development of advanced lubricant formulations for high-performance industrial applications.

Performance Analysis of Conical Journal Bearing under Varying Supply Pressure and Cone Angle

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Abs.ID: C087

ABSTRACT

Many high speed machines like Grinding machines, known for producing radial and axial loads on journal bearings, often rely on cylindrical journal and thrust bearings to support the shaft. However, the conical journal bearing has the unique ability to withstand both radial and axial loads and can adjust the clearance between the bearing and journal for optimal performance. To investigate the impact of varying Supply Pressure and cone angle on the pressure distribution of the conical journal bearing using water and oil as the fluid, CFD analysis was conducted in ANSYS FLUENT. The findings revealed that an increase in the supply pressure results in higher pressure generation and subsequently enhances the load-carrying capacity of the bearing. Similarly, an increase in the cone angle leads to higher pressure and an improved load- carrying capacity of the bearing. These insights are valuable for designers working on conical journal bearings for high-speed machines, indicating that the bearing's performance is significantly influenced bythe cone angle and supply pressure when operating in turbulent flow conditions.

Performance Analysis of Water-Lubricated Hydrostatic Journal Bearing

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ABSTRACT

This paper presents a comparative study examining the performance of water as a lubricant in hydrostatic journal bearings, alongside traditional ISO VG lubricants. The focus is on key performance parameters, such as supply pressure, radial clearance, rotational speed, L/D ratio etc., to evaluate the efficiency and practicality of using water as an industrial lubricant for hydrostatic bearings. Water has a lower viscosity, which influence film thickness and load-bearing capacity at higher eccentricity ratios, its advantages like decreased frictional losses and non-toxicity position it as a viable alternative. By fine-tuning parameters like supply pressure, water-lubricated hydrostatic bearings can perform effectively in moderate-load and high-speed applications, especially in industries sensitive to environmental concerns. The findings offer valuable insights into water's potential as a sustainable, cost-effective lubricant, aiding in the development of greener tribological solutions in industrial systems.

Wear Characteristics of Machined Samples of SS316L

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Abs.ID: C089

ABSTRACT

SS316L is an austenitic stainless steel, poses excellent corrosion resistance and mechanical properties, due to which it has extensive application in aerospace, marine engineering and biomedical industries. This study investigates the wear characteristics of machined samples of SS316L. Samples were machined by conventional machining method at various machining and tool parameters. Ball on disc wear tests were conducted under dry condition. The effect of machining parameters, tool geometry and surface roughness on wear resistance were analysed. Microstructural examination revealed the abrasive and adhesive wear mechanisms. Results indicated that machining parameters significantly influence the surface integrity and, consequently, the wear behaviour of SS316L. This study provides insights into the critical role of machining parameters in optimizing the wear resistance and importance of surface finish inwear intensive applications of SS316L steel components.

Effect of Carbon Nanotube and Graphene Addition on Mechanical and Tribological Properties of Ultra High Molecular Weight Polyethylene

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Abs.ID: C090

ABSTRACT

Ultra-High Molecular Weight Polyethylene (UHMWPE) is utilized as a bearing material for biomedical applications and as a crucial component in prosthetic knee and hip joint replacements, because of its exceptional wear resistance. However, the wear debris produced by two articulating surfaces of joints leads to implant failure. Thus, to reduce the formation of wear debris, UHMWPE is reinforced with 5 vol.% of each reinforcement, carbon nanotubes (CNT), and graphene (G). Composites were prepared utilizing the freeze-drying method, followed by compression molding at 220°C, at 10 MPa. Phase analysis of composites done by X-ray diffraction, confirms that no new phase has been formed and Raman spectra of CNT and graphene confirm the retention of carbonaceous material. Mechanical properties evaluation showed that the highest hardness (100.9 ± 22 MPa) and elastic modulus (2.4 ± 0.4 GPa) were obtained for UHMWPE-CNT as compared to that of (56.7 ± 9 MPa) and (1.0 ± 0.2 GPa) for UHMWPE-G and (47.4 ± 4 MPa) and elastic modulus (0.97 ± 0.9 GPa) for UHMWPE. The wear rate obtained for UHMWPE is (16×10^{-7} mm^3/Nm) which is reduced by 47.5 % for UHMWPE-CNT (8.6×10^{-7} mm^3/Nm) and by 26.8 % for UHMWPE-G (12.0×10^{-7} mm^3/Nm) attributed to high hardness and modulus. Therefore, it can be concluded that CNT exhibits a robust interaction with a polymer, resulting in enhanced mechanical and tribological capabilities. UHMWPE-CNT claims to be the potential material.

Investigating the Sliding Behavior of Carbon Nanotubes

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ABSTRACT

At the macroscopic level, surface irregularities or asperities cause friction. However, at the atomic level, even seemingly smooth surfaces—such as low-dimensional materials like graphene and carbon nanotubes (CNTs)—demonstrate frictional characteristics due to van der Waals forces. Nonetheless, the intensity of atomic-level friction is significantly lower than that of conventional friction, placing them within the domain of superlubric material. Additionally, double walled carbon nanotubes (DWCNTs) exhibit exceptional wear resistance and great mechanical properties, making them suitable for microelectromechanical systems (MEMS) and composite reinforcements. In order to utilize DWCNT effectively, its interfacial sliding characteristics should be studied, which is essentially our purpose. Using molecular dynamics simulation, we investigate the interlayer sliding behavior of double-walled carbon nanotubes (DWCNTs). We observe a critical inner tube length and its dependence on the inter-tube distance, which aligns with our research on graphene sliding. This study will contribute to the design of MEMS devices, as wellas tribology.

Microstructural and Tribomechanical Investigation of Tin-Stabilized Bi-Layer Electroless Ni-B Coatings

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ABSTRACT

This study investigates the microstructural and tribomechanical properties of tin-stabilized bi-layer electroless nickel boron (ENB) coatings. The coatings were deposited on AISI 1040 steel substrate using a two-step electroless process with distinct chemical baths. Microstructural analysis was conducted using field emission scanning electron microscopy (FESEM) and X-ray diffraction (XRD) was used to examine the phase composition. The weight gain of the deposition was calculated 5.95×10^{-2} g/cm^2, which showed a substantial coating growth. The FESEM analysis revealed a characteristic of cauliflower-like morphology. The tribomechanical properties such as wear resistance and scratch hardness, were evaluated through reciprocating sliding wear test and scratch test under the load of 5 N and 10 N respectively. The acoustic emission data were collected during the scratch test which confirms the coating adhesion. The influence of tin stabilization on microhardness, wear volume, and frictional behavior was analyzed. The Vickers microhardness of the coating was evaluated and found to be 1230 HV at 100 g of load. Also, low coefficient of friction (COF) and reduced wear volume was observed. Results showed that the bi-layer ENB coatings with tin stabilization enhanced the tribological performance. Thus, its potential for applications with improved wear resistance and mechanical stability are evident in comparison to those coatings results presented by traditional Ni-B coatings.

Mechanical and Tribological Properties of Cross-Linked Polymer Networks

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ABSTRACT

Mechanical and tribological properties are critical when designing soft materials such as polymers, as they significantly influence performance and functionality across various applications. Key mechanical properties include stiffness and elastic modulus, while tribological properties, such as the friction coefficient, are vital for material behavior under load. Crosslinking is an essential mechanism for tuning polymer properties. Crosslinked polymers exhibit high strength, lightweight characteristics, and self-healing capabilities due to their microstructure arrangements. The degree of crosslinking can range from weakly crosslinked elastomers to highly crosslinked epoxies.

In this study, we present a computational investigation of indentation using explicit indenters in weakly crosslinked polymer (WCP) networks through molecular dynamics simulations. The indentation technique is commonly employed to measure elastic modulus and stiffness via force-distance curves. Additionally, we explore the structural characteristics and evaluate the coefficient of friction as a function of crosslinking bond density in polymer networks. We establish a relationship between force-depth response and local bond-breaking in WCP networks.The results indicate that as the fraction of monomers increases, both the stiffness of the material and the friction coefficient rise. Moreover, an increase in indentation depth leads to higher friction forces.

High Temperature Air Jet Erosion of Different Scale Forming Iron based Material

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Abs.ID: C094

ABSTRACT

Solid particle erosion is an important material degradation mechanism in number of industrial applications. At elevated temperature it is governed by the thickness, pliability and adhesion characteristics of the scale that forms on exposure at elevated temperature. Thus, objective of present investigation is to evaluate the influence of the types of scale forms on erosion rate at high temperature. To achieve this objective, three iron based materials namely mild steel, 304 stainless steel and iron–aluminide are taken to examine the influence of types of scale formation on the erosion response of these steels at elevated temperature. Mild steel forms Fe_2O_3 scale, 304 stainless steel forms Cr_2O_3 scale and iron aluminide forms Al_2O_3 scale on exposure to high temperature. These steels are subjected to solid particle erosion for two different impact angles and two different impact velocities. The erosion rates of these steels are evaluated and compared. By examining the morphology, chemical state and area beneath the eroded surface, the materials removal mechanisms are determined. All the steels exhibit higher erosion rates at oblique impact than that at normal impact. Further, Cr_2O_3 scale forming steel has lower erosion rate than Fe_2O_3 scale forming steel. The results will be presented and discussed in details.

Indentation and Scratch Response of 3 Different Types of Plasma Sprayed Coatings

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ABSTRACT

Thermal sprayed coatings are extensively used in several engineering applications because of their inherent advantages. These coatings are critical in industries such as aerospace and automotives etc. In this work, three different types of thermal sprayed coatings are investigated to understand their mechanical properties. First type of coating is Abradable coating used at intermediate temperature in rotating machinery. Second types of coatings are intended as tribology coating. It is essentially Al_2O_3 containing different amount of TiO_2 to enhance the toughness of the coatings. Finally, TiO_2 coating is investigated as thermal barrier coatings. These coatings are deposited on Ni base substrate using plasma sprayed technique. Microstructural features of these coatings are evaluated extensively. Plasma sprayed coating was subsequently subjected to Indentation and Scratch test under different load. Various mechanical properties such as hardness, toughness etc. are evaluated by indentation and scratch techniques. Details results will be presented and discussed.

An Assessment of the Pitting Susceptibility of Aluminium Alloy in Different Cooling Fluids

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Abs.ID: C096

ABSTRACT

In order to study the localized corrosion susceptibility of 2024 aluminium alloy in different cooling fluids and salts, a novel device has been developed. There are three distinct regions of corrosion: the full immersion region, the salt-water interfacial region, and cooling fluids. EIS wasused to study the corrosion process in the interfacial region over time using potentiostat. The results of the experiment showed that a layer of intense and uniform corrosion product was formed on the high salt concentration water interfacial region due to the enrichment of oxygen there. In the full immersion region, pitting corrosion was more severe than in the salt-based water interface, as indicated by a lower charge transfer resistance and more extensive pitting corrosion.

Investigating Surface Wear Pattern by Nozzle Exhaust Flow on the Enclosure Wall with Variation in Pressure - Temperature

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ABSTRACT

The CFD analysis presented in this article examines the impact of supersonic nozzle exhaust on an enclosure wall to evaluate the surface wear due to pressure and temperature variations under two different scenarios. This includes a comparative study of the nozzle base placed at the end of the enclosure versus its placement at the center. The numerical analysis is performed using commercial ANSYS Fluent software along with the k-ω Shear-Stress Transport (SST) turbulence model. An axisymmetric two-dimensional model is considered for the analysis. The results demonstrate how the nozzle exhaust flow impact the enclosure wall further surface wear, with a quantitative analysis of pressure and temperature variations and visualization of flow dynamics within the enclosure. This research aims to provide a detailed understanding of how these critical parameters evolve, with the behavior of gases producing significant variations that impact surface in contact.

Comparative Tribo-Corrosion Resistance of SS316L, cpTi, and Ti-6Al-4V for Biomedical Implant Applications

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ABSTRACT

The tribo-corrosion behaviour of materials significantly influences their selection for biomedical and engineering applications, particularly in hostile physiological environments. This study examines the tribo-corrosion resistance of three widely utilized metals: 316L stainless steel (SS316L), commercially pure titanium (cpTi), and titanium alloy (Ti-6Al-4V). The materials were subjected to a simulated body fluid solution at 37°C to replicate human body conditions, with electrochemical tests, including open circuit potential (OCP) and Potentiodynamic polarization, conducted to assess their tribo-corrosion characteristics. Key parameters such as corrosion potential, current density, wear rate, and passivation behaviour were analysed to evaluate their suitability for long-term implantation. The results indicate that cpTi exhibited the highest tribo-corrosion resistance, attributed to the formation of a stable and protective oxide layer, closely followed by Ti-6Al-4V. In contrast, SS316L displayed a relatively higher corrosion rate and susceptibility to localized pitting corrosion under mechanical wear conditions. These findings underscore the superior performance of titanium-based materials over stainless steel regarding biocompatibility and tribo-corrosion resistance, making them preferable candidates for biomedical implants in corrosive environments. This study provides critical insights for material selection in implant applications, ensuring enhanced durability and reduced risks of corrosion-related complications.

Tribological Evaluation of Multilayer Polyimide Composite Coatings

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ABSTRACT

The tribological performance of polyimide coatings can be significantly enhanced by incorporating nano lubricant composites in a multilayer configuration. This study investigates the tribological behavior of polyimide multilayer coatings reinforced with nano lubricant composites, including graphene oxide, MoS_2, and MXene. To simulate real-world conditions, the coatings were subjected to tribological tests under varying loads. Critical performance parameters such as the coefficient of friction, wear rate, and worn surface morphology were analyzed using a multifunction tribometer, surface profilometry, and scanning electron microscopy (SEM). The mechanical strength of the coatings was evaluated using nanoindentation testing.

The findings show that the inclusion of nano lubricants significantly lowers wear due to the synergistic effects of the polyimide matrix and solid lubricant nanoparticles. The hardness of the coating increases with addition of nano lubricant. The most noteworthy improvement was noticed with the introduction of MXene nanoparticles in the outer layer, which provided a self-lubricating layer on the worn surface. The worn surface analysis showed the presence of nano particles on the surface which is the cause of improvement in tribological properties of polyimide coating. This study demonstrates potential of polyimide coatings with multilayer architecture of nano lubricants for advance tribological application in aerospace, automotive and mechanical systems.

Erosion Wear Behavior of Polymer Composites Reinforced with CNTs, GO, and Hybrid Nanoparticle-Coated Carbon Fiber using Taguchi Orthogonal Array

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ABSTRACT

This study examined the erosion wear behavior of polymer composites reinforced with carbon nanotubes (CNTs), graphene oxide (GO), and hybrid nanoparticle-coated carbon fiber (GO/CNTs). Solid particle erosion tests were carried out on composite samples to determine the impact of factors like nanoparticle coatings, impact velocity, erodent particle discharge rate, and impingement angle on erosion rates. The Taguchi (L16) orthogonal array was utilized to evaluate the erosion wear performance. The analysis identified that the hybrid (H) coating material, coupled with an impact velocity of 20 m/s, a discharge rate of 2 gm/min, and an impingement angle of 15°, resulted in the lowest erosion rate. According to the ANOVA results, impact velocity was the most significant factor influencing erosion rates, whereas the discharge rate had the least effect. Scanning electron microscope (SEM) analysis of the worn composite surfaces revealed evidence of micro-cutting and plowing, extensive matrix and fiber breakage, and the positive effects of incorporating GO/CNTs, which improved durability, enhanced fiber-matrix bonding, facilitated good stress transfer, and reduced wear. Ripple patterns indicated directional erosion, contributing to the assessment of wear resistance, while the presence of broken fibers, wear debris, and surface furrows highlighted the severity of erosion. The formation of craters depicted material removal during erosion, with the failure of carbon fiber/epoxy composites involving matrix removal, micro-cracks, fiber-matrix debonding, and material loss.

Design of a Test Rig for Water Lubricated Hydrostatic Conical Bearing

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Abs.ID: C101

ABSTRACT

This paper presents the design and development of a test rig for a water-lubricated hydrostatic conical journal bearing, aimed at replacing conventional oil-lubricated systems. The bearing is subjected to significant radial and thrust loads, making it prone to operational failures during extended use. To evaluate its performance, the rig is equipped to measure critical parameters such as fluid film thickness, operating pressure and temperature, and vibrations.

The test rig includes a conventional setup comprising a belt drive, cooling system, shaft, bearing housing, and sensors. Additionally, a pneumatic load cell is integrated to apply variable loads for comprehensive testing. A detailed CAD model is developed to assemble all the components efficiently and in most optimized manner and to house various sensors that assess the bearing's performance under different operating conditions.

Water-lubricated hydrostatic conical bearings provide a greener, sustainable alternative to traditional oil-based systems. By reducing carbon emissions and environmental impact, these bearings align with modern goals of sustainability and energy efficiency. Their potential for social impact, through promoting eco-friendly industrial practices, highlights their importance in advancing green technology solutions.

Synergetic Effect of Anti-Oxidant / Antiwear Combo of a Fully Synthetic Turbine Oil Formulation in Controlling Oxidation

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Abs.ID: C102

ABSTRACT

This abstract describes about the performance assessment of a fully synthetic turbine oil fortified with antioxidant and antiwear additives for use in nuclear power plant. A well-maintained turbine oil with moderate makeup rates should last 10 to 15 years. A turbine oil when fails early through oxidation, it is often due to water contamination. Water reduces oxidation stability and supports rust formation, which among other negative effects, acts as oxidation catalyst. The subject oil has been introduced in one of the major nuclear power plants in India. Pre & post synchronization samples were collected and tested. Used oil samples were collected in the interval of 700-1000 hours. The high moisture content observed since around 1000 hrs had no significant effect on oil oxidation and the oil maintained TAN value in same level even up to 3000 hrs. High moisture content is expected to promote oxidation. FTIR spectra taken up to 3000 hours showed no presence of oxidation products. The combo of anti- oxidant & antiwear additives used in the turbine oil formulation played the critical role of protecting the oil against oxidation. Synergetic effect of anti-oxidant / antiwear combo in synthetic base oil platform offered significant performance attributes.

Effect of Materials on the Performance Characteristics of Gas Foil Thrust Bearings with and Without Slip Flow

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Abs.ID: C103

ABSTRACT

Gas foil thrust bearings (GFTBs) have a wide range of applications in oil-free turbo machinery due to their numerous advantages. The use of this type of thrust bearings becomes limited due to the low load-carrying capacity (LCC). In this present study influence of various materials on the static characteristics is studied. This study provides a numerical model to Evaluate the gas foil bearings' performance based on the properties of the materials. For numerical simulations, the 2D compressible Reynolds equation is solved by the finite difference method to obtain gas film thickness distribution and gas film pressure distribution. and then solving for the pressure by employing the Newton-Raphson method. The simulation results of static performances are verified and Based on the results, **Inconel** has been identified and selected as the most suitable material for GFTBs. For more accurate results the effect of slip flow is considered and compared with the results of non-slip flow.

Static and Dynamic Performance Optimization of Straight Grooved Journal Bearing using Grey Relational Analysis

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ABSTRACT

In this study, a straight groove texture across the surface of a journal bearing (StGJB) is proposed and optimized to enhance the static and dynamic characteristics of the bearing under radial loading conditions. The non-linear Reynolds equation for the straight-grooved journal bearing is formulated and numerically solved using finite difference discretization and the Successive Over- Relaxation (SOR) algorithm. Static characteristics, including pressure distribution, film thickness, load-carrying capacity, frictional torque, coefficient of friction, and side leakage, are evaluated, along with dynamic characteristics such as stiffness and damping coefficients. To assess the rotor- bearing system's stability, critical mass and critical whirl frequency are also determined. The performance of the StGJB is further improved by optimizing texture parameters such as groove angle, depth, width, and the number of grooves. A grey relational analysis (GRA)-based optimization approach is employed to fine-tune the bearing parameters and optimize both static and dynamic performance. Additionally, this statistical tool identifies the most significant bearing parameter that has the greatest impact on the real-time performance of StGJBs. The results of this study underscore the importance of numerical methods and optimization in the effective design of StGJBs.

Tribo-Mechanical Characterization of Electroless Ni-P-MXene Coating under Dry Lubricating Conditions

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Abs.ID: C105

ABSTRACT

This work focus on developing a novel Nickel-Phosphorous-MXene (Ni-P-MXene) coating through electroless deposition process. It investigates the impact of altering key reaction conditions, such as temperature and pH, deposition rate, deposition time, aiming to optimize the efficiency and performance of the coatings. This study ensures a comprehensive understanding of how MXene integration affects the coating's performance. Ni-P coating is deposited on SS316 and same bath composition was used to incorporate Ti_3C_2 MXene. The structural integration was successfully characterised by XRD and Raman spectra. With increase in deposition time (1 hr vs 3 hr), the MXene coverage increases on the substrate, that increases the hardness of the coating. The tribological characteristics of the coatings were tested and Ni-P-MXene coated specimens showed significant improvement in anti-friction and anti-wear characteristics over uncoated and Ni-P coated specimens effectively reducing the COF and wear depth, thus, confirming the improvements in overall tribological characteristics. Scratch resistance of the coatings was compared and Ni-P-MXene with 3 hr deposition time exhibited lowest scratch depth and scratch width compared to bare substrate, Ni-P and Ni-P-MXene with 1 hr deposition. This research demonstrates the potential of incorporating MXene into Ni-P coatings for applications requiring superior anti-friction and anti-wear properties.

Mechanical characterization of crack-induced hybrid Gr/hBN nanosheets reinforced to the Ti-based nanocomposites: A Molecular Dynamics study

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Abs.ID: C106

ABSTRACT

This work focus on developing a novel Nickel-Phosphorous-MXene (Ni-P-MXene) coating through electroless deposition process. It investigates the impact of altering key reaction conditions, such as temperature and pH, deposition rate, deposition time, aiming to optimize the efficiency and performance of the coatings. This study ensures a comprehensive understanding of how MXene integration affects the coating's performance. Ni-P coating is deposited on SS316 and same bath composition was used to incorporate Ti_3C_2 MXene. The structural integration was successfully characterised by XRD and Raman spectra. With increase in deposition time (1 hr vs 3 hr), the MXene coverage increases on the substrate, that increases the hardness of the coating. The tribological characteristics of the coatings were tested and Ni-P-MXene coated specimens showed significant improvement in anti-friction and anti-wear characteristics over uncoated and Ni-P coated specimens effectively reducing the COF and wear depth, thus, confirming the improvements in overall tribological characteristics. Scratch resistance of the coatings was compared and Ni-P-MXene with 3 hr deposition time exhibited lowest scratch depth and scratch width compared to bare substrate, Ni-P and Ni-P-MXene with 1 hr deposition. This research demonstrates the potential of incorporating MXene into Ni-P coatings for applications requiring superior anti-friction and anti-wear properties.

Study of Frictional and Nano Properties of PDMS Elastomer

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ABSTRACT

Polydimethylsiloxane (PDMS) is a versatile elastomer used widely in many fields such as bio-medicals, microfluidics chip, sensors etc. The change in properties of PDMS (SYLGARD 184) by varying the ratio between base and curing agent have long been examined in the normal range of mixing (around 10:1) but there are not much studies done in the extremities. In this work we aim to analyze the elastic modulus and hardness using nano indentation of PDMS elastomer formed by mixing base and curing agent at mixing ratio 1:1, 3:1, 5:1, 10:1 and 20:1. Hysitron TI 750D Nano indenter was used to measure elastic modulus and nano hardness. Further the effect of varying concentration of curing agent in the PDMS elastomer and also incorporation of nano particles to PDMS elastomer on frictional properties was determined by measuring coefficient of friction. The experiments were done to determine the variation of CoF by varying the load and keeping the sliding velocity constant and vice versa. Also, two different types of balls viz Polypropylene and Stainless Steel 304 were utilized to see the effect of nature of surface in contact. The tribological tests were performed in RTec MFT 2000.

Dry Sliding Wear Behavior of Vacuum Sintered Transparent YAG Ceramic

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ABSTRACT

Transparent ceramics with improved tribological properties are essential for protective optical elements, windows or domes. Yttrium Aluminum Garnet (YAG, $Y_3Al_5O_{12}$) ceramics exhibit these properties and, therefore, in present work transparent YAG is prepared using high-purity Al_2O_3 and Y_2O_3 powders via vacuum sintering. The hardness and the fracture toughness of the sintered samples were measured through Vickers indentation. The research examines the friction and wear behavior ofdeveloped YAG in unlubricated sliding conditions against chrome steel ($100Cr_6$) balls at different loads, i.e., 5, 10, and 15 N. It was observed that the coefficient of friction (COF) varied in the range of 0.423 to 0.693, and the specific wear rate varied from 9.44×10^{-5} to 1.82×10^{-4} mm^3/Nm with the change in load. At low loads, the formation of tribo-chemical layers via the wedge formation mechanism reduces the COF. As the load is increased, the iron oxide layer stabilized while the COF remains relatively constant. The formation of oxide layer on the sliding wear surface was confirmedby Raman analysis.

Comparative Study of Tribological Properties and Braking Performances of Additive-Based MR Fluids using MR Drum Brake

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Abs.ID: C109

ABSTRACT

The magnetorheological properties of MR (magnetorheological) fluid are one of the braking performance parameters for any MR brake. To improve its magnetorheological properties additives are added while preparing MR fluids. Hence, in the present work, MR fluids were prepared using graphite flakes, MWCNTS and Zinc Oxide. The magnetorheological properties were measured using magneto-rheometer to see the effect of additives on magnetorheological properties. Due to continuous interactions of MR fluid with the rotor surface of the MR brake, the MR gap which is another performance parameter, varies. Therefore, the tribological properties of prepared MR fluids were also investigated on tribometer. The investigated properties of prepared MR fluids were verified using a fabricated MR drum brake by following the IS13453 test standard on the brake inertia dynamometer. It was found from the present study that zinc oxide-based MR fluid is the most suitable MR fluid for the fabricated MR drum brake in terms of braking performance and tribological aspects.

Influence of Hydrogen Content on Fretting Damage of Zr-2.5Nb Alloy

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Abs.ID: C110

ABSTRACT

Zirconium alloys are widely used in the nuclear industry to manufacture core components due to their low neutron absorption, good mechanical strength and good corrosion resistance under reactor environment. In Pressurized Heavy Water Reactors (PHWRs), pressure tubes are fabricated from Zr-2.5 Nb due to low hydrogen absorption during reactor operation. Flow-induced vibrations during reactor operation induce relative motion between the pressure tube and bearing pads of fuel bundles which may result in fretting damage at the contact interface. During operation, pressure tube of Zr-2.5 Nb gradually absorbs hydrogen which precipitates as brittle zirconium hydride platelets when the hydrogen concentration exceeds the terminal solid solubility limit. Present study investigates the fretting damage of Zr-2.5 Nb under varying mechanical loads viz., normal load and displacement amplitude. The experiments were performed on Zr-2.5 Nb mated against a tungsten carbide (WC) pin in addition to the experiments with bearing pads of Zr-4 in order to check the effect of the contacting bodies, if any. Fretting tests were conducted under ambient conditions on as-received condition (<5 ppm hydrogen) and those charged with 30 ppm and 60 ppm hydrogen. Wear characterization involved profilometry, scanning electron microscopy (SEM), and wear volume analysis. The results demonstrated an increase in wear volume with increase in hydrogen content. At low displacement amplitudes, adhesion was the dominant wear mechanism, while ploughing and plastic deformations were more pronounced at higher displacement amplitudes.

Synergy of Tribology with Next Gen Fuels to Achieve Net Zero in Marine Sector

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ABSTRACT

Motivation: COP 28 has spoken about the need for Net Zero in Shipping sector. The Marine Sector contributes to 3% of Global emissions. IMO is aligned with COP 21 Paris Agreement. This calls for trying to reach 30% reduction in emissions by 2030 and reach Net Zero by 2050.

Methodology: IMO plans to reduce the carbon intensity through introduction of Green Hydrogen & other syn fuels (80-100%); Biofuels (90%).

Finding: - Through tribology interventions in hull management & power/ drivetrain can further reduce carbon intensity to 10%-40%. The tribology interventions include use of friction modified/ energy efficient lubricants) and reduced friction hull coatings. Some of the EAL Fluids also have high viscosity index which when used in hydraulic systems also help in improving energy efficiency. Adopting cradle to grave approach and asses the carbon footprint of raw materials at every stage of lubricants and fuel value change in the marine sector is the greatest indicator of the march towards next Zero.

Investigation of Phosphate Chemical Conversion Coatings with MoS_2 Solid Lubricant for Tripod CV Joint Roller Applications

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Abs.ID: C112

ABSTRACT

Phosphate coating has traditionally been used to treat the surfaces of sliding and rolling components. Phosphate coatings help decrease friction and wear by forming a porous layer that can retain solid lubricants, which in turn extends the lifespan of bearing surfaces. This study evaluates the structural and mechanical properties of zinc phosphate (ZnPh), manganese phosphate (MnPh) for better adhesion of molybdenum disulfide (MoS_2) solid lubricant coating on the constant velocity (CV) joints roller bearing. Phosphating is done via dipping method whereas MoS_2 coating is applied by means of spray process. Surface roughness of MnPh is 50% lesser than ZnPh. The phosphate coating has a thickness of 4-5 µm and MoS_2 coating has 2-3 µm as top coat. The results indicated that manganese phosphating showed better crystal structure, and load carrying capacity. MoS_2 coating shows marginally better adhesion characteristics with manganese phosphating as compared to zinc phosphating. Coefficient of friction for MnPh is observed to be 36% less than ZnPh. The corrosion characteristics of MnPh is found better compared to ZnPh under salt spray test.

Studies on Energy Efficiency in Automatic Transmissions of Hybrid Passenger Car Vehicles – An Indian Perspective

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ABSTRACT

Electric vehicles have been gaining popularity for use in personal urban transportation in India, however major part of this growth has been observed in the two-wheeler segment as opposed to the passenger car segment. This can be attributed to EV passenger cars being more expensive as compared to the ICE powered cars. For the ICE passenger cars, the CAFÉ norms with the Average fuel consumption for passenger cars reduced from 5.4922 litres / 100 kms to 4.7694 litres / 100 kms.

In an endeavour to meet these stringent norms, a popular option being offered by various passenger car companies in India is the Smart Hybrid option combining the IC Engine and the Electrified powertrain. As automatic transmissions have become the norm with electric vehicle powertrains, vehicle manufacturers are offering the Variable Frequency / Automatic Transmissions to tap the large and existing price sensitive customer base.

Optimization in the transmission oil formulations reduce frictional losses and contribute towards the maximization of fuel efficiency offered by these hybrid vehicles. In this paper, a detailed methodology for energy efficiency comprising Tribotesting bench level simulated screening of transmission oils and validation on hybrid vehicles mounted on a chassis dynamometer will be described. The paper describes the fuel efficiency improvements possible by optimization of the viscometrics (to reduce churning and the viscous drag) and the use of Friction modifiers in the transmission oils.

Misaligned Operation of PVP Lubricated Conical Hybrid Journal Bearing

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ABSTRACT

In rotating machineries, high speed operation induces elastic deformation or thermal distortion in the shaft which causes misalignment of journal bearing system. Misalignment of journal severely affect bearing's characteristic parameters and may lead to failure of bearing system. Furthermore, various commercially available additives are mixed in the base oil to improve performance of lubricant. The blending of long chain polymer substructures in oil gives polarity effect to the lubricant in presence of couple-stresses induced by size effect. At higher pressure conditions, these additized lubricants exhibits pressure viscosity dependency and can be idealised as piezo-viscous polar (PVP) lubricant.

To investigate the effect of journal misalignment on characteristic parameters of multi-recessed conical hybrid journal bearing (MHCJB) system operating with PVP lubricant, modified form of Reynolds equation is solved using Galerkin's technique. The solution of modified form of Reynolds equation gives oil film pressure field and subsequently, bearing's characteristic parameters are evaluated. The computed results reveal that misalignment of journal significantly affect the performance of conical bearing system. However, the application of PVP lubricant instead of Newtonian lubricant offers substantial enhancement in bearing's characteristic parameters and partially compensate the degradation in minimum oil film thickness attributed to misaligned operation of bearing system.

IIoT – Enabled Cognitive Maintenance for Oil Analysis

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Abs.ID: C116

ABSTRACT

Contamination is a significant cause of equipment failure in lubricated systems, leading to costly downtime and operational inefficiencies. Traditional maintenance approaches often fail to address this issue proactively. This paper presents the implementation of an IIoT-enabled laser particle analyzer for cognitive maintenance, focusing on real-time oil condition monitoring. The system incorporates advanced sensors to evaluate critical parameters such as Viscosity Index, Moisture Content, Total Acid Number (TAN), Total Base Number (TBN), and contamination levels. Data is securely transmitted through industrial communication protocols to a cloud-based platform, where it is processed using advanced algorithms for predictive analytics. This methodology enables proactive maintenance, improving equipment reliability, reducing maintenance costs, and enhancing operational visibility. Key findings from real-world applications demonstrate a substantial reduction in breakdowns, optimized oil consumption, and decreased maintenance budgets. This study highlights the potential of integrating IIoT technologies with advanced analytics to revolutionize maintenance practices across industries.

Effect of Load on the Friction Moment in a Ball Bearing

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ABSTRACT

Ball bearings are widely used in various applications, including household equipment, automotive systems, wind turbines, satellites, and rovers. To enhance the reliability and efficiency of these machines, it is crucial to estimate and minimize power loss in the bearings. This study presents an analytical model for predicting friction torque in deep groove ball bearings. The total friction torque in the bearings is attributed to two primary sources: the friction torque at the ball-race contacts and the ball-cage contact. Several factors influence the friction torque in ball bearings, including load, velocity, and surface roughness. In this work, the effect of load on the friction torque is analyzed. The results reveal that the friction torque at ball-race contacts increases with higher loads, while the friction torque at the ball-cage interface is predominantly influenced by speed under the operating conditions considered. Overall, as the load increases, the total friction torque in the bearing also rises.

Influence of Crystallographic Orientation on the Near-Surface Integrity in Wedge Sliding

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ABSTRACT

Sliding-based surface severe plastic deformation (SSPD) processes have drawn significant attention for their effectiveness in developing gradient microstructures and enhanced surface properties. This study provides a comprehensive analysis of plastic flow dynamics in sliding wedge contact, employing high-speed imaging coupled with particle image velocimetry (PIV). The evolution of crystallographic texture, deformation mechanisms, and near-surface material integrity is investigated in detail using scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and nanoindentation techniques. The findings reveal an intricate mode of plastic flow (non-laminar), governed by the differential displacement of surface grains, affects the integrity of the sliding surface. This non-laminar flow is caused by the squeezing, elongation, and rotation of favorably oriented grains. While laminar flow is typically desirable in SSPD processes, a transition to non-laminar flow occurs at higher wedge incidence angles. This transition is accompanied by the modification of crystallographic texture from a compression-dominated to a shear-dominated deformation mode. Compression-dominated deformation produces uniform strain fields, while the shear-dominated mode promotes surface crack formation. Overall, this study provides a deep understanding of the interplay between microstructural textures and deformation mechanisms in wedge sliding, emphasizing the critical role of plastic flow behavior in enhancing surface integrity for SSPD processes.

Electrified Contacts: Characterizing the Effect of Applied Voltage on Component Wear

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Abs.ID: C119

ABSTRACT

In recent years, the influence of applied electric potentials on lubricated contacts has become widely studied. These contacts are particularly pertinent in electric vehicle (EV) transmissions where electrical potential and discharges have been shown to influence both film thickness and tribofilm formation, leading to premature wear and component failure. Understanding this phenomenon is crucial for ensuring the longevity of EVs in India, particularly as their adoption is expected to increase significantly under Phase 2 of the Faster Adoption & Manufacturing of Electric Vehicles (FAME) scheme.

Previous work, performed using an MTM-EC equipped with SLIM (Spacer Layer Imaging Method) capabilities – both developed by PCS Instruments, showed that the presence of an electric potential significantly affects tribofilm formation, reducing tribofilm thickness by approximately 50% compared to non-EC environments, even when using a fully formulated oil. Moreover, recurrent discharge events were observed, resulting in distinct wear scar features.

This study builds on these findings by systematically investigating the effects of varying voltage (with fixed resistance), current type (AC and DC), and polarity on tribofilm thickness and the resulting wear, under fixed sliding conditions for an EV engine oil.

Evaluation of Wear Behavior in Worm Gear Pairs under Lubricating Conditions using DR Ferrography

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ABSTRACT

This paper presents a study on the effect of wear particles in a worm gearbox. The analysis of the oil is conducted using Direct Reading (DR) Ferrography, a method for examining wear particles in lubricating oils. This technique is useful for predicting and diagnosing potential machine failures. Oil samples are collected under controlled operating conditions from the worm gearbox, and the results of the DR Ferrography analysis of these samples are calculated. The findings suggest that wear particles serve as an early warning for component failure, helping to prevent breakdowns through Ferrographic examination. A wear predictive model will be developed based on quantitative Ferrographic oil analysis.

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