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Mechanics of discrete contact with application to tribology

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ABSTRACT

The internal stresses within contacting bodies as well as normal and shear contact stresses essentially depend on the mechanical and surface properties of the bodies. Due to surface roughness the contact is discrete, and the real contact area is much smaller than the nominal one calculated from the classical contact mechanics. In contact interaction of dry surfaces adhesive stresses between the interacting bodies arise due to molecular interaction. In case of existence of a thin film of fluid in the gap between the surfaces, the capillary adhesive forces arise due to a meniscus of fluid formed near the contact regions. Surface microgeometry and adhesive forces play a significant role both in normal and sliding contacts of deformable bodies. The analytical approach [1,2] is developed to study the normal contact of elastic bodies taking into account their microgeometry parameters, mutual influence between the contact spots, and the adhesion between the contacting surfaces. Based on this approach the dependence of the friction force in sliding contact on the parameters of microgeometry, adhesion and elastic properties of the contacting bodies is analyzed. The adhesive component of the rolling friction force is also calculated, and its dependence on the height distribution of asperities on the surface of the rolling body is studied.

This study was supported by RSF (project No. 22-49-02010).

Keywords: contact mechanics, contact interaction, microgeometry, adhesion and elastic properties.

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The development of synchrotron operando X-ray diffraction technique for contact areas

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ABSTRACT

Observing contact areas in operando environments is crucial for understanding tribological phenomena. Contact areas are surrounded by two solid surfaces, making direct access difficult. However, replacing one or both of the solid surfaces with transparent materials allows us to directly observe the contact area by optical technique. Over time, numerous operando observation techniques, including visible cameras, infrared thermometers, FT-IR, and Raman spectroscopy, have been developed in the field of tribology. These techniques have enabled the observation of hydrodynamic film formation, wear progression, temperature changes, and the growth of chemical reaction films. My research group has developed an operando observation technique based on the X-ray diffraction principle. X-ray diffraction is a powerful tool for revealing material crystal structures, providing insight into material behaviour within the contact area. The operando observation technique utilizes a X-ray beam from the synchrotron radiation facility SPring-8 in Japan. The beam is directed into the contact area from the side of a specialized friction test rig. On the opposite side, a two-dimensional X-ray detector is positioned to capture the Debye-Scherrer rings diffracted from the contact area during friction tests. Additionally, the operando observation system has visible and near-infrared cameras that operate simultaneously with the synchrotron X-ray diffraction system. In this presentation, I will introduce some intriguing phenomena such as plastic flow with heat generation, phase transformation, and growth of chemical reaction films observed using our developed operando observation system.

Keywords: operando observation, synchrotron, XRD, crystal grains, chemical reaction films

Nanotribology of molecular lubricants and 2D materials

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ABSTRACT

Friction and wear of engineering components result in enormous energy losses, reliability issues and environmental problems. Macroscopic contact involves interactions between micro- and nanoscale asperities owing to the surface roughness of the components. Observing and understanding the nanoscale mechanisms at play is inhibited by the hidden nature of the buried interface. Recent advances in novel experimental methods based on atomic force microscopy (AFM) are enabling such interactions to be studied with unprecedented resolution and insight. I'll discuss AFM based approach for investigating nanotribological properties of lubricants, additives and 2D materials. The interaction of lubricants and lubricant additives with material surfaces, including confinement induced structuring of lubricant molecules [1] as well as formation of protective tribochemical films [2] are key to the lubricant performance. The growth mechanisms of such tribochemical films are still poorly understood. Greater understanding of the formation of these films using AFM based approach can enable rational design of more environmentally friendly and energy-efficient engine oil formulations. I'll also discuss recent investigations of tribology of 2D materials where we demonstrate self-generation of lubricious graphene based tribochemical films on silica glass which reduces scratch induced surface damage [3]. In addition, our results reveal that super-lubricious and highly scratch-resistant glass surfaces can be realized using a few layer graphene films. Finally, in situ nanotribology of WS2 monolayer, which are excellent solid lubricants, will be discussed where role of defects, ageing and morphology of the monolayer as well as shear induced phase transitions play important role in determining its friction and wear behaviour [4, 5].

Keywords: friction and wear, microscopic contacts, nano-tribology

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Test methods to address next generation tribological applications such as space, electric vehicles and semi con devices

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ABSTRACT

The reach of tribology has expanded in diverse fields and has seen immense growth during the last few years. It's not uncommon for several researchers to point out that tribology and materials science is entering its golden age. Tribology analysis is no longer limited to standard lubricant, grease, and coating testing. Today its finding its footing in testing consumer goods, quantify taste, perception etc. This talk shall briefly touc upon several new trends in tribology characterization, specific examples include electric vehicle tribology (thermal fluids), space tribology (cryogenic testing), ultra-low friction bearings (super lubricity), semiconductor device durability (high speed connectors), perception (curved surface, touch) etc. The talk will reflect on the need to look beyond standard testing and introduce a new class of test instruments that are being developed to help researchers solve next generation of tribological challenges.

Keywords: coating, semiconductor, space tribology

Tribological issues of thermal barrier and abradable coatings of advanced aero-engine

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ABSTRACT

Thermal barrier coating (TBC) systems [1] and abradable coatings [2] used in aero-engine are important layers which have undergone considerable development over the years. TBC is used to increase efficiency of engine by allowing it to operate at the highest possible temperature by protecting the turbine blades from high temperature exposure and corrosion. The abradable coatings act as sealing layer and increase the efficiency of the engine by preventing leakage of air. This coating itself gets abraded and protects blade tips from abrasion. Both these layers are subjected to solid particle erosion (SPE) at room and elevated temperature [3]. Erosion rate of TBC decreases [4] and that of abradable coating increases [5] with temperature. However, TBC deposited by electron beam physical vapor deposition system exhibits lower erosion rate than that of TBC deposited by plasma spraying. These coatings also require significant cohesive strength. Indentation and scratch response [6] is examined to assess their cohesive strength. Abradable coating deposited by flame spraying followed by pressed isostatically at ambient temperature exhibits the highest elastic modulus and the best combination of scratch hardness, lateral hardness and scratch toughness [7]. In this presentation, SPE response of TBC and abradable coatings as function of temperature will be presented. Response of both coatings under indentation and scratch at ambient condition as a measure of their cohesive strength will be illustrated in detail.

Keywords: Thermal barrier coating, erosion, cohesive strength

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Advanced composite technologies: upscaling, sustainability and industrial deployment

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ABSTRACT

Advancement in composite technology is persistently implemented for industrial utilization e.g., lightweight structural part for aerospace applications. Recently, agencies are promoting usage of futuristic sustainable materials technologies to address the abrupt climate change and incremental energy demands. Fiber reinforced polymer composites, characteristically supports lightweight effectiveness. Continuous fibre reinforced thermoplastics (CFRTP) are strategically preferred due to their high specific strength, dimensional stability, elevated thermomechanical performance, recyclability to some extent and molding capabilities to conform intricate structure. Composites researcher and manufacturers are unceasingly exploring for efficient upscale processing technologies and innovative deployment methods for lightweight structural applications e.g., primary aviation structure and structure for electric powered vertical takeoff and landing eVTOL The challenges coupled with composite sustainability are landfill disposal, limited choice of commercially available bio compatible polymer/reinforcements and lack of recycled technologies to reused composites at end-of-life. Few allied R&D initiatives are consistently implemented to overcome the issues. For example, by utilizing thermoplastic-based composites manufacturing process, tailored fiber placement, utilization of innovative recycling techniques and compelling designs. The presentation will highlight the research related to advanced prepreg technologies, hybrid composites development by additive manufacturing process, structural health monitoring, nanomechanical/nano tribological analyses. The subsequent section will include case studies on the strategic translational technologies demonstrated in liaisons with industry.

Keywords: Sustainable composite materials, eVTOL, composites recycling, prepreg, carbon fibres, material for harsh operating environment.

Integrating surface design, adaptive lubrication and tribo-chemistry for augmented friction and wear performance

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ABSTRACT

The importance of system durability in guaranteeing safety and lifespan is of utmost importance, and the resilience of surfaces plays a crucial role in this particular context. Customised lubrication systems serve the dual function of minimising failures and significantly contributing to the reduction of friction, wear, and energy consumption. There is significant potential for large breakthroughs to be achieved by integrating surface design, self-adaptive lubrication, and the complex field of tribo-chemistry. This study examines the complex interplay among surface design, tribo-mechanism, and lubricant effects, specifically emphasising their importance in gear applications. The topic is divided into two main domains: the first part centres on parameter optimisation using a tribometer facility, while the second part involves the implementation of these optimised parameters to achieve the best possible gear performance. The contact simulations conducted on the tribometer involve a thorough examination of both gear sliding and rolling contacts, specifically focusing on reciprocating contact. In the present study, laser beam/masking techniques are employed to examine three distinct sample kinds, namely finished, superfinished, and textured. The primary goal is to preserve the negative skewness of surface roughness while simultaneously optimising the form and size of the texture. The regulation of textured dimples is determined by the criterion of the maximum size of wear debris. This study investigates two distinct categories of lubricants: (1) conventional commercial gear oil and (2) commercial gear oil that has been enhanced using nanoparticles, such as graphene and hBN, among others. To assess the tribo-mechanisms at play, we have utilised techniques such as scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) to acquire valuable information regarding wear mechanisms and the compositions of tribofilms. Fourier Transform Infrared Spectroscopy (FTIR) is a technique used to analyse changes in the chemical composition of lubricants across various situations. The systematic methodology is employed to elucidate the fundamental mechanisms present in different lubrication regimes during a gear mesh cycle, encompassing Boundary Lubrication (BL), Mixed Lubrication, and Elasto-Hydrodynamic Lubrication (EHL). This methodology improves the comprehension of textured surfaces and their impact on the reduction of failures and energy conservation. The objective is to optimise surface design in order to enhance tribological properties. The elucidation of nanoparticle functions, namely their interactions with substrates, other nanoparticles, and lubricants, has been extensively discussed, highlighting both homogeneous and heterogeneous effects. The study finishes by highlighting prospective obstacles and predicting the development of texturing, nanolubricants, and mechanochemistry, providing a strategic plan for forthcoming advancements in the field. This study provides a comprehensive overview of the latest improvements in gear optimisation.

Thixotropic colloidal gel based aqueous lubricant

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ABSTRACT

Non-renewable materials are utilized as additives in the two most used lubricating media, grease and oil, which harm the environment and human health. As a result, there is an urgent need to develop "green" lubricants made from renewable resources. We developed and studied a thixotropic colloidal gel using aqueous dispersion of environment friendly synthetic hectorite clay, Laponite for its rheological and tribological performance as a lubricant. Ultrapure sodium chloride (NaCl) was added to the colloidal gel in varying millimolar concentrations to see the effect on its structural, rheological and tribological properties. Our findings reveal that the incorporation of NaCl induces notable enhancement in the colloidal gel's viscosity, yield stress, and elastic modulus. This increase is attributed to the reduction of the shielding charge within the system, which expedites the formation of its structure. Furthermore, an increase in NaCl concentration decreases the material's relaxation time dependence on waiting time (tw). Lubricated investigations of a steel-steel tribo-pair were conducted on a ball-on-disc tribometer under unidirectional sliding. Coefficient of friction and specific wear rate were investigated under different load and sliding speed conditions. The analysis of tribological study yielded that the utilization of a thixotropic colloidal gel containing Laponite and 10mM of NaCl resulted in the most substantial reductions in both, coefficient of friction and specific wear rate. Specifically, it led to a reduction of 74.11% in the coefficient of friction and a decrease of 98.12% in the specific wear rate. Severe abrasive wear on disc surface under dry test, gradually mitigated upon the introduction of these lubricants. We identify two mechanisms for effective lubrication. First, smooth sliding of the friction pair facilitated by the alignment of Laponite particles in the direction of shear forces. Second, the stable structure of Laponite, coupled with the addition of NaCl, enabling continuous replenishment of the wear track with lubricant.

Keywords: Thixotropic colloidal gel, steel-steel, tribo-pair.

Fabrication of test rig for evaluating the performance characteristics of conical journal bearing

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ABSTRACT

The hydrodynamic journal bearing is the most commonly used bearing for supporting rotating machines. These machines often generate both radial and axial loads, and typically require journal and thrust bearings to sustain these loads. However, these bearings can be expensive and take up a lot of space. Therefore, there is a need to explore the feasibility of using a single compact conical hydrodynamic journal bearing to replace the two independent bearings.

Conical bearings have additional advantages, such as being able to be conveniently preloaded by adjusting the gaps, and improving performance for carrying thrust loads on rotating members. This research work uses analytical methods, design and development of an experimental setup, and computational fluid dynamics (CFD) analysis to investigate the performance of a conical hydrodynamic journal bearing.

A customized experimental setup for the conical hydrodynamic journal bearing is developed to validate the numerically simulated results through experimental work on a test rig. The finite element method is used to solve the modified Reynolds equation in the spherical coordinate system for the conical hydrodynamic journal bearing. The analysis focuses on the stability of the rigid rotor-bearing system to determine the bearing's performance. Based on the investigation, it has been found that the axial and radial load carrying capability of the conical journal bearing improves with an increase in the semi-cone angle and aspect ratio. All of the numerically computed results and experimental work in this influencing parametric study are useful for academics, research scholars, and industrial bearing designers.

Keywords: Conical journal Bearing, CFD, Test Rig.

Smart/intelligent lubricants – influence on lubricating performance of fluid film bearings

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ABSTRACT

The recent research activities in the area of fluid film bearings clearly demonstrates that the performance of tribo-pairs can be improved significantly by the use of smart/intelligent lubricants. Fluids like electrorheological (ER) lubricants, magnetorheological (MR) lubricants, Magnetohydrodynamic (MHD) lubricants and Ferrofluid lubricants, are better equipped to cope with alterations in bearing fluid film stiffness/damping characteristic attributes in real time under high speed operation. These lubricants makes use of application of an external stimuli between the tribo-contacts, which causes a change in rheological behaviour of lubricant and allows for real-time control of tribo-components behaviour.

This presentation is basically aimed at to outline the research efforts undertaken so far in the area of hydrostatic / hybrid bearings operating with smart/intelligent lubricants and to present some salient findings of studies related to these class of bearings. To get the numerical solution of such type of problems, the modified Reynolds equation is solved using Finite Element Method by considering the relevant constitutive equations. Newton-Raphson method is used to solve the non-linear system of equation resulted due to the use of different smart lubricant models. In general, the simulated results of available studies reveal that the use of intelligent lubricants provides enhanced values of lubricant film thickness, load carrying capacity, fluid film stiffness/damping coefficient, and improved stability threshold speed.

Keywords: Intelligent lubricant; Hydrostatic/Hybrid bearings; FEM; Journal/Thrust Bearing.

Polymer blend composition effects on adhesion properties of polydimethylsiloxane and polyvinyl alcohol as skin substitutes

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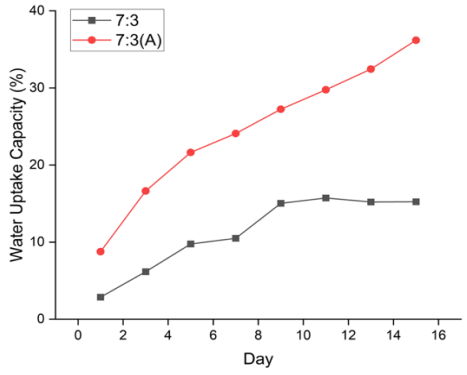
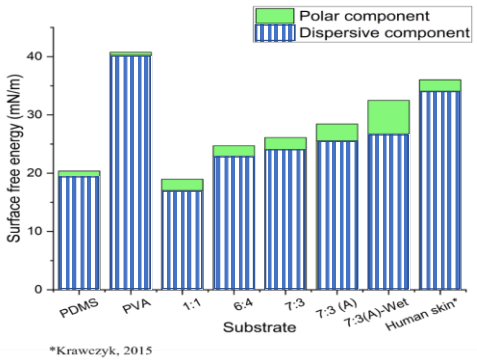
ABSTRACT

The current trend in the field of cosmetic research encompasses the development of artificial skin as a means to reduce reliance on animal skin. Nevertheless, the significance of adhesion properties in the development of artificial skin should have been considered. The present investigation focuses on the determination of the surface free energy (SFE) of artificial skin, which is composed of a blend of Polydimethylsiloxane (PDMS) and Polyvinyl alcohol (PVA) at varying ratios, through the utilisation of contact angle analysis. An in-house Goniometer was employed for the purpose of measuring the contact angle. The theory proposed by Fowkes was subsequently applied to determine the surface free energy (SFE) of the artificial skin. The findings of these studies suggest that artificial skin composed of a 7:3 ratio of PDMS to PVA has the ability to imitate the stratum corneum (SC) of human skin. The moisture content of modified 7:3 composition artificial skin demonstrates a strong water-absorption capacity capable of imitating human SC moisture content and exhibits the capacity to develop artificial skin for various practical applications.



Water uptake capacity (%) of artificial skin at composition 7:3 and 7:3(A).



Comparison surface free energy of artificial skin with human skin.

Keywords: artificial skin, surface free energy, stratum corneum.

Tribological analysis of white etching areas (WEAs) formation in bearing steel under dynamic loading

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ABSTRACT

Countries worldwide are looking forward to establishing sustainable energy to build a stronger and healthier economy to meet future energy demand. Wind energy is one of the potential and promising renewable energy sources to run on par with the emerging needs of the future. Critical issues such as the longest downtime and maintenance cost due to the major wind turbine gearbox (WTG) premature bearing failure need to be addressed to accomplish this ambitious goal. The premature bearing failure is due to distinct rolling contact fatigue failure called white etching cracks (WECs) and white etching areas (WEAs) formation in bearing steel. The replication of WEAs formation and study of bearing failure analysis using conventional test rigs is a cumbersome, time-consuming task along with laborious post-test analysis and finally, it can only give insufficient information about the failure. This approach is inadequate to develop a suitable mitigation strategy in a longer time. A novel modified dynamic load Pin-on-disc tribometer design along with the real time hydrogenating lubrication methodology is experimented to replicate "white etching areas" (WEAs) formation on bearing steel in laboratory level testing. Controlled formation of white etching area within a short duration has been achieved with the help of this new approach. Investigation of subsurface microstructural changes has opened a new insight in analysing the sequential formation of white etching area associated with premature rolling element bearings failure. The dynamic loading under hydrogenation establishes the sequential microstructural changes such as clustering, agglutination and deformation, followed by the dissolution of cementites to form WEA in the bearing steel. Further, this study investigates the effect of loading frequency and hydrogenation to instigate the WEAs formation under severe sliding conditions of bearing steel. Experiments were carried out at 1.5 Hz and 4.5 Hz loading frequencies by varying the contact pressure from 1 to 2 GPa using the dynamic load PoD tribometer. Steel-on-steel tribo-pair was lubricated by two different lubricants, PAO and real- time hydrogenating oil, under boundary lubrication. Synergic interaction between hydrogen- enhanced and mechanical stress-induced drivers on WEAs formation was established.

Keywords: hydrogenating, lubrication, clustering, agglutination.

Surface integrity variation of metal additive manufactured complex internal and external features during finishing with sustainable polymer rheological abrasive fluids

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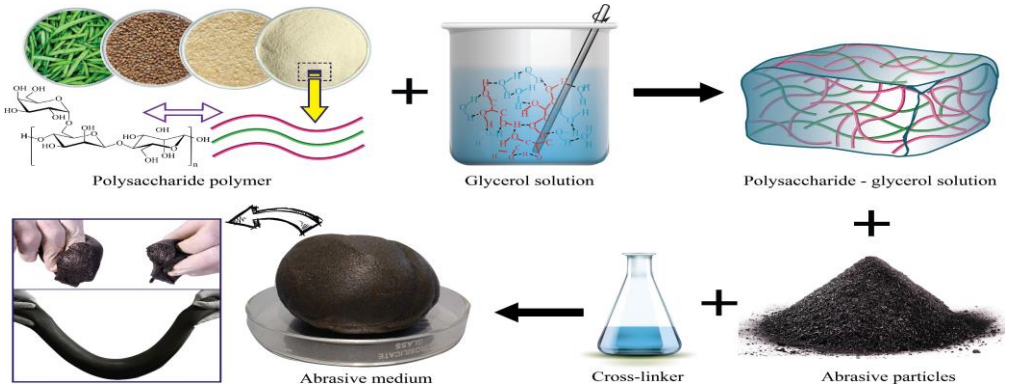
ABSTRACT

Additive manufacturing has revolutionized the manufacturing industry by enabling the creation of complex and customized components that were previously impossible to make with conventional techniques. However, the poor surface integrity of metal additive manufactured products necessitates further post-processing to improve their surface quality and functionality. Conventional finishing processes such as grinding, honing, lapping etc., fail to address this issue as they can be employed for simple geometrical shapes of the component. Abrasive flow finishing (AFF) is an advanced finishing process where the surface roughness of the component is gradually reduced by reciprocating a viscoelastic semisolid abrasive medium. A typical abrasive medium consists of base polymers, rheological additives, and abrasive particles. In most cases, the base polymer chains are based on siloxane, natural or synthetic rubber, thermoplastic polymers etc. The abrasive media developed with these polymers are expensive, and most of them are not biodegradable. During their preparation, they emit hazardous gases into the atmosphere. In this work, an attempt has been made to develop an alternative abrasive medium that is economical and biodegradable. The developed abrasive medium comprised galactomannan biopolymer, crosslinker, solvent, abrasive particles, and other additives. Apart from rheological characterization, FTIR and TGA analysis were carried out to examine the various functional groups present in the abrasive medium and to check its degradation with respect to the rise in temperature. The developed abrasive medium showed better rheological properties and thermal degradation compared to the hydrogel-based abrasive media. The schematic of medium development is shown in Fig. 1.



The finishing performance of the developed abrasive medium is evaluated by finishing atomic diffusion additively manufactured pure copper through the abrasive flow finishing process. The amount of material removed increases with the number of cycles and extrusion pressure, whereas it decreases with the increase in abrasive mesh size. A maximum amount of material removal of 45 mg is observed at 7.5 MPa, after machining for 250 cycles using #54 abrasive particles. The percentage improvement in surface roughness along the longitudinal direction, i.e., built direction ($\% \Delta R_a^{\parallel}$) and transverse direction ($\% \Delta R_a^{\perp}$), increases with the number of cycles and extrusion pressure, whereas it decreases with the increase in abrasive mesh size. The maximum $\% \Delta R_a^{\parallel}$ and $\% \Delta R_a^{\perp}$ are observed as 90.19% and 74.58%, respectively, after machining the copper sample for 250 cycles at an extrusion pressure of 7.5MPa using #54 abrasive mesh size particles. Depending on the abrasive particle's mesh size, the critical surface roughness in the lateral direction ($R_a^{\perp}$) may result in less number of cycles than in the longitudinal direction ($R_a^{\parallel}$). The initial and final surface roughness profiles are shown in Fig. 2, and Fig.3, respectively

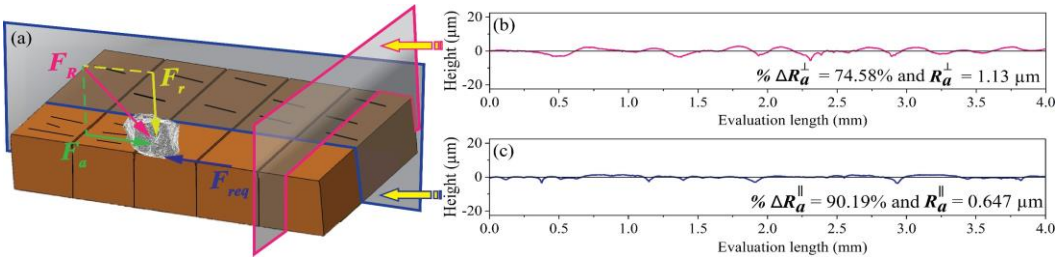


Fig. 2. (a) surface morphology and surface roughness profiles in (b) lateral direction and (c) longitudinal direction of the as-built before finishing

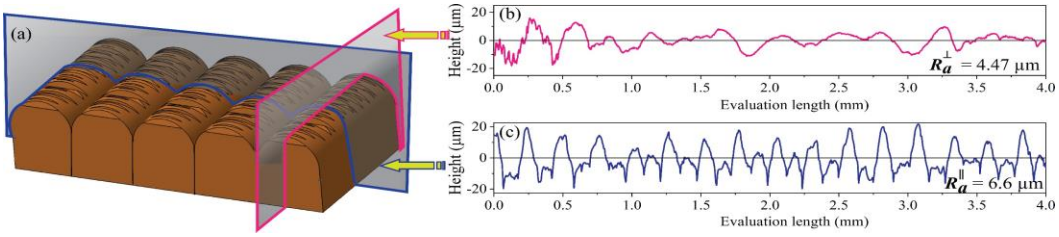


Fig. 3. (a) surface morphology and surface roughness profiles in (b) lateral direction and (c) longitudinal direction of the as-built after finishing

Monomodal and bimodal particle distributed abrasive media were employed for examining the material removal and reduction in the surface roughness of the selective laser melted maraging steel (18Ni300). It was observed that irrespective of the abrasive particle size, the monomodal distributed abrasive media resulted in critical surface roughness in much time compared to the bimodal abrasive particle distributed abrasive media. Finally, the bimodal abrasive particle distributed abrasive media results in the least possible surface roughness on the SLM 18Ni300 component of as-built surface roughness of 7.40 μm to 0.49 μm.

Keywords: galactomannan, biopolymer, rheological, monomodal

Friction units in space equipment

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ABSTRACT

The exploration of outer space requires the creation of increasingly complex space stations, spacecraft, satellites and other space devices and equipment's. The urgency of creating space technology is increasing due to the creation of manned space stations, the planned exploration of the Moon, flights to Mars, Venus and other planets. For space equipment, due to the increase in their service life, the wear resistance of their friction units is of particular importance. They, as a rule, determine the performance of the space product as a whole. In the planetokhod for Mars shown in Fig.1 and the soil sampling device on Mars (Fig.2), rolling and sliding bearings, gears are used, the performance of which is determined by the correct choice of structural and lubricants materials. Similar design solutions are used for the exploration of the Moon. Rolling and sliding bearings are used in robots and manipulators of the International Space Station. All of them must be operable in open space conditions with a variable temperature difference in near-Earth orbit from minus 125°C to plus 150°C, exposure to cosmic radiation and in deep vacuum. On the Moon, the temperature range is from minus 196°C to plus 200°C. Both for plain bearings and rolling bearings, solid lubricant coatings can be used, which will provide the required service life. At present, the Russian and Indian parties are developing a joint project to research and create solid lubricant coatings for this purpose. The work is carried out using modern methods for studying the physical and mechanical properties of materials, building mathematical models of frictional interaction and test tribology parameters.

Fig. 1. A planetokhod for Mars

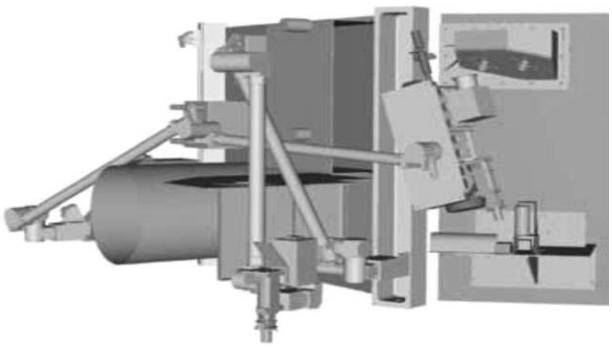

Fig.2. A device for taking soil on Mars

Keywords: Rolling and sliding bearings, solid lubricant coatings.

A comparative study on tribological properties of coated 316l steel using powder mixed-edm technique

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ABSTRACT

The coated 316L steel fabrication with the desired surface integrity and tribological characteristics is very challenging using the traditional processing techniques. In this work, an investigation of coated 316L steel processing with superior tribological performance is explored. A comparative study on tribological properties of coated 316L steel using powder mixed-EDM technique is presented. The viability of mixed of Hydroxyapatite (HAp) and carbon nanotubes (CNT) powders for processing 316L steel using powder mixed-EDM technique is investigated. The carbon nanotubes (CNT) powders with high electrical and thermal conductivity are mixed with Hydroxyapatite (HAp) powders suspended in mineral oil to ameliorate surface defects arising out of powder mixed-EDM processing and surface characteristics of 316L steel. The characterizations techniques including scanning-electron microscope (SEM) and X-ray diffraction (XRD) have been carried out. Addition of the carbon nanotubes (CNT) powders in the Hydroxyapatite (HAp) mixed mineral oil improves tribological characteristics. The present work proposes the coating compositions opted for enhanced optimal tribological characteristics of 316 L steel.

Keywords: carbon nanotubes, Hydroxyapatite, tribological characteristics

Cold-sprayed ti-based composite coatings for bio-implant applications

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ABSTRACT

The orthopedic implant market is experiencing rapid growth, with implant lifetimes ranging from 15-20 years. Prolonging implant service life is essential to delay replacement surgeries. Corrosion and wear are the main reasons for the degradation of bio-implants. SS316L is commonly used for implant manufacturing due to its low cost, good mechanical properties, and high corrosion resistance. Surface modification plays a crucial role in implant longevity. Cold spray as surface modification technology emerges as a promising alternative, keeping material integrity and offering advantages like oxidation prevention and improved mechanical properties. The study investigated the impact of substrate roughness on the bonding of cold-sprayed Ti/TiO_2 composite powder coatings on SS316L steel substrates. Various surface conditions were tested, with mirror-polished (MP) surfaces proving to be the most suitable for achieving good coating adhesion. This was attributed to sufficient Ti-particle deformation, leading to proper jetting and adhesion. Different compositions of Ti-based powders, including TiO_2, hydroxyapatite (HA), and baghdadite (BAG), were deposited on MP SS316L steel substrates using high-pressure cold spray. Laser surface treatment was employed to enhance coating properties by eliminating pores and improving mechanical characteristics. Laser-treated coatings exhibited equiaxed grains, enhanced density, and improved microhardness. These laser-treated coatings exhibited better corrosion resistance and sliding wear performance than their as-sprayed counterparts. Following this, electrochemical corrosion tests were conducted on cold-sprayed composite coatings of Ti/BAG and Ti/HA in an SBF environment. The outcomes revealed that the Ti/BAG composite coating exhibited superior corrosion resistance compared to the Ti/HA coating. Additionally, when subjected to laser treatment, the cold-sprayed Ti/BAG coatings displayed outstanding corrosion resistance in the SBF environment. These findings indicate promising expectations for the application of cold-sprayed Ti/BAG composite coatings, particularly those treated with lasers, in the field of bio-implants.

Keywords: Bio-Implant, Cold Spray, Baghdadite, Hydroxyapatite, Titanium

Tribological and magnetorheological properties of smart fluids

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ABSTRACT

Magnetorheological (MR) fluids are one of the most valuable smart soft materials for vibration dampers and shock absorbers in a wide range of engineering applications because they change their viscoelastic properties when subjected to external magnetic fields. These fluids are prepared by dispersing the soft magnetic micro-size particles in the nonmagnetic carrier oils, i.e., mineral oil (MO) and synthetic oil with stabilizing additives. The prominent feature of these fluids is their propensity to the reversible transformation from fluid to semi-solid-state and vice versa within milliseconds under the external magnetic field. The long-time stability and low magnetorheological effect are still considered one of the most critical problems that need to be solved. The rheological, tribological, and stabilization characteristics of magnetorheological (MR) suspension were assessed by dispersing core–shell particles (graphene oxide (GO) as a shell and carbonyl iron (CI) as a core). A simple wet stirring technique was utilized to achieve the grafting of bare carbonyl particles (CIPs) with para-aminobenzoic acid (g-CIPs), and graphene oxide with concentrations of 1 and 2 wt%. The limited magnetic response (low MR effect) and inadequate corrosion resistance properties of bare carbonyl iron particles create significant challenges, hindering their widespread application. To address this concern, a hybrid composite coating was developed. This coating comprises a core of carbonyl iron (CI) particles, while the shell is composed of graphene oxide (GO) and iron oxide (Fe_2O_3) nanocomposites. This innovative approach allowed the dispersion of the hybrid composite in a blended oil, consisting of 90% rice bran oil and 10% silicone oil. By utilizing this new hybrid composite, the issues related to the conventional carbonyl iron particles can be mitigated, making it more promising for potential applications. Consequently, this technique offers an economical and effective approach for formulating MR fluids with desirable rheological and tribological characteristics and corrosion inhibition properties, making them suitable for various environmental and industrial applications.

Keywords: MR fluids, Rheological characteristics, Tribological characteristics, Stabilization characteristics, Hybrid composite coating

Investigation of contact characteristics and internal stresses in elastic rough contact

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ABSTRACT

The roughness of the contact surfaces has a significant impact not only on the contact characteristics, but also on the internal stresses within the contacting bodies. Numerous theoretical and experimental studies show that the real contact area is a collection of individual spots and is a small part of the nominal one. As a result, concentrations of contact pressures are observed on the contact spots, and concentrations of internal stresses are observed in the subsurface regions. For the theoretical study of rough contact, various methods have been developed, both analytical and numerical. The advantage of analytical approaches is the possibility to explicitly identify the defining parameters and to evaluate their influence on the real contact characteristics. However, only a narrow range of problems can be solved analytically. For example, an efficient method has been developed for solving periodic contact problems, i.e. the localization method [1]. In this paper, the contact of a periodic system of identical punches of two height levels with an elastic half-space is considered. The contact characteristics defined with the localization method [2] are used to study the stress distribution inside the half-space. For the axes of symmetry of punches, expressions for internal stresses can be written in analytical form. The effect of the spatial arrangement of punches and the shape of their contact surface on the internal stresses within the elastic half-space is studied. Additionally, it is shown how to use the obtained solution to consider the problem at the macro level, namely, to solve the problem of the contact of bodies taking into account their surface roughness. The solution of the periodic contact problem shows that the location and magnitude of stress concentrations depend both on the shape of asperities and on the density of their location on the surface of the body. Thus, obtained results can be used in choosing parameters of the surface microgeometry to control the processes of wear and subsurface fracture of contacting bodies.

This study was supported by RSF (project No. 22-49-02010).

Keywords: contact surfaces, wear, fracture.

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Study of tribological performance of graphene based thermoplastic polyurethane (Gr/TPU) nanocomposites

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ABSTRACT

The ongoing research on tribological fields aim to unlock the full potential of high-performance polymer nanocomposites (PNCs) materials that enhance the efficiency, reliability, and durability of engineering systems. The selection of suitable nanoreinforcement is indeed a critical aspect to achieve a synergistic effect and maximize the tribological behaviour of PNCs. Graphene's high surface area, low coefficient of friction (COF), and excellent load-bearing capacity make it a promising candidate for enhancing the wear resistance, reducing friction, and providing better lubrication properties to thermoplastic polyurethane (TPU) materials. The study aims to investigate the effects of different graphene (Gr) loadings, dispersion methods, and processing techniques on the tribological behavior of the graphene-based thermoplastic (TPU) nanocomposites. Gr/TPU nanocomposites are prepared by ultrasonication method. Uniform dispersed solutions of Gr/TPU nanocomposite materials are prepared in Hielcher's probe ultrasonicator (UP200Ht). The test specimens have been prepared in appropriate dimensions as per the required standards of ASTM, DIN for characterization. Different experimental methods namely, microstructural study, abrasion testing and coefficient of friction testing have been carried out to compare the results of such tests with those from Molecular Dynamics (MD) simulation works. It is observed from SEM micrographs that there is no case of Gr agglomeration up to 3 wt. % Gr in the Gr/TPU nanocomposite. But presence of more than 3 wt. % Gr in TPU matrix, cause cracks, distortions and agglomerations which is observed in SEM micrographs. However, in coefficient of frictions test minimum static and dynamic coefficient of friction values for 3 wt. % Gr/TPU nanocomposite are found as 0.44 and 0.36 respectively. Similar trends are also observed in abrasion testing where minimum relative volume loss is found 46.85 mm3 for 3 wt. % Gr/TPU nanocomposite. Further addition of Gr in TPU matrix help to increase both COF and abrasion rate (AR) due to high stress concentration of agglomerated large Gr sheets that initiate material removal. According to morphological studies with SEM micrographs, property enhancement of Gr/TPU nanocomposites may be achieved by morphological control of Gr. Higher COF might be associated with increase in rough surfaces caused by addition of more than 3 wt. % Gr into TPU matrix. The tribological properties are decreased due to excess addition of Gr content. This may be due to the growth of the number of cracks around the TPU matrix.

Keywords: high-performance polymer nanocomposites, Hielcher's probe ultrasonicator

Tribological aspects of natural fiber reinforced polymer matrix composites in environment friendly materials- A review

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ABSTRACT

Due to global environmental concerns, natural fiber reinforced composites are becoming attractive as they give cost effective and environment friendly solutions. Industries such as construction, packaging and automobile are finding alternatives to synthetic fiber composites, which creates environmental pollution. Though woody products comes under environmental friendly materials, but it leads to deforestation and burning of agro-waste such as paddy straw, rice husk makes pollution. Use of agro-waste material to make light weight, biodegradable and cheap products not only reduces pollution but also makes cheap environment friendly products. Natural fiber composites are having completely different properties than metals. Mechanical, thermal and tribological properties such as strength, stiffness, density, thermal conductivity, friction, wear etc. of natural fiber reinforced composites are decided by amount of filler loading, physical properties such as fiber length, fiber orientation, chemical properties of binder polymer and its interaction with polymer matrix. This review attempts to look into different types of friction and wear mechanisms, information on various natural fibers, polymers, their composites and its tribological development. It also attempts to find drawbacks of previous work and path for future work of polymer composites from tribological point of view.

Keywords: Thermal conductivity, friction, wear, polymer, composites.

Tribological performance of laser textured Ti3AL2.5V alloy for artificial hip joint

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ABSTRACT

The use of laser to fabricate micro-textures on the surface of the artificial hip joint is an effective method to improve their tribological properties. In the present study, three different micro-textures namely, hexagon, concentric circles and lines were fabricated on Ti3Al2.5V alloy using nanosecond fiber laser at three different pitches (300µm, 400µm and 500 µm) articulating with silicon nitride balls for ceramic on metal (CoM) hip joint prosthesis. The tribological properties of the polished and textured samples were investigated using linear reciprocating tribometer against silicon nitride balls under simulated body fluid (SBF) lubricant at different loading conditions. The results revealed that the coefficient of friction and wear rate of all textured samples were reduced compared to polished surface with concentric circle acting as the most effective texture for lowering friction and wear rate. In addition, as the pitch size increases the friction and wear rate increases, implying more closely placed textures helps in reducing the friction by serving as storage spaces for lubricant. The worn out surfaces of the samples were examined using scanning electron microscope (SEM) revealing adhesive and abrasive wear as the main wear mechanism.

Keywords: textured, adhesive, wear, friction.

Biomass-derived nanostructured graphene-like carbon as a sustainable material for enhancement of tribological properties

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ABSTRACT

The quest for sustainable and eco-friendly lubricants has driven research toward novel materials that offer improved tribological performance while reducing environmental footprints. In the present work, biomass-derived nanostructured graphene-like lamellar carbon material (BGr) is synthesized by a facile and scalable approach. The Raman, XRD, and HRTEM analyses revealed the graphene-like lamellar structure of BGr with an interlamellar spacing of 0.35 nm. The long alkyl chains are covalently grafted on the surface of BGr to improve their dispersibility in hydrocarbon lube base oil. The surface interaction between alkylsilane and BGr is confirmed by FTIR and XPS analyses. The steel tribopair is used in the present work for tribological performance studies. The chemically functionalized BGr as an additive to hydrocarbon lube base oil (optimized dose: 0.05 mg.mL-1) decreased the coefficient of friction and wear volume by 36 and 64%, respectively under the load of 392 N. The analysis of contact interfaces of steel balls by Raman microscope confirmed the formation of graphene-based tribofilm, which is believed to extend the antiwear properties and decrease the coefficient of friction. The present work paves a new direction for the utilization of lignin-rich biomass for the preparation of graphene-derived nanostructured carbon, which can be a potential solution for sustainable and environmentally friendly lubrication practices.

Keywords: hydrocarbon, XRD, HRTEM, tribopair.

Performance of ER lubricated textured hybrid spherical thrust bearing

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ABSTRACT

This paper deals with the theoretical investigation of capillary compensated textured hybrid spherical thrust bearing system operating with the ER lubricants. Finite element method has been used to solve the modified Reynolds equation governing the lubricant flow in the bearing clearance space along with restrictor flow equation and the relevant boundary conditions. A MATLAB source code has been developed to numerically simulate the lubricating performance of the textured hybrid spherical thrust bearing lubricated with ER lubricant. In the present work, the effect of geometric shapes micro-textures (i.e., circular and square) and the ER lubricant behaviour have been analysed. The numerically simulated result shows a strong dependence on the combined effect of ER lubricant behaviour and a chosen geometric shape of a micro-texture. It is expected that the results presented in this work would be beneficial to the bearing designers and the academic community.

Keywords: Reynolds equation, Finite element method, Electro-rheological lubricant, Hybrid Spherical thrust bearing, Micro-texture

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Exploring the tribological behavior of nano-grained 304LN stainless steel under dry and polyalphaolefin lubrication conditions

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ABSTRACT

This study investigates the impact of grain size on the wear resistance of a 304LN stainless steel sheet through severe cold rolling (CR) to create a nano-grained structure. The sheet was subjected to a rolling strain of 92%, and tests were conducted under dry and lubricated conditions, comparing the nano-grained sheet with coarse-grained samples. The results indicate that the nano-grained CR sheets exhibit reduced wear resistance in dry conditions due to the increased presence of grain boundaries, intensifying the oxidative wear process. However, when Polyalphaolefin (PAO4) lubricant is applied, a significant improvement in wear resistance and friction reduction is observed for the nano-grained CR samples. These findings provide valuable insights into the wear behavior of the material, highlighting the transition from severe oxidative wear to adhesive wear. The practical implications of this knowledge are relevant for industries seeking effective anti-wear design strategies to enhance the performance of 304LN stainless steel.

Keywords: 304LN-SS, wear, cold rolling, nanostructure, tribological test

Evaluation of the tribological performance by implementing various surface textures using CFD techniques

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ABSTRACT

Surface texturing has been reported to increase the load-bearing capacity between interfaces by maintaining adequate lubricant film thickness. Further, it will enhance performance by reducing friction and storing the wear debris generated between the surfaces. Researchers have identified biomimetic surfaces from nature and replicated them as surface textures in various shapes over a wide range of mechanical applications. Investigating the performance and effects of surface textures through tribometers takes a lot of effort and time. Computational Fluid Dynamics (CFD) simulations are useful to estimate the exact lift force for different texture geometries and shapes. In this study, various surface textures such as dimples, ellipses, triangles, rectangular, and stars. These shapes are compared among themselves by considering the various geometrical and flow parameters. A flat plate geometry is modified to hold both single-texture geometry and patterned texture surfaces. Flat-on-Flat surface sliding contact is considered throughout this study under hydrodynamic lubrication conditions. The effect of groove dimensions, sliding velocities, and orientations is studied along with the different sliding velocities. The results of load-bearing capacity and the coefficient of friction are compared.

Keywords: Computational fluid dynamics, texture, hydrodynamic, lubrication.

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Effect of stoichiometric ratios of reinforcement (6 wt. %) particles on high temperature wear behavior of AA 6061/B4C/SiC hybrid composites

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ABSTRACT

Due to their high strength [1], improved corrosion resistance, thermal efficiency, and minimal thermal expansions, hybrid composites are becoming increasingly common. Given that AA 6061 is a well-known aluminium alloy for structural applications, it is vital to research the wear characteristics of hybrid composites made with AA 6061 as their base metal. These composites' tribological behaviour at high temperatures has not received much research. On the wear behaviour of AA6061/SiC/B4C at room temperature, there aren't many researches [2]. In earlier tribological research on aluminium hybrid composites, the importance of reinforcing particle concentration (vol. % or wt.%) at various loading situations was primarily emphasised. In the current research, the wear characteristics of a hybrid AA6061/SiC/B4C composite at high temperature (300 °C) were examined. Stir casting was used to create six compositions, including the pure AA6061 alloy, with variable B4C-SiC ratios. The as-cast samples were expertly cut to fit within the wear test rig's fixture. Analysis of volume loss or weight loss was performed following the wear test. In addition to the wear loss, the test yielded some additional information on the frictional force and coefficient of friction. To look into the wear tracks created during the test, the worn-out area was further examined using an HR-SEM.

Keywords: aluminium alloy, hybrid composites, reinforcing, HR-SEM.

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Evaluation of high toughness corrosion resistance (HTCR) rail for improved rail life

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ABSTRACT

Research & Development Centre for Iron & Steel of Steel Authority of India Limited in association with Bhilai Steel Plant and Indian Railways developed various grades of rails for diverse applications on Indian Railway Network. High Toughness Corrosion Resistance (HTCR) rail grade is one such grade which has been developed for Indian Railways to arrest plastic deformation and minimize wear of rail head. This grade also retards sudden fracture and corrosion. Two HTCR grade rails namely HT3 and HT4 were tested for wear and compared with the wear performance of 90UTS rails. All tests were performed against BG coach wheel grade to determine the relative wear performance. Wear tests were carried out at three different loads (300 N, 338 N, 375 N) and at 300 RPM on Amsler Roller Sliding Wear Testing Machine. The weight loss method was adopted to compare the wear rates of these three rails. Samples were tested for 8 hours each and weight loss after every 2 hours was recorded. Tested samples were also investigated under Scanning Electron Microscope (SEM) with Energy Dispersive Spectroscopy (EDS) attachment to study the mode of crack formation and crack development. Wear patterns of all samples were analyzed and it was found that wear takes place from inside to outside of the metal by the formation of cracks which leads to metal loss in the form of flakes. The experimental study revealed the superiority and the metallurgical advantage of HTCR grade of rail over 90UTS in context to wear resistance.

Keywords: Wear, HTCR, Weight loss

Evolution of microstructure and fracture mechanism of H13 steel during room temperature tensile deformation

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ABSTRACT

For hot work application in industrial processes such as forging, extrusion and die casting dies must possess better high temperature strength, tempering resistance, ductility that to at decent cost. These properties are available in widely used H13. Obligatory characteristics of hot die steel for a specific application can be produced by controlling heat treatment parameters which leads to significant changes in microstructure. A comprehensive investigation is done to quest upon the impact of plasma nitriding on austenitzed AISI H13 hot tool die steel by varying the nitriding cycle time on microstructure and fracture behavior. Preheated samples of made out of a rectangular block were austenitzed at 1010°C, 1050°C and 1050°C. Thereafter samples were plasma nitrided at 480, 500, and 520°C for 6hr, 10hr and14hrs. Microstructural and fracture mechanism were examined using SEM, TEM and X-ray diffraction of the tensile deformed samples at 20℃ at constant strain rate of 1mm/min on universal tensile testing (UTM) machine. Variation in mechanical characteristics as well as fracture mechanism is recorded due to fluctuation in nitriding temperature and cycle time. These phenomena were developed in conjunction with microstructure development during room temperature deformation. The mechanics of deformation and the involvement of various carbides in crack development and propagation have been explored. Through this study plasma nitriding temperature and cycle time best suitable required to slow down the formation and propagation of cracks in of aluminum extrusion dies will be selected.

Keywords: AISI H13 steel, Plasma Nitriding, Tensile Strength, UTS, microstructure, fracture mode.

Design and analysis of a composite leaf spring

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ABSTRACT

Composite materials are extensively used in many tribological engineering applications due to high strength and stiffness to weight ratio. The objective is to compare the stresses, deformations and weight saving of a composite leaf spring with that of a steel leaf spring. The design constraint is stiffness. The automobile industry has great interest for replacement of steel leaf springs with that of composite leaf springs, since the composite materials have high strength to weight ratio and good corrosion resistance.. The design parameters were selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. In this paper, the tribological properties, design and analysis of a composite leaf spring is compared with a standard steel leaf spring. The materials selected are Epoxy carbon, Aluminum Alloy and Titanium Alloy against a conventional steel leaf spring. The design parameters are selected and analyzed with the objective of comparing stress, deformation, elastic strain and weight of the composite leaf spring with a conventional steel leaf spring. The leaf spring was modeled and analysis of it was done using Autodesk Fusion 360 Software. By doing this project we have found out that Composite Elements like Epoxy Carbon can replace conventional materials like steel etc during manufacturing of leaf springs in our day-to-day life. Hence tribological properties of composite materials can be considered during manufacturing processes of Leaf Spring in the future.

Keywords: Epoxy, carbon, aluminum, composite, leaf spring.

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Vegetable oils as sustainable biobased tribo fluids

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ABSTRACT

Vegetable oils/ fats were used as a source for fuels and lubricants for several years. Discovery of petroleum and distillation process lead to the availability of economical lube oils and fuels. The vegetable oils started attracting the attention again during wartime and oil shortage situations. Over the past few decades, a continual interest in vegetable oil-based fluids has grown due to environmental concerns. Vegetable oils can be used as lubricants in their natural forms. These biofluids offer many advantages over concentional petroleum based products. Vegetable oils have excellent lubricity, viscosity, viscosity index, flash point etc. than that of mineral oil. The present research is aimed at finding out the physicochemical and tribological properties of vegetable oils in its natural form. The industrial/ automotive applications can be targeted based on the set of properties, which depend on the fatty acid composition. The properties were improved with the blend of synergistic additives to improve its performance. Due to the benefits associated with vegetable oils, it is speculated that they will be become predominant in applications where environmental and safety concerns are desired.

Keywords: viscosity, lubricity, Vegetable oils, flash point.

Design and study of phase evolution, mechanical and tribological properties of TiNbMoCrCo0.2 HEA for biomedical applications

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ABSTRACT

Biomedical high entropy alloys (HEAs) have gained considerable attention due to their potential applications in the biomedical field. This study focuses on the synthesis and tribological behaviour of the novel TiNbMoCrCo0.2 HEA. For synthesis, a combination of mechanical alloying (MA) and spark plasma sintering (SPS) has been used. The microstructure, morphology, and phase evolution of both the milled powder and the sintered sample have been studied. The effect of normal load (10, 15, and 20 N) on the coefficient of friction, specific wear rate, and wear volume was tested in the presence of simulated body fluid (SBF). Mechanical properties such as Young's modulus and hardness were also calculated using instrumented micro-indentation tester. The selection of the atomic percentage of individual elements is based on the parametric approach. After 50 hours (h) of milling, the powders form dual body-centered cubic (BCC) phases. The 50 h milled powder shows a crystallite size (CS) of ~ 8 nm, which further indicates the nanocrystalline characteristics of the milled powder. The sintered sample shows the existence of α-phase (HCP) along with the dual BCC phases. The wear result indicates that the TiNbMoCrCo0.2 HEA exhibits a favourable wear resistance, demonstrating minimal material loss and limited wear track formation under all three applied load conditions. The sintered sample reveals a hardness of ~ 6.45 GPa and Young's modulus of ~ 97 GPa respectively. These findings contribute to the development of TiNbMoCrCo0.2 HEA with improved mechanical performance, paving the way for their potential use in biomedical implants and devices.

Keywords: hardness, nanocrystalline, wear resistance, sintered.

The contact between the Ti-6Al-4V and SS316L rough surfaces is elastic in a vacuum under high temperatures

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ABSTRACT

Ti-6Al-4V alloy tribological performance was tested against fastened SS316L bearing balls under varying loading conditions and speeds. The work focuses on the influence of surface roughness on all surfaces under a certain magnification. This roughness determines the mechanics of contact, the beginning of plasticity, wear, friction, and the effect of frictional heating. An important parameter describing the mechanical and physical properties of coarse contacts. Under vacuum conditions, we study the evolution of the actual contact area, which increases pressure at high temperatures.

Keywords: plasticity, wear, friction, bearing balls.

2D/2D Heterostructure of transition metal dichalcogenides (MoS2/WS2): role of interfacial heterogeneity for enhancement of lubrication properties

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ABSTRACT

Layered transition-metal dichalcogenides (TMDs) like MoS2 and WS2 are widely used lubricating materials as solid lubricants under extreme tribological conditions, lubricious thin films, and additives to liquid lubricants. The weak van der Waals interaction between their adjacent molecular lamellae furnishes low resistance to shear under tribo-stress and reduces the friction; whereas high mechanical strength and good adhesion of 2D ultrathin sheets of TMDs form the tribo film to extend the antiwear properties. Considering the many similar properties, the MoS2 and WS2 can prepare heterostructure by their interfacial interaction along the basal planes. Such heterostructure (MoS2/WS2) can overcome the limitations of mechanical mismatches and differences in thermal expansion coefficients, which in general arise by doping heteroatoms and preparing the composites of MoS2 and WS2. Moreover, WS2 as heterogeneous nuclei promotes the oxidation-resistance of MoS2 in MoS2/WS2 heterostructure and improves the stability of lubricating film. The present work address a combinatorial process to prepare the MoS2/WS2 heterostructure comprising the preparation of WS2 nanosheets by solvent-assisted exfoliation (top-down approach) followed by the growth of nanostructured MoS2 on highly dispersed WS2 nanosheets via a wet-chemistry-based bottom-up approach. The chemical grafting of long alkyl chains on the surface of MoS2/WS2 heterostructure makes them dispersible in hydrocarbon lube base oil (SN 500). The synthesis and grafting of long alkyl chains on the surface of MoS2/WS2 heterostructure are confirmed by chemical, structural, and crystalline features based on FTIR, XPS, Raman, HRTEM, and XRD analyses. The MoS2/WS2 heterostructure as an additive to hydrocarbon lube base oil (0.1 mg.mL-1) decreased the coefficient of friction and wear scar diameter of steel tribopair by 51 and 33%, respectively. Moreover, the Raman microscopic measurements of the worn scar revealed the formation of MoS2 and WS2-based lubricious tribo thin film. A detailed lubrication mechanism will be discussed during the presentation highlighting the role of interfacial heterogeneity in the significant improvement of lubrication properties by MoS2/WS2 heterostructure.

Keywords: XPS, Raman, HRTEM, XRD, tribopair, friction.

Enhancement of triboactivity of nanoporous lanthanum-doped zinc borate reinforced by vanadium selenide nanosheets

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ABSTRACT

To investigate the impact of porosity and doping on the lubrication properties of zinc borate, nanoporous zinc borate (ZB) and 10% lanthanum-doped porous zinc borate (LZB) were synthesized. The presence of nanoporous structures in both materials was confirmed through HR-SEM, TEM, and HR-TEM analyses. The tribological performance of blends containing these materials, along with paraffin oil (PO), was evaluated using ASTM D4172 and ASTM D5183 standards on a four-ball tester. To enhance the tribological properties further, vanadium selenide nanosheets (VSe2) were incorporated to reinforce the LZB structure. The superior performance of LZB/VSe2 compared to LZB and VSe2 nanosheets was evident from the obtained tribological data. The combination of porosity and lanthanum doping exhibited commendable tribological activity, while the VSe2 nanosheets reinforced the LZB matrix. Analysis of the worn surface using EDX and XPS techniques revealed the presence of other constituent oxides in the tribofilm, including ZnO, B_2O_3, La_2O_3, and V_2O_5, which contributed to the lubrication process. The tribological results were further supported by AFM and SEM investigations of the wear track.

Keywords: nanosheets, reinforce, lubrication, tribological paraffin oil.

Tribological performance for micro-milling of Ti6Al4V under environment-friendly cooling/lubrication approaches

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ABSTRACT

Micromachining processes, which are downscaled macro machining processes, have the potential to meet the growing demand for highly accurate and precise micro features in various parts. The products' accuracy level is achieved by precisely controlling machining parameters, tool geometry, and cutting environments. Micro-milling is one such micromachining process used for producing micro slots, microchannels, microcavities, etc. This work aims to analyze the tribological performance of the micro-milling of Ti6Al4V under sustainable cooling environments, i.e., minimum quantity lubrication (MQL). The MQL is considered an environment-friendly cooling/lubrication approach as it substantially reduces the consumption of cutting fluids. The micro-milling experiments are performed using TiAlN coated tungsten carbide (WC) end mill having a diameter of 300 µm. The cooling and lubrication approaches employed are MQL with Canola oil, nanoemulsion, and carbon nanotubes. The experiments are performed at two different feed rates, keeping spindle speed and axial depth of cut constants. The tribological performance is examined by considering the thermal conductivity and viscosity of each lubricating fluid, tool wear, and surface morphology of machined slots. The results indicate that canola oil and nanoemulsion exhibit excellent surface finish at a low feed rate due to their lubricating properties, reducing friction and tool wear. It is attributed to their penetration near the cutting edge due to comparatively lower viscosity than other fluids. In contrast, a dry environment lacks lubrication, leading to increased friction, tool wear, and a rougher surface finish. Thus, it can be concluded that MQL is advantageous in improving the tribological performance of cutting tools and workpieces in the micro-milling process.

Keywords: Micro-milling, micromachining, Canola oil, nanoemulsion, carbon nanotubes.

Mechanical and tribological behavior of graphite reinforced aluminum 6061 metal matrix composites

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ABSTRACT

Aluminium metal matrix composites have acquired considerable recognition in automotive, aerospace, agricultural machinery, and a range of other industrial applications because of their crucial characteristics, including high strength, low density, and exceptional wear resistance when compared to other metals. The current study looks at different graphite reinforcement addition ratios to the aluminium 6061 matrix. The base alloy's characteristics are enhanced by the addition of reinforcement elements. The effects of different composite combinations on the characteristics of different aluminium alloys have been studied. In the current study, an aluminium 6061 metal matrix composite is made by stir casting and graphite powder in various weight percentages of 5%, 10%, and 15%. A homogeneous distribution of reinforcing particles (graphite) in the matrix material was visible in the microstructure. The hardness of composites made of an aluminium metal matrix reduces monotonically with increasing graphite particle loading. Tribological testing was carried out in dry conditions using a ball-on-disc tribometer. Moreover, a composite wear mechanism from the worn surface is seen.

Keywords: reinforcement, aluminium 6061, wear resistance, ball-on-disc tribometer

Rolling contact fatigue – contribution of graphene nanolubrication

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ABSTRACT

Surface hardness, compressive residual stress and lubrication are the major factors that individually contribute to the rolling contact fatigue (RCF) performance. The contribution of surface hardness to the RCF L10 life has already been demonstrated [1]. This research intends to determine the potential contribution of graphene nanolubrication (GNL) to the RCF performance under pure rolling conditions. The experimental value and predicted resulting life are compared, and the contribution factor for each percentage of graphene additive in base oil is further determined. A 2-fold increase in RCF life was found when hardness and compressive residual stress effect were combined with base oil lubrication, while a 3.5-fold increase in life was found when GNL with optimum weight percentage was used. The RCF L10 life contribution factor has been found to improve with increasing graphene concentration in the base oil. According to the findings, graphene lubricants with greater additive concentrations (1.5 wt.%) contribute 50% of the overall life enhancement.

Keywords: graphene nanolubrication, additive, surface hardness.

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Machine learning-based analysis of tribological performance for Al-Co-Cr-Fe-Ni high entropy alloy under dry and lubricating conditions

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ABSTRACT

This study delves into the often-overlooked tribological properties of high-entropy alloys (HEAs) in both lubricated and dry conditions. Despite their remarkable hardness, strength, and corrosion resistance, the tribological performance of HEAs remains relatively underexplored, particularly under varying lubrication conditions. The investigation also examines the chemical compositions of lubricants to gain insights into their adsorption behavior onto metallic surfaces, as this directly influences the tribological performance of these materials. To achieve this, a data-driven modelling approach is employed, enabling the construction of a training model and validation of wear behavior conclusions for the alloy. The research findings provide valuable knowledge regarding the tribological behavior of HEAs across different operational settings and lubrication types. Specifically, the Al-Co-Cr-Fe-Ni HEA exhibits exceptional tribological performance under both dry and lubricated conditions. Moreover, the study highlights the significant impact of lubricant chemical composition on surface contacts, influencing the wear properties of the alloy. Consequently, the selection of appropriate lubricants for specific tribological applications is of paramount importance.

Keywords: High Entropy alloy, Lubricant, Wear resistance, Frictional properties, Machine learning

Tribo-mechanical and corrosive investigation of electroplated nanocoating for automobile application

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ABSTRACT

This study performed the Ni-TiO2/hBN nanocoating on the mild steel substrate by electrodeposition from the Watts Nickel bath solution. The three levels of design of the Taguchi method of the L9 orthogonal array have been chosen, and the experimentation was done in the run order of this L9 orthogonal array. The surface morphology of the coating was investigated using scanning electron microscopy coupled with energy dispersive spectroscopy (SEM/EDS). The phase analysis to confirm the presence of material on the substrate was found using X-ray diffraction. The wear property of the coating was measured using pin-on-disc, and the influence of process parameters on the coefficient of friction (lower the better. Low coefficient of friction results in less wear) was investigated by the S/N ratio and mean effect studies via Taguchi method, and they were ranked by order. The voltage and duration of electroplating influence the coefficient of friction of the coating, and to confirm the ranking, the ANOVA test was carried out, which confirmed that the ranking was correct [1]. Experimental results show that the TiO2/hBN particle provides a new orientation of the metal matrix and modifies the surface structure expected to contribute maximally to the increase in hardness and wear resistance [2], [3]. Hexa-Boron Nitride is a solid lubricant and hence has an excellent friction-reducing effect, and the TiO2 nanoparticles possess good carrying load capacity. The synergetic effect of TiO2/hBN is expected to make the coating display better tribological performance.

Keywords: Nano coating, wear, tribological perfomances

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Tribological behavior of chemically modified polytetrafluoroethylene coating for hydrogen valve application

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ABSTRACT

Hydrogen embrittlement (HE) poses a critical concern in hydrogen refueling stations (HRSs), as it can lead to catastrophic failures of stainless steel valves, resulting in reduced efficiency and increased operational costs. This study investigates the effectiveness of a polymer coating in mitigating HE, reducing friction, and minimizing wear in these valves. Chemically modified polytetrafluoroethylene (CM-PTFE), chosen for its low permeability and exceptional lubrication properties, is applied as a solid lubrication polymer. Tribological characterization and durability analysis are conducted using a multi-environmental benchtop pin-on-disc tribometer machine, with tests performed under ambient and hydrogen charging conditions, applying a constant normal load of 10 N. CM-PTFE-coated 316L stainless steel discs and uncoated 316L stainless steel discs are tested against stainless steel pins, and comprehensive coating characterizations are performed. Results reveal significant differences in the coefficient of friction (COF) and specific wear rate between ambient and hydrogen charging environments. Uncoated 316L stainless steel discs charged with hydrogen gas exhibit higher COF and wear values compared to CM-PTFE-coated discs charged with hydrogen gas, demonstrating the effectiveness of the CM-PTFE coating in reducing friction and wear in hydrogen environments. This study provides valuable insights into the tribological behavior and durability of CM-PTFE coatings, highlighting their potential to arrest hydrogen permeability, reduce friction, and mitigate wear, ultimately improving the performance and cost-effectiveness of hydrogen refueling stations.

Keywords: Chemically modified Polytetrafluoroethylene (CM-PTFE), spray coating process, coating characterization, tribology test and hydrogen charging

Tribological characteristics of functionally graded material fabricated by twin wire arc additive manufacturing

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ABSTRACT

The tribological performance of the developed structure is an important consideration, especially for journal bearings, rotors, and machinery used in various applications. The present research targets to provide a baseline to the research community regarding the tribology performance in general and wear performance in particular of functionally graded materials (FGM). In this work, FGM with SS316LSi and ER70S-6 deposited by sandwich strategy using the twin WAAM process is experimentally presented, and tribological performance, mechanical and microstructure characterization of the developed FGM were analyzed. While SS316LSi shows δ-ferrite scattered within an austenitic matrix, ER70S-6 displays a microstructure defined by a bainitic structure. The average ultimate tensile strength is 901 MPa, yield strength is 634 MPa, and percentage of elongation is 48%, respectively. Scanning electron microscopy in a focused ion beam channel was employed to visualize a drop in grain size that was noticed in these materials during the wear tests, notably beneath the wear scar. The obtained results suggest that deposited FGM using twin WAAM process, there is a significant enhancement in the tribological performance, microstructural, and mechanical characterization of journal bearings, rotors, and machinery used in various applications.

Keywords: Wire arc additive manufacturing; Functionally graded material; Wear; Microstructures; Strength; Fractography.

Insights into nanoindentation response of polymer nanocomposites via coarse-grained molecular dynamics simulations

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ABSTRACT

Polymer nanocomposites (PNCs) representing the cutting-edge domain of research have been exploited through indentation with experimentation and simulation. However, comprehending the underlying deformation mechanism via indentation in PNCs is still an open question. The present study emphases on the influence of incorporating different sizes of nanoparticles (NPs) with varied volume fraction to regulate and improve mechanical properties of PNCs through molecular dynamics (MD) simulations. The coarse-grained MD simulations for nanoindentation of crosslinked polymer network without and with NPs are performed. The identification of static and dynamic properties reveals the domains of dispersion and agglomeration with structural conformations in the PNCs. The NPs act as promising reinforcements that significantly strengthen the polymer system through improvement in mechanical properties. Further the analysis of curing percentage and bond breakage play vital role in understanding of stress-relaxation during indentation. From MD simulations, the prominent improvement in deformation resistance is shown with particles exhibiting smallest radius which enhances with increase in volume fraction of NPs. The observations evoke the fact that agglomeration of NPs brings down stiffness and diminishes the resistance against force which generates higher shear strain in polymer chains. The main aim of this study is to provide design rule for incorporation of NPs coordinated towards tuning mechanical performance of PNCs. Additionally, insights into the deformation mechanisms are highlighted providing directions to confer multi-functionalities to advanced PNCs.

Keywords: Polymer, nanocomposites, molecular dynamics, simulation.

A synergetic effect of TiC and CaF2 reinforcements on tribological behaviour of copper-nickel matrix-based composite

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ABSTRACT

The Cu-Ni alloys have exceptional thermal and electrical conductivities and corrosion resistance properties. The powder metallurgy route was used to fabricate the Cu-Ni alloy-based composite reinforced with TiC (10 wt%)/CaF2 (4 and 8 wt%) particles. Tribological tests of Cu-Ni matrix composites reinforced with TiC/CaF2 particles were conducted to evaluate the tribological properties, at normal loads of 10 N, 15 N and 20 N with a sliding distance of 50 m. The sliding distance test of 250 m in intervals of 50 m was also conducted. The worn surfaces were characterized by an Optical microscope, 3D profilometer, field emission scanning electron microscope (FESEM), energy-dispersive spectroscopy (SEM-EDS) and Raman spectroscopy. The Cu-Ni/10wt% TiC/8wt% CaF2 composite occurs the lowest coefficient of friction (0.212). The wear surface of Cu-Ni composites exhibited adhesive wear, oxidative wear, and abrasive wear. The worn surface possesses the formed oxides (Cu2O, NiO, TiO2, Fe2O3 and Fe3O4)) during sliding, which affects the friction behaviour during sliding wear.

Keywords: Cu–Ni/TiC/CaF2 composite, Physical and Mechanical Properties, Tribological properties, Sliding wear

Wear resistant rails for Indian railways

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ABSTRACT

Indian railway has ambitious plan to run 100t wagons on its route. The rails for such route should have better Tensile Strength and Hardness than the existing rails for better life. Residual stress in rails reduces the load bearing capacity of rails which is a major point of concern for both the manufacturers and users. Residual stresses in rails are generated through manufacturing process. The natures of residual stress in rail are tensile and compressive at different location of its cross section. Tensile stresses are normally found at foot centre and head of the rail while compressive stresses are found in web. Compressive residual stresses are not harmful, whereas, tensile stresses are undesirable for foot fatigue life. Every rail manufacturer has tried in its own way to minimise the residual stress. The maximum residual stress at foot centre of the rail has been allowed up to 250 MPa as per latest revision of IRS-T12-2009 specification. Indian Railway has also studied the suitability of 880 grade, 60kg rails for 25t axle load operation. Research Design and Standards Organisation (RDSO), Lucknow, Ministry of Railways has considered higher values of residual stress and minimum value of yield strength which has resulted in unsuitability of this rail. International Heavy Haul Association (IHHA) also issues guidelines for selection of rails on the basis of wear and axle load. INNOTRACK project has also provided guidelines for rail selection on the basis of wear and rolling contact fatigue of rails. This study deals with the efforts taken for reduction in residual stress in rails and selection of yield strength value in stress calculation for 25t axle load operation under the Indian condition. A revised calculation under the methodology of Indian Railways is also proposed. A review of rail selection on the basis of wear and rolling contact fatigue in rail is also discussed.

Keywords: axle load, residual stress, straightening, wear, Rolling Contact Fatigue

Aiding the energy transition with energy-efficient hydraulic fluid

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ABSTRACT

Hydraulic fluid is used in a wide variety of hydraulic machinery ranging from construction /mining equipment to machine tools and other equipment extensively used in various industries. In order to generate hydraulic pressure, a huge amount of fuel power/electricity is required as an input for drive unit. Equipment owners have become increasingly aware of the total cost of ownership, which has led to a rise in demand for machines that require low maintenance, have high reliability, high accuracy, short cycle times and consume lesser energy. Being aware of the role that lubricants could play in a sustainable future, we at BPCL have developed an energy-efficient hydraulic fluid aimed at reducing the overall carbon footprint in line with global energy transition scenario. Depending on the type of application, an efficiency increase of up to two digits is possible with this energy-efficient hydraulic fluid. In comparison to conventional hydraulic fluids, energy-efficient hydraulic fluids can save up to 10% of fuel consumed in construction or mining equipment and up to 2% of energy consumed in stationary manufacturing equipment. The energy-efficient hydraulic fluid is formulated with severely hydrotreated high Viscosity Index (VI) base oils and a specific efficiency-boosting performance polymer with exceptionally high shear stability. This results in an energy-efficient hydraulic oil with high VI, directly contributing to a lower traction coefficient, reduced shear loss, high efficiency, and high thermal and oxidative stability with a higher level of protection versus a standard mono-grade/ multigrade fluid. Consequently, the fluid translates to shorter warm-up times, optimum viscosity at working temperature and low friction properties help reduce frictional losses. With the use of this fluid, hydraulic equipment runs more efficiently and can reduce its energy requirements by anywhere between 2% and 10%. The gain in energy efficiency with the use of this energy-efficient hydraulic oil results in a reduction of GHG emissions by 10%. Moreover, the use of re-refined base oil in the formulation has the potential to support circular economy and have resulted a further reduction in the carbon footprint by 5%, without compromising on the benefits as stated above. In addition, by eliminating the use of traditional Zinc-based additives and adopting an advanced Zinc-free additive technology, the product delivers more than double the service life of those formulated with conventional additives thus enabling effective utilization of energy resources. This hydraulic fluid holds immense potential in the future as a sustainable solution for aiding the energy transition.

Key Words: Hydraulic fluid, Energy-efficiency, Re-refined base oil, Viscosity Index, Energy transition, Circular economy, Sustainability

Catheter Friction and Stribeck-Like Characteristics under Varying Speeds and Loads

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ABSTRACT

Catheters are widely used in surgical procedures and disease management. The surfaces are coated with hydrophilic, lubricious materials that reduce patient discomfort and tissue inflammation. In this study we evaluate the friction of several commercial catheters under varying loads and speeds using a novel setup. In this setup, the catheter was gripped using a special holder and tested against silicone rubber with a Shore hardness of 60. Loads were varied from 0.2 to 1 N corresponding to several kPa contact pressure. Speeds were varied from 0.001 to 0.1 m/sec to investigate possible 'Stribeck-like' behaviour for soft contacts. Furthermore, to understand the bulk stiffness of the catheter on friction, catheters were tested with and without inserts. This novel test configuration opens the possibility of evaluating both surface coatings and bulk stiffness effects of catheters on measured friction. With load variation, certain catheters showed a transition from adhesion to deformation regime of friction. Increasing the bulk stiffness of the catheter resulted in lower friction. Under speed variation, certain catheters offered better lubricity compared to others. In certain regimes of load and speed, the lubricious catheters even demonstrated 'superlubricity' with a COF < 0.01.

Keywords: Catheters, coating, bulk stiffness.

Study on use of re-refined base oil in compressor oil application

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ABSTRACT

A compressor is a mechanical device that converts normal air into denser and high pressurized air for performing various tasks in the different industries. Compressor oil reduces friction and wear in the pressurized section, improves the sealing of pressurized spaces, provides corrosion resistance and cooling. India produces over 1.3 million tonnes of used oil annually. But only less than 15% is re-refined. This re-refined base oils (RRBOs) can be gainfully used to produce new lubricants, helping to reduce waste and emissions associated when compared to traditional way of lubricant production process. Judicious use of re-refined base oil helps to create a circular economy in lubricant industry. Lubricants with conventional base stocks are homogenous in nature with inherent consistent physico-chemical properties like consistent saturation level, controlled sulphur content, Viscosity Index, Pour Point, and Flash Point etc. However the quality of the re-refined base oils (RRBOs) significantly varies due to the variation of source of RRBOs from which it is processed. Present research paper hence highlights the use of re-refined base oil (RRBOs) in the compressor oil application. The compressor oil should have adequate fluid film thickness in screw compressor applications where the outlet temperature is greater than 100°C in mobile applications. The present study depicts the effect of re-refined base stocks on the physico-chemical properties, oxidation tests like RPVOT, Pneurop Oxidation Test and deposit forming characteristics. Due to the presence of previous remains in RRBOs surface active properties like air release value and foaming play a significant role in finished product and can also affect the actual field performance. Hence, various tribological properties like film formation and coefficient of friction were studied to elaborate the effect of re-refined base oil.

Keywords: Re-refined base oil, friction and wear, film formation.

Development of a screening test methodology of FZG failure stage using bench top oscillating tribometer

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ABSTRACT

The evaluation of gear lubricants for practical applications such as wind mills, industrial gearboxes, and automotive gears requires extensive long-duration tests and field trials. These tests assess the friction and wear performance of candidate oils, imposing high costs and time demands on lubricant oil evaluation. The current screening methodology involves conducting expensive and time-consuming FZG gear tests in the laboratory to assess the anti-wear (AW) and extreme pressure (EP) characteristics, which are crucial indicators for scoring and scuffing under heavily loaded conditions. To address these issues, this experimental investigation proposes simulating the FZG test conditions on a bench top oscillating tribometer. This study aimed to overcome the limitations of the existing screening methodology by utilizing the oscillating tribometer to screen gear oils for their frictional characteristics. The screening tests could replicate the line contact configuration encountered in FZG gears, and offered a cost-effective alternative to full-scale FZG gear tests. Additionally, these screening tests could be completed within a short duration of 1 or 2 hours, which saved experimentation time during the oil screening process. The research work focused on simulating the FZG screening test for AW and EP properties of oils using a bench top oscillating tribometer and line contact configurations. Nine candidate oils were selected based on their FZG failure load stage, and a correlation between the FZG test and tests for EP and AW on the tribometer was established through experimental results. Based on the criteria of either 50% stroke reduction or sharp rise in coefficient of friction, screening tests for lube oils utilizing bench top oscillating tribometer could closely approximate the performance of oils under FZG test conditions. The results suggest that the oscillatory sliding line contact EP tests can approximately simulate the FZG load test (A/8.3/90) for determining the failure load stage of gear oils. The methodology presented in this study can accurately predict the failure load stage of gear oils within one load stage of actual FZG tests.

Keywords: Bench top oscillating tribometer, FZG load stage, line contact, gear oils, screening test

Tribological characterization of silver- doped eggshell derived hydroxyapatite reinforcement in PMMA based composite

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ABSTRACT

Polymethylmethacrylate (PMMA) and Hydroxyapatite (HAP) are the two most promising biocompatible materials used in biomedical applications. The current research performs the wettability and tribological characterization of the novel hybrid biocomposite of PMMA reinforced with eggshell-derived, silver-doped hydroxyapatite (HAPAg). Varying weight percentages of HAPAg (0, 2.5, 5.0 and 7.5) in PMMA termed as PHA0, PHA2.5, PHA5 and PHA7.5 are analysed using a ball on disk Tribometer at varying normal load (20, 40 and 60N) with constant sliding speed, frequency, track length and sliding duration. Interestingly, the coefficient of friction (COF) shows a decreasing trend with an increase in normal load, whereas it increases with the increase in reinforcement till 5 wt%. Also, the magnitude of maximum wear rate increases with an increase in normal load at 5 wt%, then shows uneven wear at 7.5 wt% reinforcement of HAPAg in PMMA. The XPS and FTIR analysis confirms the uniform reinforcement of HAP, and the worn surface behavior is analysed using SEM, Stereo zoom microscope and 3D surface profilometer. The low wear characteristic at higher loads ensures the application of developed biocomposite material in dental and orthopedic applications.

Keywords: Hydroxyapatite; Polymethylmethacrylate; biocomposite; Characterization; Tribology

Stability analysis of textured surface journal bearings operating with electro-rheological lubricant

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ABSTRACT

Hydrodynamic journal bearings operating with smart lubricants provides better rotor dynamic control. The viscosity of smart lubricants can be controlled by managing the strength of activating applied electric or magnetic fields. Such lubricants can be transformed to jelly like substance (within milliseconds) on application of activating fields and vice-versa. Smart lubricants such as Electro-rheological (ER) lubricant can be theoretically modelled using the continuous Bingham model. This paper deals with the numerical simulation of hydrodynamic journal bearing operating with ER lubricant. The numerical simulation has been performed using the finite element method (Galerkin approach). The effect of ER lubrication, non-circular bearing geometry (multi-lobe) and micro-texture has been investigated on the bearing performance indices such as minimum film thickness, frictional torque, film stiffness and damping coefficients. The influence of micro-texture shapes and size attributes are analyzed on the bearing performance indices and journal center trajectories. It has been found that the presence of micro-texture and ER lubricant improves the steady-state and dynamic performance of journal bearing. These effects are noticeably profound for journal bearing with non-circular configurations.

Keywords: hydrodynamic journal bearing, smart lubricant, electro rheological lubricant.

Automotive brake pad-disc system: effect of quartz on the tribological performance of copper-free composite friction material

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ABSTRACT

Brake pads play a crucial role in assuring the safety and performance of a vehicle by establishing a frictional connection with the brake disc. Increasing environmental concerns and regulations have prompted the automotive industry to seek alternatives to copper-containing brake pads, which have been identified as a significant source of environmental contamination [1] [2]. As a result, copper-free brake pad formulations have garnered a great deal of attention. This investigation examines the impact of quartz on the tribological performance of copper-free brake pads. The aim of this study is to assess the impact of quartz, an abrasive, on the frictional and wear characteristics of copper-free composite friction material. A thorough experimental strategy was adopted, which included material characterization, friction experiments, and wear analysis. By incorporating varying quantities of quartz particles into a composite matrix devoid of copper, numerous brake pad formulations were produced. The experimental results demonstrate that the addition of quartz to copper-free brake pad formulations significantly improves their tribological performance. The presence of quartz particulates modifies the contact conditions between the brake pad and disc surfaces, thereby altering the frictional behavior. Several factors contribute to the observed improvements in tribological performance, including the reinforcing influence of quartz particles on the brake pad matrix, enhanced thermal conductivity, and altered surface roughness at the frictional interface. The interactions between the quartz particles and other formulation components, such as binders and additives, also contribute to the overall performance. The results contribute to the automotive industry's ongoing efforts to develop environmentally sustainable, high-performance brake pads that meet regulatory requirements.

Keywords: Pin-on-disc Tribometer; Composite Friction Materials; Quartz; Abrasive; SEM; Friction and Wear.

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Effect of polymer solution concentration on tribological behavior of spin coated polymer film

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ABSTRACT

This study investigates the effect of polymer solution concentration on the tribological properties of polystyrene (PS) films. Polystyrene is often employed as a protective coating for applications including microelectromechanical systems (MEMS) and nanotechnology. The tribological performance of these films depends on several factors, including the concentration of polymer in solution during the spin-coating process. Effect of concentration is of particular interest with respect to overlap concentration (C*) of the given polymer. C* typically indicates the transition from a dilute to a semi-dilute regime. In this work, PS films from a toluene solution of varying polymer concentrations were fabricated through a spin coating method. The tribological behavior of the films was characterized using a ball-on-disk tribometer. The surface morphology of worn and unworn specimens was analyzed using Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM). Coefficient of friction and specific wear rate were investigated under varying load and sliding speed conditions. AFM images revealed the absence of aggregates and the presence of predominantly fine-grained domains in thin films made from dilute concentrations (<C*). Films with concentrations near to C* showed increased aggregation and coarser domains. The results revealed significant differences in the tribological behavior of the PS films prepared from solution having polymer concentration below and above overlap concentration. The findings from this study can be useful for preparing polymer films with desired tribological properties.

Keywords: Polystyrene, polymer films, tribological properties.

Tribological study on durability of fuel-efficient engine oil on heavy-duty diesel engines

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ABSTRACT

Research has shown that low viscosity engine oil could help to save fuel, reduce environment pollution & carbon footprint, simply by switching from high viscosity engine oil to low viscosity engine oil. In India, many truckers, fleet owners are skeptical of lower viscosity engine oils, believing they won't offer enough protection. Hence, study was carried out to evaluate the effect of low viscosity (SAE 10W-30) heavy duty diesel engine oil on wear characteristics, deposit formation tendency and durability of the engine parts by dismantling the engine completely before and after the field evaluation with respect to the reference engine oil (SAE 15W-40). The best way to establish the durability of an engine is to dismantle the engine before and after field evaluation and measure the wear of various engine parts such as piston rings, bearings, liner etc, and deposit formation on various locations of all the pistons and inlet & exhaust valves. In this study, four heavy-duty diesel vehicles of similar age were taken and divided in two categories i.e. trial vehicles (SAE 10W-30) and reference vehicles (SAE 15W-40). Out of the above mentioned two categories, one vehicle from each category was dismantled completely before and after trial completions. After dismantling, photographs of engine parts were also taken before and after trial for visual inspections along with physical measurement of various engine parts. Physiochemical analysis of engine oils was done to predict the durability of other trial and reference vehicles, for which engine was not dismantled. During the field evaluation, in-service engine oil samples were taken from the all the four vehicles under study at regular intervals (20000 km) and analyzed them for various performance parameters. This helped in understanding the effect of low viscosity engine oil on the wear pattern of various engine parts such as piston rings, bearings, liner etc. and, the oil's performance parameters such as soot loading capacity, wear mechanisms of rubbing surfaces in an engine.

Keywords: Engine oil, wear, heavy duty diesel vehicle.

A machine learning genetic algorithm (ML-GA) approach to optimize process parameters of trochoidal toolpath during hybrid-electrochemical magnetorheological (H-ECMR) finishing

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ABSTRACT

Hybrid- Electrochemical Magnetorheological (H-ECMR) Finishing process is an advanced surface finishing technique that produces surface roughness (Ra) up to a few nanometers required for the implants. In this study, duplex stainless steel (DSS), a biomaterial constituting ferrite and austenite in equal proportion, is considered 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 (Ra). Kurtosis (Rku), and Skewness (Rsk)) 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.

Keywords: Hybrid- Electrochemical Magnetorheological, duplex stainless steel.

Mechanical characterization of layered composite hydrogel beams for biological applications

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ABSTRACT

Biological tissues and organs are heterogenous in nature, for example, skin has primarily three layers namely epidermis, dermis, and hypodermis depending on the functionality. To develop various biomedical applications, hydrogels are extensively used as tissue-mimicking materials due to its retention of water content capability like biological tissues. Recently, we investigated the fracture characteristics of hydrogel with different water content during needle insertion. We found that under certain conditions the hydrogel exhibited periodic cone cracks when the needle penetrated deep into the hydrogel [1, 2]. In this work, we investigate the mechanical properties of layered hydrogel composite beams under bending of own weight. The elastic modulus of the composite hydrogel is measured experimentally and compared with the numerical simulations using nonlinear bending analysis. Further we study the friction and fracture characteristics of layered hydrogel composites under deep penetration of hypodermic needles of various geometries. Preliminary results show that the role of unbounded water molecules inside the hydrogel network have significant influences on friction between the needle canula and the hydrogel interface. These results help in understanding the tissue damages during needle insertion involved medical interventions including biopsy, and drug delivery.

Keywords: Hydrogels, friction, biological tissues.

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The tribological characterization of thermal barrier coated diesel engine combustion chamber: A review

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ABSTRACT

A thermal barrier coating has a multilayer of low thermal conductivity ceramic material, applied on engines to increases the performances and reduction of emissions. There are using of many materials of ceramics Cr2 O3 and CeO3, m-Zro3, Al2 O3-Tio2, MgZrO3, BaO·ZrO2, SrO·ZrO2, and Al2O3 .SiO2. MgO.etc, we know that thermal conductivity of insulating ceramics material is low, specific heat capacity is the high and high melting point which cause materials able to sustain high thermal environments. The zirconates had maximum time used in thermal barrier coating due to low thermal conductivity, low sintering activity and good cycling resistance. Zirconia (ZrO2) with yttria content 7-8% as a thermal coating material found in different researcher's studies as Yttria Stabilized Zirconia (YSZ). In the application of thermal barrier coating, Yttria stabilized Zirconia (YSZ) is used as standard material in automotive industry research due to favorable physical properties like as low thermal conductivity, good phase stability in high temperatures, high coefficient of thermal expansion, and chemical inertness in the engine combustion chamber as compared to other ceramics materials. The review in this paper presents the micro structural study with powders/coating morphology, the wear behavior, hardness test, coefficient of friction, Field Emission Scanning Electron Microscopy and Energy Dispersive X-ray analysis of ceramic coating cylinder walls.

Keywords: Thermal barrier coating, Zirconia, wear. coefficient of friction.

Friction and wear study of pressure-assisted sintered composite material and laser cladded gci disc at elevated temperature

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ABSTRACT

This study investigates the friction and wear performance of pressure-assisted sintered composite brake pin dry slide against two different Laser Cladded (LC) discs to determine the better frictional pair for automotive brake pad disc application. The present research aims to evaluate the frictional and wear characteristics of the brake pin-disc interface at room temperature (RT) and elevated temperatures (150°C and 300°C). The methodology includes the fabrication of brake pins by moulding and hot-pressing; the friction material was made of 9 wt% lubricants, 2 wt% abrasive particles, 15 wt% fibres, and remaining fillers and resin. The counterpart disc was Laser Cladded and prepared by two alloy powder samples (P1 - Cobalt based alloy and P2 - Nickel based alloy powders) which was Laser Cladded onto lamellar grey cast iron disc, and their frictional characteristics were compared with uncoated GCI disc. The frictional tests were conducted using a pin-on-disc wear test rig at 60 N loads, 1000 rpm, for 50 minutes. The hardness of the cladded surfaces was 540 HV1 for P1 and 470 HV1 for P2. Scanning electron microscopy (SEM) characterization technique was employed to examine the brake pin-disc interface's wear mechanisms and surface morphologies before and after the friction tests. The results indicate that the pressure-assisted sintered composite brake pin exhibits excellent frictional performance with P1 LC GCI disc, demonstrating low wear rates and stable friction coefficients at RT and least with temperature at 300°C. The LC alloy materials have an evident influence on frictional behaviour, with observed differences in wear characteristics and temperature dependence.

Keywords: Pin-on-Disc; Friction and Wear; Laser Cladding; Composite Frictional Material; SEM.

Parameter optimization of the gear lubrication of open girth gears

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ABSTRACT

The use of Open Gear Lubricants (OGL) in various industries, ranging from bituminous products to oil-based greases, plays a crucial role in ensuring efficient machinery operation. However, conducting field trials to evaluate lubricant performance under actual operating conditions can be impractical or costly. Therefore, the development of suitable laboratory tribological evaluation methodologies becomes essential. Literature on laboratory tests for comparing test conditions with actual operating conditions in coal-fired power plants describe quantification of wear as a key parameter for lubricant performance evaluation. This paper examines the existing research on laboratory test methods and performance parameters for open gear lubricants, presents a test method aiming to simulate real-world operating conditions in a controlled laboratory environment and optimize the lubricating parameters in the field condition. The important operating conditions to be simulated in the laboratory test methods are outlined, including load, temperature, gear dimensions, sliding speed, spraying pattern, and test duration. The modification of the FZG rig to accommodate the spray lubrication system is proposed to evaluate lubricating and wear protection properties of OGL. The spray lubrication system, include the components such as a spray nozzle, pump system, solenoid valve, and compressor. The cyclic timers attached with the solenoid air valve and OGL flow line motor control the OGL lubricant spray interval time. Wear loss measurement, thermal imaging technique and 3 phase energy meter readings, are employed to quantify the effectiveness of the OGL lubricant in reducing wear, controlling temperature distribution on gears and energy consumption in the gear system. This study presents insights into the performance of the OGL lubricant, contributing to the optimization of gear functionality and longevity. Optimum nozzle-gear contact surface distance is required for proper distribution of lubricant over gear contact surface which is crucial for optimal performance. A lab-scale test setup also helps to determine the spray interval to simulate starvation, which is dependent on the lubricant's performance. This study summarizes lubrication parameters to be optimized in open gear lubrication and enhancing gear functionality and durability by systematically varying these parameters and analyzing their effects.

Keywords: Open Gear Lubricants, FZG, Spray Lubrication

Friction and wear behaviour of Al-CNTs composites fabricated by solution mixing process

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ABSTRACT

Aluminium-carbon nanotube (Al-CNT) composites have confirmed significant potential for friction and wear applications. This study investigated the wear behaviour of Al-CNT composites with uniformly dispersed CNTs without any structural damage at concentrations of 0.5 wt%. The wear behaviour of these composites has been compared with that of pure aluminium, which was fabricated using the identical solution mixing, compaction, and extrusion procedure. The objective of the study was to assess how the wear behaviour of the composites affects the CNT content and applied load. The researchers utilized scanning electron microscopy (SEM) to analyse the surface characteristics of the worn samples. The findings of the study revealed a notable increase in both hardness and wear resistance as the CNT content present. Compared to pure aluminium, the composite with 0.5 wt% CNTs exhibited a 38.8% reduction in wear rate and the average value of the coefficient of friction (cof) also decreased. When 0.5 wt% CNTs samples were subjected to different loading conditions, the wear rate and coefficient of friction rose. TEM analysis of these worn surfaces revealed CNTs' significant involvement in enhancing wear characteristics. The CNTs developed a carbon layer which covered the surface, functioning like a solid lubricant and significantly enhancing the wear characteristics of the composites.

Keywords: Aluminium-carbon nanotube, wear, solid lubricant.

Tribological and mechanical properties of Fe-TiB2-CrB2 detonation coatings after pulse-plasma treatment

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ABSTRACT

Detonation sprayed coating materials are characterized by increased hardness and wear resistance compared to HVOF and atmospheric plasma spraying [1]. Detonation spraying does not cause a large change in the chemical composition of the material and it is possible to adjust the chemical composition of the coating by changing the process conditions. Further improvement of the quality characteristics of boride coatings is possible by external high-energy exposure. The most effective technology is a complex pulse-plasma treatment (PPT) including surface modification by: magnetic field, electric current (flow of charged elementary particles), high gradient heat jet (plasma) containing metallic and non-metallic alloying elements [2]. The coatings were applied by detonation spraying (DS) on a multi-chamber detonation machine. Pulsed plasma technology was used to modify the resulting detonation coating on the surface of the product. After PPT, the surface roughness decreased compared to before PPT. The reduction in the roughness index is due to pulsed plasma melting. The tribological parameters in the present work were evaluated according to the "ball-and-disk" scheme. The test results showed that after PPT the coating has increased wear resistance according to XRD (X-ray diffraction analysis) this may be due to an increase in boride particles (TiB2 and CrB2) According to the study of tribological characteristics of the coating surface it was found that the pulse plasma treatment had a significant effect on the coefficient of friction of the coating surface and wear resistance.

Keywords: Detonation sprayed coating, pulse plasma treatment, surface roughness.

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Analysis of perception towards the impact of tribology on environment-friendly and sustainable future transportation using electric vehicles

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ABSTRACT

Recently, there has been an increased interest in more energy-efficient and environmentally friendly industrial processes and transportation systems across the globe. One-fifth of all energy used worldwide is reportedly consumed by friction. Vehicles during transportation use one-third of their total energy. While this is happening, all-electric vehicles propelled by cutting-edge batteries are the result of decades of devoted research and are paving the way for a much more environmentally friendly and sustainable transportation future. To reduce the frictional losses in electric vehicles, the tribological study of rubbing components is very essential. The research paper aims at factors impacting energy losses due to tribological wear and tribological elements such as lubricants, and component materials to be optimized in the future for electric vehicles based on severity of failure of the components, fuel efficiency, cost efficiency and impact on environment. The survey is carried out based on primary and secondary data sources. Primary data was collected from 100 academic and industry experts in field of tribology and automobile field on pan India basis. Factor analysis, t-Test and ANOVA were used to determine perception towards the impact of tribology on environmentally friendly and sustainable future transportation. The present study concludes that lubricant selection and the material of the component are the parameters to be optimized to reduce tribological losses based on the severity of failure of the components in the future for electric motors. The study also compares the energy efficiency, cost efficiency, and environmental effects of electrical vehicles with IC engine vehicles. Further, it suggests that switching from fossil to renewable energy sources which makes it environmentally friendly.

Keywords: electrical vehicles, tribological behaviour, wear, ANOVA.

Tribological behaviour of Ti-xNb alloys developed by powder metallurgy in dry and simulated body fluid conditions for dental implant application

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ABSTRACT

Titanium-niobium (Ti-Nb) alloys have gained significant attention in recent years as potential candidates for dental implant applications due to their superior biocompatibility and mechanical properties. However, the tribological behavior of these alloys under simulated body fluid (SBF) conditions remains relatively unexplored. This study aims to investigate the tribological performance of Ti-xNb alloys, where x represents different niobium concentrations (x = 0, 5, 10, 15, 20, and 25 wt%), under simulated body fluid and dry conditions. Ti-xNb alloys with varying niobium contents were prepared using powder metallurgy processing route. The microstructure and phase composition of the alloys were characterized using scanning electron microscopy (SEM) and X-ray diffraction (XRD), respectively. The tribological behavior of the alloys was evaluated using a ball-on-disk tribometer, where a polished Ti-xNb alloy disc was slide against a zirconia ball under dry and SBF condition. Further the worn surfaces were characterize using SEM and Energy dispersive spectroscopy (EDS) to know the mechanism of wear and tribo-activity took place on the worn surface. The results revealed that the addition of niobium influenced the microstructure and phase composition of the Ti-xNb alloys. With increasing niobium content, a transformation from a predominantly α-phase to a dual-phase α+β structure was observed. The tribological tests demonstrated that the friction coefficient and wear rate of the Ti-xNb alloys were influenced by the niobium concentration.

Keywords: Ti-Nb alloys, Coefficient of friction, wear, Powder metallurgy, Simulated body fluid (SBF), Dental implant

Tribological and corrosive degradation of differently surface engineered 17-4 PH steel

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ABSTRACT

In the present work, alumina (Al2O3)-0.8 wt.% ceria (CeO2)-0.2 wt.% reduced graphene oxide (rGO) coatings were deposited on 17-4 PH steel using high velocity oxy fuel (HVOF) thermal spray process. The results were then compared with the nitrided 17-4 PH (N17-4 PH) steel. Mechanical properties of the bare substrate, coating and nitrided substrate were investigated in terms of micro (Vickers) hardness, scratch hardness, nano indentation and high temperature (300 ℃) nano indentation studies. Tribological behaviour of all the specimens mentioned earlier were studied in a universal mechanical tester in ball on flat reciprocating wear test mode for different loads. Electro-chemical response in terms of corrosion properties in 3.5 wt.% aqueous salt solution were recorded and analysed. The results showed that the ceramic coating outperforms the other two specimens in terms of mechanical, tribological and electro-chemical properties. For example, coating was nearly ten and six times more wear resistant compared to 17-4 PH steel and N17-4 PH steel, respectively at 50 N load. The better performance of the coating was attributed to the coating hardness, dense microstructure and introduction of rGO in the coatings which participate in the tribological process. Further detailed analysis of the properties of all the specimens reveals that the nitriding process can be replaced with the proposed ceramic coating through HVOF technique for tribological, tribo-corrosive and other applications for 17-4 PH steel.

Keywords: Graphene oxide coatings, tribological behaviour, 17-4 PH steel.

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Study of the influence of fillers on the tribotechnical properties and surface roughness of machine-building polymeric composite materials

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ABSTRACT

One of the urgent problems of modern mechanical engineering is the creation of composite polymer materials and coatings with desired tribological properties that ensure the stable operation of friction units and meet modern environmental requirements [1–4]. The friction force and the friction coefficient, as well as the surface roughness of filled local polypropylene composite materials have been studied for machine-building purposes. For the experiment, a ball was taken from steel grade "IIIX" (ball bearing steel with chromium), hardness 38-40 and a steel ball diameter of 3-5 mm, a polypropylene sample with a diameter of 40-50 mm and a thickness of 4 mm. Contact pressure from 1 to 20 N, rotation speed from 0.5 to 1 m/s. A steel ball with a diameter of 3.0 mm was placed perpendicularly on a tribometer disk with a diameter of 50 mm. The pressure, provided by a special strain gauge loading mechanism of the tribometer, was set and the disk was set in motion. The friction machine measured the friction force and the coefficient of friction, and this was recorded on a computer using special software. The surface roughness was measured using a Micron-beta interference profilometer. During the experiment, it is possible to stop testing to record micrographs of the wear spot of the ball and the width of the friction track using a mini microscope, which makes it possible to build the dependence of wear on the test time, i.e., to record the wear rate of both the surface and the counter body. The software of the microscope allows you to register, recognize, determine the geometric dimensions, and carry out statistical calculations of digital images. Studies have shown that the coefficient of friction and wear is strongly influenced not only by the type of filler, but also by its amount in the composition. To do this, their optimal number is determined empirically. It is difficult to achieve the required properties by adding fillers to the polymer composition separately, so a mixture of several fillers is used. For example, to reduce the coefficient of friction and wear of the polymer, a certain amount of such additives as graphite and talc, phosphor gypsum, graphite and soot, asbestos and talc are used [5–8]. It is shown that when kaolin (K) and iron powder (I) are added to the composition of polypropylene, its viscosity decreases (Fig. 4). When the amount of kaolin (K) and iron powder (IP) was 5%, the impact strength of the material was 45-50 kJ/m2, and the elongation was about 7-8%. As the number of fillers increased, the impact strength of the material decreased and became equal to 25–30 kJ/m2, and the relative elongation changed very little. The change in the coefficient of friction over time is represented by five different stages. I - the coefficient of friction in the first stage increases over the number of cycles until a maximum value of 0.65 is reached for the second cycle. The coefficient of friction then decreases to about the tenth stroke for the second stage. After that, it remains constant at an average of 0.15 during the third stage, which lasts until the first 30 cycles. A sharp increase in the friction coefficient characterizes the I-stage, and this coefficient

averages 0.4-0.6. The last stage III is the transition zone, followed by the stable zone. The maximum value of the friction coefficient of the first graph reaches f = 0.50 - 0.60 at a speed of 0.5 m / s for 10 hours of friction duration, for 1 m / s this value is f = 0.50 - 0.60. i.e., decreases within 20-30 hours of friction and stabilizes after 3 hours in the remaining period. It is known that wear is directly proportional to the normal load, that is, the greater the load, the greater the wear. The reason for this is that the increased load brings the surfaces together, resulting in an increase in both their mechanical (penetration) and molecular (mutual attraction) components. The maximum value of the wear rate is 2-2.5 mg/thousand. 3 m/ At speed c, N = 5 N, for 1 m/s this value is 0.4-0.5 mg/thousand, the minimum value is 1.4, respectively; 0.35 and 0.25 mg/min reach N=1 N. Relatively little change is observed at V=0.5 m/s. friction increases. The effect of surface roughness on the wear process is determined by its initial values. Depreciation is high mainly in the initial period, i.e., during the running-in period, after smoothing the bumps (running in), the wear slows down somewhat [5,8]. Therefore, the initial roughness should be close to or equal to the run-in roughness. As the surface roughness increases, the coefficient of friction decreases. Accordingly, the coefficient of friction is 0.55, 0.65 and 0.85 at N=5 N, Ra=0.1; slowly decreasing to a minimum value of 0.35, 0.38 and 0.4 at Ra = 0.6-0.7. With an increase in surface roughness, the friction coefficient decreases, and at N=10 N the friction coefficient is respectively equal to 0.22, 0.36 and 0.63 at Ra=0.1, slowly decreasing to a minimum value of 0.2, 0.34 and 0 .4 at Ra = 0.6-0.7. As a result, it was found that for each friction pair, the optimal values of surface roughness are determined empirically. The results of the studies are in good agreement with the data obtained in the foreseen works. When a polypropylene sample is rubbed against a steel ball, due to the normal load and sliding speed, the ball leaves a mark on the surface of the sample, the size and magnitude of which depends on the friction mode and the type of materials.

Key words: filler, viscosity, elongation, coefficient of friction, wear, surface roughness, material.

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Effect of Ag concentration on solubility and interfacial adhesion in MoS_2-CaF_2-Ag composite coatings

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ABSTRACT

Composite MoS2-based solid lubricating coatings utilize silver diffusion to the sliding interface to enhance crack healing and promote ductile shearing. This approach effectively mitigates the negative impacts of oxidation, humidity, and brittle fracture, ensuring improved performance and durability. However, the interfacial adhesion of MoS_2 coatings on iron and its alloys is affected due to the non-solubility of Ag in Fe. The goal of this research study is to improve the adhesion of MoS_2 and Ag-based composite coatings by mitigating abrupt interface effects, interfacial voids, and interfacial phase segregation. To accomplish this, the research study involves depositing single-layer solid lubricating thin film coatings of MoS_2-CaF_2-Ag with varying percentages onto bearing steel AMS 5898 substrates. The deposition process employs DC and RF magnetron sputtering techniques using MoS_2, CaF_2, and Ag targets in an Argon plasma. By adjusting the power density of the Ag target, the percentage of Ag and consequently CaF_2 within the coating matrix is systematically altered. Subsequently, the coatings are examined and evaluated using progressive load scratch tests (PLST). A Berkovich indenter is utilized during PLST. The critical loads corresponding to different degrees of failure are determined by monitoring variations in lateral force and coefficient of friction (COF), as well as observing signs of cracks, chipping, and delamination. To analyse the extent of cracking and delamination during PLST, field emission scanning electron microscopy (FESEM), in conjunction with energy-dispersive X-ray spectroscopy (EDX), are utilized. These techniques provide insights into the structural integrity and extent of damage caused by cracking and delamination during the scratch tests. It is envisaged that this study will be instrumental in determining role of Ag and CaF_2 in the interfacial adhesion of composite MoS_2 coatings, thus improve the coating performance and durability.

Keywords: MoS_2-CaF_2-Ag, solid lubricating coatings, coefficient of friction.

Impact of tempering conditions on mechanical properties and wear behaviour of AISI H13 steel

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ABSTRACT

Martensite is formed by heating the steel to its austenitic phase and quenching it rapidly. For industrial applications, martensite is too brittle to be used as die material. Thus, tempering is done to obtain tempered martensite that has improved toughness. In this paper, H13 steel samples are austenitized at the different austenitizing temperature of 1000°C, 1020°C, 1040°C, 1060°C. They are then tempered at three different tempering temperatures of 540°C, 560°C, and 580°C. And tempering is done for three different time periods of one hour, two hours, and three hours. To determine the sliding wear characteristics of H13 die steel, experiments are conducted on pin-on-disc tribometer. Counter material used is D2 steel disc having 61 HRC. Uniaxial tensile tests to fracture, and indentation hardness test is done, along with the examination of fracture surface post tensile test. Reduction in wear resistance is found for reduced tempering temperature. But it is also seen that secondary hardening occurs for H13 tool steel around 560°C tempering temperature.

Keywords: H13 steel, wear, mechanical properties.

Enhancing tribological and mechanical properties of glass fiber-reinforced epoxy composites with CNTs and GNPs using taguchi DOE

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ABSTRACT

In this study, efforts were undertaken to enhance the tribological and mechanical properties of glass fiber-reinforced epoxy composites (GFRE), which were fabricated by the hand layup technique. This was achieved by incorporating carbon nanotubes (CNTs) (1 wt.%), graphene nanoparticles (GNPs) (1 wt.%), and a combination of both materials in a hybrid form (0.5 wt.% GNPs and 0.5 wt.% CNTs). The tribological property was evaluated under the dry sliding conditions on the reciprocating wear machine. For wear analysis, to investigate the relationship between various factors (Types of filler, normal load, sliding frequency, and temperature) and the resulting response measurements (weight loss), Taguchi's design of experiments (DOE) and analysis of variance (ANOVA) approach was employed. The study selected control variables for the wear test, including normal loads (10, 20, 30, and 40N), sliding frequency (6, 8, 10, and 12 Hz), and temperature (30, 40, 50, and 60 °C) to be examined in the study. The tensile and flexural tests were also performed to evaluate the mechanical property. It was observed that the synergetic effect of both CNTs and GNPs increases the interfacial adhesion and mechanical interlocking between the fiber and matrix more as compared to other composites, due to which it shows lower wear and higher tensile and flexural strength than other composites. Scanning electron microscopy (SEM) was used to analyze the worn surfaces.

Keywords: carbon nanotubes, ANOVA, SEM, tribological and mechanical properties.

Effect of Magnetorheological (MR) lubricant on the performance of spiral grooved hybrid circular thrust pad bearing system

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ABSTRACT

In the present technological scenario, there is a tremendous requirement to optimize the engineering system for better performance and longevity. In this study, a theoretical model to analyze the influence of magneto-rheological lubricant behavior on the performance of spiral grooved circular recessed hybrid thrust pad bearing systems has been developed. The finite element method is used to solve the modified Reynolds equation for circular thrust pad bearing compensated with an orifice restrictor. The continuous Bingham fluid model has been used to simulate the performance behavior of magneto-rheological lubricant operated hybrid circular thrust pad bearing. The numerically simulated result shows that the MR lubricant significantly enhanced the load-carrying capacity and fluid film-damping coefficient of the hybrid circular thrust pad bearing.

Keywords: Spiral groove, MR lubricant, Orifice restrictor, MATLAB

Study on a novel cationic surfactant as multifunctional grease additive

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ABSTRACT

In this study, a novel cationic surfactant was synthesized and evaluated as a multifunctional additive in organoclay grease. Firstly, the synthesis of the intermediate was done by the reaction of p-Dimethylaminobenzaldehyde with 1-Bromotetradecane. After this, the intermediate reacts with the N-Phenyl-p-Phenylenediamine through the imine coupling, forming final additive (DMBz-BrTD-PPA). The successful synthesis was confirmed through spectroscopic techniques, FTIR and NMR. To assess the synthesized additive's thermal stability, thermogravimetric analysis was performed. The results indicated that the additive exhibited good corrosion stability at a concentration of 0.5% (w/w) and displayed remarkable antioxidant properties at all tested concentrations. Additionally, at an optimal concentration of 1% (w/w), DMBz-BrTD-PPA demonstrated an excellent 36.34 % improvement in anti-wear property and an impressive 49.24 % reduction in friction coefficient. The worn surface analysis further revealed the formation of a stable film composed of nitrogen and bromide, which played a crucial role in delivering outstanding tribological performance for DMBz-BrTD-PPA.

Keywords: cationic surfactant, anti-wear property, tribological performance.

Review of techniques adopted to evaluate the tire wear in monorails

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ABSTRACT

Monorail is an urban transit system, which, unlike conventional railways, uses pneumatic tires for traction similar to automobile tires and runs on a single track. Monorails are categorized into two types, straddle type and suspended type. The straddle-type monorail consists of three sets of wheels: Load Wheels, Guide Wheels and Stabilizing Wheels that are made of rubber. The car body of the monorail consists of two bogie arrangements. The bogie frame is a supporting structure which houses the suspension system. The load wheels are in contact with track beam carrying the vertical load of the monorail, transmitting tractive and braking force to track beam. The guide wheels and stabilizing wheels are in contact with the vertical surface of the track beam. The guide wheel performs the function of steering the vehicle through the track beam whereas, the stabilizing wheels help to stabilize the vehicle from excessive rolling and provide anti-overturning stability of the vehicle while passing over the curve section. Wear of these pneumatic tires had always been an area of concern in operation of Monorail systems. Early wear of these tires results in the frequent tire changing which is a major and time-consuming maintenance activity. The reason for tire changing reported in literature was uneven and accelerated wear of tire. This frequent tire changing affects the availability of monorail for revenue services, overall reliability of its operations and increasing the operation and maintenance cost. Many researchers have worked on understanding the wear of the tire in Monorail and causes for the uneven wear. Various tire and wear models have also been utilized by them to understand the wear of these tires. However, the critical technological review of these models is not available in the literature. This study summarizes and provides a critical review of various techniques adopted for evaluating the tire wear in Monorail also presents the gaps in the literature. This will help researchers to study the behavior and utilize the most suitable technique for evaluation of Monorail tire wear and further improve the tire performance.

Key word: Monorail, Tire Wear, Tyre Model, Wear Model, Straddle type

Enhancing friction and wear performance of bio-lubricant with graphene nanoparticles

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ABSTRACT

This study examines the tribological behaviour of graphene nanoparticles added to Callophyllum Inophyllum base oil. The use of graphene, which is renowned for its remarkable mechanical and lubricating capabilities, is anticipated to enhance the bio-lubricants anti-wear and friction reducing properties. The additive was dispersed in the base oil with the help of ultrasonicator between 0.2% to 0.5% wt. Four ball tribotester was used for friction and wear tests according to ASTM-D4172.The outcomes demonstrate that the graphene nano-flakes decreased the friction coefficient and enhanced antiwear properties at concentrations tested, particularly at 0.3%wt. In order to understand the potential wear mechanism. FESEM and EDS analysis of the worn-out samples was performed. It was discovered that the main factor contributing to the improved tribological properties of the lubricating oil appears to be the accumulation of nanoparticles in valleys and the formation of a thin film at the interface. An Anton paar MCR 102 rheometer was used to perform rheological tests, enhancing the rheological properties of lubricating oils through the introduction of nano additives, such as graphene, has shown remarkable possibilities. It is possible to customize the viscosity and flow characteristics of the lubricating oil by the successful modification using graphene, which are essential elements for effective lubrication in a variety of applications.

Keywords: Graphene, ASTM D4172, Rheology, friction, wear.

Friction, wear and corrosion analysis of Al-Mg-CeO2 surface composites

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ABSTRACT

The present study examines the friction, wear, and corrosion properties of Al-Mg-CeO2 surface composites fabricated through the solid-state friction stir processing (FSP) route. Multi-pass FSP was utilized to distribute the reinforcement particles more uniformly in the aluminium matrix. A pin-on-disc configuration was used to conduct wear testing with various applied loads and sliding speeds. Results reflected that the inclusion of CeO2 particles reduces wear rates and friction coefficients. The addition of CeO2 reinforcement increases the load-bearing capacity and effectively lubricates the composites, increasing their resistance to wear. Electrochemical tests, such as potentiodynamic polarisation and electrochemical impedance spectroscopy, are used to assess corrosion resistance. The results showed that compared to the non-reinforced Al-Mg matrix, the Al-Mg-CeO2 surface composites display superior corrosion resistance. The findings from the study contribute to the understanding of microstructural evolution, surface morphology and elemental composition of the composites using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). The results provide valuable insights for the developmental and homogeneous distribution of CeO2 particles within the Al-Mg matrix, contributing to the enhanced tribological and corrosion properties.

Keywords: Friction; Wear; Corrosion; Al-Mg alloys; composites; Microstructural evolution

Optimizing nano-additives for lubricating oil using taguchi-grey relational analysis

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ABSTRACT

In the field of tribology, lubrication plays an important role in minimizing friction and wear. Friction and wear in mating parts eventually lead to failure of parts. Lubricants derived from mineral oil or synthetic hydrocarbon blends prevents the failure of parts by minimizing friction and wear. However, lubricants fail to satisfy the requirements of the Original Equipment Manufacturer (OEM). A common solution to this problem is to improve the attributes of lubricants, such as improving anti-oxidation capability, thermal properties, and tribological characteristic; a few additives can be added to the base oil. Since from discovery carbon nanotubes (CNT) have attracted much attention due to their properties including in the field of tribology also as lubricant additive for improving tribological properties. In this study, an attempt has been made to obtain the optimized proportion of CNT addition in oil with respect to load for improving wear preventive (WP) characteristic or minimizing wear scar diameter and coefficient of friction (CoF). The Taguchi-grey relational analysis is employed to obtain an optimized combination of load and & wt. % of CNTs additives for improving wear preventive characteristics of base oil. The wear preventive and frictional characteristic of base oil seems to be improved with the addition of CNTs because of the mending and ball-bearing effect created by nano additives forming protective tribofilm over contacting friction pair.

Keywords: Lubricant additives; CNT; Load; Taguchi-Grey Relational Analysis.

Diagnosis of honeycombing effect at concrete foundation as a root cause of induced draft fan high and unsteady casing vibration

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ABSTRACT

In a continuous-running process industry, the Reliability and Availability of critical Rotating Machinery depend on maintenance practices adopted by the organization. Amongst all condition monitoring technique vibration monitoring and analysis is dominantly used in industry. A Primary Reformer induced draft fan (ID fan) of the Ammonia Process is in line since the year 1978. ID fan is a steam turbine driven as well as electric motor driven. This paper discusses a case study of high and unsteady vibration in ID fan since 2006. ID Fan casing vibrations used to increase with the increase in speed of the ID fan and vice versa, limiting the speed of the ID fan at the lower side. The explored reasons for ID fan vibrations were documented in Cause and Effect Analysis Diagram and eliminated one by one reason to arrive at a root cause of vibrations. Even after the repair of the concrete base, bearing base plate, and bearing bracket foundation bolt tightening and re-grouting, the reduction in fan vibration didn't last for long and increased without doing any activity or jobs. ID fan bearings condition deterioration and impeller unbalance-related issues were also ruled out. There was evidence of oil spillage on the foundation, which subsequently seeped through the edges of base plates into the concrete foundation. Oil seepage tends to get mixed up with the concrete foundation which gets penetrated to find a path for flow of oil through the concrete. Therefore, it was suspected that there is a loss of foundation stiffness because of the honeycombing effect due to oil seepage and penetration into the foundation, which resulted in high and unsteady vibration. A honeycomb is a rough and stony concrete appearance with air spaces between aggregates. Therefore, it was decided to inspect the ID fan base plate and its foundation along with the foundation rectification job during April-May2011 planned shutdown for implementing energy saving scheme. The observations were as follows. The oil accumulation was observed at the bottom surface of both the base plates A honeycombing effect due to seepage, and oil penetration into the foundation was observed. Foundation concrete chipping, base plate leveling, and re-grouting jobs were carried out. Thus ID fan high and unsteady vibration problems have been diagnosed as a honeycombing effect at concrete foundations due to oil seepage and penetration into the foundation. To avoid/eliminate the honeycombing effect in the future, foundation re-concreting was carried out using Conbextra GP2 cement. GP2 cement has properties of free flow, high strength, and non-shrink. The free flow property ensures a high level of contact load-bearing area. During 2011 after foundation rectification job ID fan was tested for different rpm. ID Fan vibrations were reduced considerably from 13.3 (max) to 0.6 mm/sec and since then till today vibrations are normal.

Keywords: Bearing oil, seepage, honeycombing effect.

Friction units materials in open space

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ABSTRACT

To date, a large number of materials have been developed for friction units of space equipment in open space. The main ones are: (i) Radiation resistant lubricants. (ii) Solid lubricant coatings (iii) Self-lubricating materials. (iv) Materials based on carbon. (v) Ceramic materials. (vi) Diamond-like coatings. (vi) Micro-arc oxidation coatings. Solid lubricant coatings have the following main advantages: low volatility, low coefficient of friction, performance in a wide range of temperatures in air, vacuum and gaseous media, radiation resistance of 106–1010 rad, and are able to large contact loads. Under vacuum conditions, the coefficient of friction of the diamond-like coating paired with the solid-lubricant coating "Eonit 3" in the range of 0.02 - 0.05, no change in the weight of the sample with a diamond-like coating was registered. Micro-arc oxidation coatings during friction on solid lubricant coatings of the counter body have friction coefficients of 0.002 - 0.004. Tests of samples of diamond-like coatings showed their high wear resistance at various temperatures, under vacuum conditions up to 10-4 Pa. A significant role in the wear resistance of diamond-like coatings is played by the finish of the initial surface of the part to be coated.

Keywords: Solid lubricant coatings, high wear resistance, Micro-arc oxidation coating, ceramic materials.

Design and development of metal mesh foil bearing for oil free turbomachinery

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ABSTRACT

The oil free turbomachinery is becoming popular due to its environmental friendly design. The bearings used in this turbomachiney do not require lubricant. It need air or gas. It works in extreme temperature (low or high). There is no issue of lubricant leakage, have less maintenance. It is used in air cycle machines, automotive turbochargers, fuel cell air compressor, micro gas turbine etc. The bump type foil bearing is widely used in oil free turbomachinery [1-2]. The compliant thin foils namely corrugated bump foil and plane top foil are used between shaft and the sleeve. The fabrication of corrugated foil is complex task and costly. The damping property of the bearing is less. The alternative for the bump type foil bearing is metal mesh foil bearing (MMFB). The knitted wire mesh is used between shaft and the sleeve. The fabrication of metal mesh is simple and low cost process. The damping factor of MMFB is higher than the bump type foil bearing [3]. In this paper, design, fabrication and testing of MMFB is presented. The finite element model for the MMFB will be developed. The various patterns of wire mesh will be explored and the stiffness of the structure will be optimized. A fabrication of bearing will be carried out and the stiffness of the bearing will be measured using inhouse test rig. The comparison of stiffness with numerical and experimental test results are presented.

Keywords: metal mesh foil bearing, Finite element model, oil free turbo machinery.

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The role of oxygen in achieving an ultra-low friction of (PEI/GO)15 multilayers in air and dry atmospheres

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ABSTRACT

Superlubricity (COF < 0.02) was achieved for multilayer polyethyleneimine / graphene oxide, (PEI/GO)15 thin films on steel in dry gas environments (H2, N2), contrary to humid air, which showed high friction and low wear life [1,2]. However, the individual role of oxygen and water vapor (H2O) on frictional behavior of (PEI/GO)15 requires further investigation. Thus, the tribological behavior of (PEI/GO)15 films against PMMA counterface ball, is investigated in different gas environments with different oxygen concentrations. The environments are ambient air, dry air (~ 1 ppm of H2O), pure air (90% N2 + 10 % O2), dry N2 and argon. The COF of steel against PMMA in air is ~0.23. COF of (PEI/GO)15 on steel against PMMA, in air, dry air (~ 1 ppm of H2O), pure air (90% N2 + 10 % O2), N2 and argon, are, ~ 0.11, 0.06, 0.04, 0.02 and 0.02, respectively. Strong correlation between the oxygen concentration and the COF is observed. It signifies the role of oxygen in increasing the friction and wear. Therefore, detailed characterization of the wear debris from transfer films on ball surface and wear tracks in the disc were performed to understand the origin of these tribological properties.

Keywords: Graphene oxide, Oxygen, Superlubricity, Nanoscrolls, Environments

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Investigations on surface properties of friction stir welded dissimilar AA2024-T3 and 304 stainless steel joints

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ABSTRACT

The present study investigated the effect of process parameters on the surface properties of the AA2024-T3 and SS304 dissimilar joints welded through friction stir welding (FSW). The SS304 plate was kept on the advancing side (AS) and AA2024-T3 was kept on the retreating side (RS). The optimum condition was achieved at a tool rotation of 560 rpm, traverse speed of 25 mm/min, and tool pin offset of 1 mm towards the aluminum side. At the optimum tool pin offset of 1 mm, the heat input achieved was sufficient to initiate proper plastic deformation and adequate material flow which in turn resulted in ultrafine grain refinement in the stir zone (SZ) and interfacial area. The potentiodynamic test revealed that FSWed samples exhibit better corrosion resistance against the BM-AA2024-T3. Vicker's hardness revealed an effective increase in hardness values in the SZ of FSWed samples due to grain refinement. All the welded specimens including base materials (BMs) were investigated for wear and scratch tests at different loads. Results reveal FSW process parameters have an effective role in the wear and scratch hardness of welded specimens.

Keywords: friction stir welding, wear, scratch hardness, AA2024-T3, SS304.

Wear prevention and extreme pressure capabilities of non-edible vegetable-based biolubricants

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ABSTRACT

The availability, biodegradability, and toxicity issues of conventional lubricants moved the market towards the use of vegetable oil-based lubricants. The international biolubricants market is growing at a CAGR of 5.43% between 2022 and 2029 and reaching USD 3.22 billion by 2029, up from USD 2.11 billion in 2021. The factors boosting biolubricant demand include rising environmental consciousness, the adoption of stringent regulations, and the increasing acceptability of biolubricants in the industry. The biolubricants are synthesized from non-edible vegetable feedstock karanja and jatropha oil through base catalyst transesterification. The synthesized biolubricant was characterized by FTIR and GC analysis. The physicochemical and thermal properties of the biolubricants were tested. As environmental concerns and sustainability drive the search for alternative lubricants, this study investigates the wear prevention and extreme pressure capabilities of synthesized karanja and jatropha biolubricants using a four-ball tribometer. Through experimental analysis of biolubricants and comparison with polyalphaolefin synthetic oil, the paper evaluates the potential of non-edible vegetable-based biolubricant to effectively reduce friction and wear characteristics and withstand high-pressure conditions. The rheological characteristics of karanja and jatropha biolubricants were evaluated and compared with polyalphaolefin oil. The findings contribute to a deeper understanding of the tribological properties of non-edible vegetable-based biolubricants, offering insights into their applicability in various industrial contexts while promoting environmentally friendly lubrication solutions. It is concluded that non-edible vegetable-based biolubricants have the potential to replace conventional synthetic-based lubricants.

Keywords: Biodegradability, vegetable oil-based lubricants, biolubricants, rheological property.

Surface alloyed materials with improved hardness, adhesion, corrosion, and wear resistance for water industry applications

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ABSTRACT

A surface alloying technique is reported to increase the concentration of nickel and chromium on the surface alloyed layer of mild steel (ASTM A216 WCB grade steel) sand casting by coating the mold surface with a slurry containing nickel and chromium. The incorporation of Ni and Cr into the surface alloyed layer can lead to the composition gradients, resulting in different parts of the steel specimen undergoing phase transformation at different temperatures and times during solidification and heat treatment. The tooling, mold design, and casting conditions similar to plain WCB castings were successfully used to produce sound surface alloyed valves castings under industrial conditions. The surface alloying was achieved by adding powders of Ni, and Cr to the slurry containing a binder coated on the mold surface. The surface alloyed coatings on the surface of WCB steel valves castings were enriched in Ni, and Cr respectively. The depths of coatings were as high as ~ 200-300µm. After normalizing and tempering heat treatment, the surface alloyed layer exhibited an increase in corrosion resistance as compared to base metal WCB steel. The time lag in phase transformation in different parts of the surface alloyed sample induces residual stresses in the surface alloyed layer. X-Ray Diffraction analysis was used to measure the residual stress of surface alloyed mild steel since this method allows for more accurate measurements of residual stress, unlike the hole drilling technique which requires removing a significant layer thickness. Samples with a surface-alloyed layer enriched with Ni and Cr, and mild steel as base metal were tested for residual stresses. The average tensile residual stress was measured to be 319 MPa, which is not likely to cause problems during further processing or use. Adhesion tests using thermal cycling indicated that there was no tendency for delamination of surface alloyed layer for temperatures under 200 °C. Hardness and corrosion measurements were also carried out indicating that the surface alloying of mild steel led to significant improvements in the hardness and corrosion resistance of the adherent surface alloyed layer.

(a) Glove Valve (b) Gate Valve

Keywords: Coatings, adheshion, hardness, corrosion resistance.

Effect of nano additives on SAE 10W40 engine base oil

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ABSTRACT

In the recent era, the effort has been made towards the improvement of properties of the lubricating oil properties. Various nano-additives and hybrid nano-additives are added to the base engine oil to improve the performance of the oil. The main objective of the study is to provide recapitulation of the different nano-additives which are added in commercially available SAE 10W40 engine oil. Various experiments to evaluate the tribological properties of engine oil (SAE 10W40) with nano-additives. Based on experiments friction coefficients, tribological and rheological properties and wear parameters have been analyzed using a pin-on-disc tribometer, rheometer, four ball tester and 3D optical profilometer. The available results showed that the reduction in coefficient of friction and improve the anti-wear capability of the engine oil with nano-additives than base engine oil (SAE 10W40). The SEM results of nano-additives lubricating oil showed the images illustrating the formation of the protective tribo-films of nano-additives as compared to pure base oil (SAE 10W40).

Keywords: 10W40, tribo-films, nano-additives, wear.

Influence of laser surface texturing on tribological performance of SS 316L, SS 304 and AISI 52100 in dry and lubricated sliding conditions

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ABSTRACT

Laser surface texturing (LST) is a valuable technique in surface engineering that offers significant improvements in the tribological behavior of metals and alloys. This study investigates the synergistic effect of incorporating hexagonal boron nitride (h-BN) as a solid lubricant with laser surface texturing on the tribological performance of SS 316L, SS 304 and AISI 52100. Circular textures with varying pitch distances (100, 150, and 200 µm) were created on the surfaces of the mentioned materials using LST. The friction coefficient and wear behavior of both untextured (UT) and textured surfaces (TS) were analyzed under dry and lubricating conditions. Wear tests were conducted using a universal tribometer under a load of 10 N, a sliding frequency of 10 Hz, and a sliding time of 30 minutes. The results demonstrate that the presence of dimple textures significantly influences the tribological behavior of the materials. Under dry conditions, the dimple-textured surfaces exhibited reduced friction coefficients and wear rates compared to non-textured surfaces. However, the effectiveness of the dimple texture varied depending on the material type and pitch. Under lubricated conditions, the tribological performance was further enhanced, with reduced friction and wear observed across all material types and pitch variations. The worn surfaces were characterized using optical microscopy, 3D profilometer, Field Emission Scanning Electron Microscopy (FESEM), Energy-Dispersive X-ray spectroscopy (EDAX) analysis, and Raman spectroscopy. Overall, this study demonstrates the potential of LST combined with h-BN as a solid lubricant in improving the tribological properties of metals, offering valuable insights for surface engineering applications in various industries.

Keywords: Laser surface texturing, Hexagonal boron nitride (h-BN), Solid lubricant, SS316L, SS304

An optimized effect of tool rotational speed on microstructure and mechanical properties of AA6061/SiC surface composites using friction stir processing

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ABSTRACT

This study focuses on an optimized effect of Tool Rotational Speed (TRS) on the microstructure and mechanical performance of AA6061-T6/Sic surface composites adopting through friction stir processing (FSP). The TRS of the tool was varied from 800 rpm to 1600 rpm. Whereas other process parameter, such as Tool Traverse Speed (TTS), Tool Tilt Angle (TTA), and Axial Force, are keeping constant. The optical microscope has been used to examine the microstructure of surface composites based on aluminium alloys. A visual examination indicates a flawless and defect-free weld surface. Fine equiaxed grain are observed in all the parameter. Grain size of NZ decrease with increase in TRS up to 1200 rpm with further increase in TRS, grain size increases. Tensile strength and microhardness value increase from 800 rpm to 1200 rpm after that gradually decreased from 1200 rpm to 1600 rpm.

Keywords: Friction stir processing, TRS, Reinforcement, Composite, Optimization

Investigating sliding wear behavior of WC-Co against Ti6Al4V in dry and lubricated conditions experimentally

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ABSTRACT

This research investigates the tribological behavior of Ti6Al4V and WC-Co materials under dry and lubricated conditions using a pin-on-disc setup. The study focuses on the coefficient of friction (COF) and specific wear rate for different loads (30 N, 50 N, and 100 N) and speeds (1 m/s, 1.5 m/s, and 2 m/s). Results reveal that lubrication has a significant impact on the tribological behavior of Ti6Al4V and WC-Co. The COF is higher in the lubricated state compared to the dry state, with a maximum COF of 0.57 observed at 30N and 1.5m/s, as opposed to 0.44 under dry conditions. The specific wear rate also increases in the lubricated state, reaching a maximum of 15.7785 mm3/N-m, while it remains at 8.858 mm3/N-m in the dry state. Scanning Electron Microscopy (SEM) analysis reveals different wear mechanisms. Under dry conditions, delamination is predominant at 30 N, while oxidation wear occurs at higher loads. At 50 N and 100 N, a combination of wear mechanisms is observed. In the lubricated condition, adhesion and fatigue wear mechanisms are observed across all load and speed levels, characterized by the formation of step-like features on the pin's worn surface. Elemental analysis using Energy-Dispersive X-ray Spectroscopy (EDX) integrated with SEM confirms the diffusion of Ti from the disc to the pin surface, indicating disc wear. These findings provide valuable insights into the tribological behavior of Ti6Al4V and WC-Co, enabling improved machining performance and durability in Ti6Al4V machining applications.

Keywords: Ti6Al4V, dry and lubricated conditions, pin-on-disc, wear mechanisms.

Tribocorrosion and in-situ profilometry of Al 6061 reference material

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ABSTRACT

Tribocorrosion comprises of wear-accelerated corrosion (i.e., chemical wear) and corrosion-accelerated wear (i.e., mechanical wear). Development of tribocorrosion resistant materials requires quantification of the relative magnitude of chemical wear and mechanical wear. The test methods for chemical and mechanical wear are not well established. Furthermore, gravimetric analysis as a post-test indicator of wear can be misleading in corrosive environments due to formation of chemical complexes with different material composition. In this study, an electrochemical workstation was integrated with a tribometer using a three electrode configuration. A 3D non-contact profilometer was used for in-situ measurement of wear depth and volume. A modified ASTM G119 protocol was developed using Al 6061 as the test sample in a 2 wt% NaCl solution. The potential between WE (working electrode), typically the test sample and RE (reference electrode) was regulated under open circuit potential, cathodic and potentiodynamic polarization conditions. Current between WE (working electrode) and CE (counter electrode) was measured under sliding wear conditions. The potential shift and increase current during rubbing was recorded and used as an indicator of the tribocorrosion performance of materials. Wear and corrosion augmentation factors were determined to help development of tribocorrosion resistant strategies.

Keywords: wear-accelerated corrosion, working electrode, counter electrode, electrochemical.

Failure analysis of the bearings in the household submersible pump

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ABSTRACT

Electrical submersible pumps are used in various applications such as oil well, city water supply, irrigation purpose, multistory building and domestic utilization [1]. This paper deals with the case study that involves failure analysis of the bearings in the household 1 hp submersible pump in Prayagraj region. The standard failure analysis includes various procedures such as visual inspection, fracture analysis, micro structural analysis, simulation method and analytical stress calculation [2]. The most common causes of bearing failure in electrical submersible pump (ESP) are insufficient lubrication, contaminated lubrication, overloading, misalignment, corrosion and mechanical damage [3]. The root causes of the failure are identified. The various preventive methods to reduce the bearing failure are discussed.

Keywords: Bearing failure, lubrication, fracture, corrosion

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Wear behaviour of deep cryogenically treated coated tool during end milling of XH67MBTHO

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ABSTRACT

XH67MBTHO is a nickel-based alloy which find application in high temperature region of aero engines and due to its inherent properties like high hot hardness, work hardening tendency etc tool wear during machining of this alloys was very high. Among various tool modification technique to reduce tool wear cryogenic treatment of tool was gaining attention due to its sustainability nature of treatment as compared to conventional wet type lubrication. In this study deep cryogenic treatment (DCT) of TiAlN coated tool was performed for 24hr time at -1960 C using liquid nitrogen (LN2) in open chamber with controlled cooling, at a rate of 0.5oC/min, to avoid thermal shocks followed by tempering at 200oC for 2 hour. XRD analysis of both cryo-treated and untreated were performed to find the phase transformation after cryogenic treatment. Slot milling were performed using both treated and untreated tool, under three levels of cutting speed (Vc), feed rate(fz) and axial depth of cut (DOC). Influence of these parameters over flank wear (VB), surface roughness (Ra) and cutting force (Fc) were studied using Analysis of Variance (ANOVA) and mechanism of tool wear analysis were done using SEM micrograph and EDS analysis of worn-out tool. Adhesion, chipping and Built-Up layer formation were observed to be lower in cryo treated tool along with improved resistance to tool wear due to various microstructural changes. Reduction of flank wear up to 13.32% along with a reduction of 31.25% in surface roughness were observed for treated tool compared to untreated tool

Keywords: cryogenic, wear, Slot milling, SEM, EDS, ANOVA.

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Effect of phosphonium ionic liquid as oil additive on hydrogen ingression and white etching areas formation in bearing steel under dynamic loading

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ABSTRACT

White Etching Areas (WEAs) and White Etching Cracks (WECs) are premature failures that shorten the life of mechanical components that are subjected to severe operating conditions. One of the key elements impacting accelerated subsurface microstructural deterioration is lubricant chemistry. Therefore, improving lubricant characteristics is anticipated to reduce the development of WEAs in the bearings. Ionic liquids (ILs) are a recent development in tribology that can potentially be lubricant additives. Reduced phosphorus gear oils must be developed to lessen phosphorus-induced exhaust catalyst poisoning and the resulting hazardous emissions. This study prepared low phosphorus oil formulations using phosphonium cation and phosphate anion ionic liquid additive. The composition with optimum performance will be selected, and white etching area tests will be carried out in dynamic pin on disc tribometer under severe slippage. Subsequently, comprehensive microstructural analyses of bearing ball samples were performed using various metallographic and spectroscopic techniques. The performance of lubricant mixture (IL + PAO) against WEAs formation in AISI 52100 bearing steel will be compared with the test results of base oil PAO.

Keywords: bearing steel, dynamic loading, friction and wear, hydrogen ingression, phosphonium ionic liquid, white etching areas

Friction mechanism in automotive brake pads

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ABSTRACT

The friction mechanism of automotive brake pads plays a vital role in ensuring safe and efficient braking performance. This work focuses on the analysis of Alicona images as a method to investigate and understand the friction mechanism of tested brake pads. By utilizing high-resolution surface metrology, the analysis of Alicona images provides valuable insights into the material behaviour, surface features, and wear characteristics of brake pads during frictional contact with the rotor. This analysis facilitates the identification and characterization of various features, such as microstructures, cracks, wear patterns, and transfer film formation, which contribute to the friction mechanism. The analysis of Alicona images helps to elucidate the adhesion, abrasion, and transfer film formation processes occurring during braking. Adhesion can be observed through the presence of material transfer and shear patterns on the brake pad and rotor surfaces. Furthermore, the analysis of Alicona images allows for quantitative measurements of surface roughness, contact area, and wear depth, enabling a comprehensive evaluation of the frictional behaviour of the brake pads. This information contributes to understanding the wear mechanisms, optimizing material compositions, and improving the overall design of brake pads. In conclusion. By capturing high-resolution surface data, this technique enables the examination of material behaviour, surface features, and wear characteristics. Leveraging these insights, one can optimize brake pad design and composition, leading to enhanced braking performance and improved safety in automotive applications.

Keywords: Friction, wear, roughness, adhesion.

Computational indentation in cross-linked polymer networks

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ABSTRACT

A typical experimental method for examining the mechanical properties of polymeric materials is indentation. Indentation testing offers a significant advantage by providing a direct relationship between a material's structure and its mechanical properties, while normal tensile testing is unable to do it. Studies in a specific field have primarily focused on examining biomaterials, elastomers, and soft hydrogels. Although the complex network structure plays a crucial role in determining the physical characteristics of weakly cross-linked polymer (WCP) networks, indentation in these systems has received less attention. In this work, we explore the mechanical properties of a weakly crosslinked polymer network (WCP) using computational indentation with two different indenter diameters. The resulting indentation is compared to identify force response and lock broken bond. This will help to optimize the polymer's design for its application or guide future experiments.

Keywords: Indentation, Molecular dynamics simulations, cross-linked polymers

Effects of thermal barrier coating on the performance and emissions of naturally aspirated ci engines fuelled with 1-hexanol – diesel nanoblends

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ABSTRACT

This study aims to explore the potential performance enhancements in a compression-ignition (CI) engine by utilizing a thermal barrier coated piston along with a blend of 1-hexanol and diesel fuel. To achieve this, a layer of Cerium Zirconium Oxide (CeZrO4) is applied using plasma spray technology with a thickness of approximately 150 µm on the piston crown. 1-Hexanol is mixed with different concentrations of diesel (H10, H20, H30) and regular diesel. Additionally, cerium oxide nanoparticles (NPs) with a size of 50 ppm are added to the 1-hexanol-diesel blend. The evaluation is conducted using an unmodified 4-stroke CI single-cylinder engine. The performance and emissions characteristics of the different variations are compared to those of a standard diesel engine with uncoated pistons. The findings indicate notable improvements after the application of the coating, including reduced brake-specific energy consumption (BSEC) by 6.13% for H20, increased brake thermal efficiency (BTE) of 5.63% for H10. 1-hexanol-diesel nanoblends also showed significant decrease in emissions of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx) and smoke opacity at part load conditions. The results demonstrate that ceramic coatings, enhance engine performance while significantly reducing pollutant emissions compared to regular diesel fuel.

Keywords: Cerium Zirconium Oxide, 1-Hexanol, Thermal Barrier Coating, Performance, and Emissions

Effect of coefficient of friction on friction moment in ball bearings

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ABSTRACT

Friction plays a crucial role in ball bearings, which are widely used in various mechanical systems and devices. Ball bearings are designed to reduce friction and facilitate smooth motion between moving parts. The friction coefficient has a significant impact on the friction moment in a ball bearing. A lower friction coefficient reduces the frictional resistance and friction moment, leading to improved efficiency, lower energy consumption, and increased longevity of the bearing. Friction in ball bearings occurs primarily at two points: the contact between the balls and the raceway and the contact between the balls and the cage. The friction coefficient between the contacts is one of the important factors in understanding the efficiency and reliability of ball bearings. This paper presented the effect of coefficient of friction on friction moment generated due to the contact between the balls and the raceway, as well as the contact between the balls and the cage. The friction moment due to elastic hysteresis in rolling, the friction moment due to the geometry, the friction moment due to the pivoting on contact ellipse, and the friction moment due to the sliding between ball and cage are studied analytically. It is concluded that understanding the effect of coefficient of friction indeed plays an important role in the total friction moment generated in ball bearings.

Keywords: Ball bearings, friction, tribology.

Experimental investigation of tribological properties of walnut oil

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ABSTRACT

The performance evaluation of bio lubricants with the focus on utilizing cold-pressed walnut oil as a base oil is an extensive study. In this research, preliminary tests were conducted to confirm the suitability of walnut oil as a base for formulating a sustainable bio lubricant. Viscosity of oil was measured using the ASTM D445 test on Anton par MCR 102 rheometers to assess its flow behavior. Addition of graphene nano particles to virgin walnut oil-based grease escalated the viscosity of the grease as studied on Anton Paars rheometer. Wear examinations were performed on steel balls using an optical microscope and scanning electron microscopy Lubricating abilities were tested using ASTM 2266, four ball test to evaluate the performance of the lubricants. This study holds significant importance in terms of the potential application of the proposed bio lubricant as an environmentally friendly and sustainable alternative. The investigation of bio lubricants, particularly when utilizing walnut oil as a base, offers promising avenues for exploration. By addressing the limitations of vegetable oils and developing effective approaches to enhance their lubrication properties, this research may contribute to the advancement of sustainable lubrication solutions. Also, addition of 0.25% of graphene nano particles (GNPs) reduced the coefficient of friction substantially. By addressing the limitations of vegetable oils in order to enhance their lubricating properties, this research might contribute to the advancement of sustainable lubrication solutions.

Keywords: Bio-lubricants, GNPs, tribology.

A review of thermo-hydrodynamic and tribological characteristics of bearings with nano-lubricant

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ABSTRACT

Lubrication is one of the important and crucial factors in engineering. A lubricant is generally composed of base oil (either mineral oil or synthetic oil) and additives. These additives perform various roles in enhancing the tribological properties of a lubricant. With the increase in industrialization, the demand for lubricants has also increased and thus, the mineral and the synthetic base stocks are now facing the problems of depletion and bio-degradability [1]. In order to protect and improve environmental quality, control and reduce pollution from all sources, researchers are thinking for an alternative solution for mineral oil and hence, the possibility of using vegetable oil as a lubricant has come into lime light. The main advantages of vegetable oil as a lubricant are its non-toxic nature, better lubricity, biodegradability and environment- friendly nature. But it also faces problems of oxidation and also their performance deteriorates at low temperature. Therefore, in order to enhance the tribological behavior of lubricants, various blends of lubricants are used. Some investigations on vegetable oil blended with other lubricants indicated better and comparable tribological properties as compared to the conventional lubricants [1]. The use of nanoparticles as additives to modify the flow behavior of base fluids have been attempted in many applications. One such application is in lubrication; where, a new class of lubricant termed as nano-lubricant is synthesized by dispersing nanoparticles in base oils. The applications of nanomaterials have increased in many tribological applications. The reduction of wear and coefficient of friction in case of nano-lubricants is due to the following mechanisms: the colloidal effect, rolling effect, small-size effect, protective film effect and third body effect [1]. Addition of Al2O3, TiO2, SiO2, BN, CuO, Graphene nano-particles in lubricants exhibit some promising results in this regard.

Keywords: lubricant, nanoparticles, graphene, vegetable oil.

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Tribological study of soybean oil based biolubricants

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ABSTRACT

In recent times, lubricants made from biodegradable vegetable oil are viewed as an environmentally friendly alternative to conventional lubricants made from petroleum products. Among the most abundant vegetable oils produced worldwide is soybean oil. In this paper, we have studied soybean oil-based biolubricants as an alternative lubricant considering only their tribological performances. In this study, paraffin oil was chosen for comparing the tribological performances of biolubricants as it is the most commonly used base oil for conventional lubricants. From the study, it has been found that the chemically modified soybean oil has better coefficient of friction and wear preventive characteristics than the natural soybean oil as well as the paraffin oil.

Keywords: paraffin oil, biolubricants, biodegradable, soybean oil, friction and wear.

Molecular dynamics simulation of dry sliding between non-gaussian copper rough surfaces

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ABSTRACT

Friction has an immense effect on the degradation of sliding metallic surfaces of gears and bearings used in Nano and micro electro-mechanical systems (NEMS/MEMS). Ploughing and adhesion forces are responsible for generating friction force between surfaces. Surface interaction needs to be studied at the nano-scale to investigate the characteristics of dry sliding friction happening in mechanical devices. Molecular dynamics (MD) simulation has been performed to understand how asperities are making contact at the nano-scale. In this work, two non-Gaussian rough surfaces interacted at different plate spacing of 9-12 Å. The Von Mises strain, atomic wear, and changes in the atomic arrangement after sliding action are obtained for Cu-Cu (soft-to-soft) tribo-pair at a given sliding speed of 10 m/s. Traction force and normal force are computed and plotted with respect to sliding distance. Traction force starts to increase when asperities are about to make contact and then decreases to zero after the contact is completed. The average friction force on the lower surface increases when the space between surfaces is decreased. More percentage changes in surface topography and atomic wear are found for the lesser plate spacing of 9 Å. The changes in surface topography parameters during sliding action may have an immense effect on the performance of tribo-pair in NEMS/MEMS.

Keywords: tribo-pair, Molecular dynamics, Von Mises strain, atomic wear.

Influence of pseudoplastic lubricant on the performance of a porous hybrid circular journal bearing system

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ABSTRACT

In the present work, the influence of pseudoplastic lubricant on the performance of porous hybrid circular journal bearing system has been numerically investigated. The governing Reynolds equation for a non-Newtonian lubricant in the bearing clearance space of porous hybrid circular journal bearing is solved using a finite element model. The performance indices of porous hybrid journal bearing have been numerically simulated and presented in terms of fluid film thickness, rotor dynamic coefficient (i.e. stiffness and damping coefficient) and stability threshold speed margin. Findings of this study indicate that the porous hybrid journal bearing operating with a pseudoplastic lubricant offers a higher value of stability threshold speed margin as compared to Newtonian lubricant. The present study is expected to be beneficial to academia and bearing designers.

Keywords: Reynolds equation; Finite element method; Porous hybrid journal bearing system; Pseudoplastic lubricant.

Potential application of heterolamellar Bi_2Se_3/Bi_2WO_6 nanosheet composite as antifriction and antiwear agents

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ABSTRACT

The objective of this study was to enhance the tribological efficiency of hydrothermally synthesized bismuth selenide (Bi_2Se_3) nanosheets by incorporating lamellar bismuth tungstate (Bi_2WO_6) to form a hetero lamellar structure. The use of two-dimensional (2D) materials in composite fabrication was based on the weak van der Waals forces between adjacent layers, which promote lubrication behavior and enhance dispersibility. High-resolution scanning electron microscopy (HR-SEM), transmission electron microscopy (TEM), and high-resolution transmission electron microscopy (HR-TEM) analyses confirmed the uniform distribution of Bi_2WO_6 nanosheets on the Bi_2Se_3 nanosheets. The tribological properties of the identified nano additives (Bi_2Se_3, Bi_2WO_6, and Bi_2Se_3/Bi_2WO_6) were evaluated in paraffin oil (PO) using ASTM D4172 and ASTM D5183 tests on a four-ball tester, with an optimized concentration of 0.050% w/v. The tribological data, including mean wear scar diameter (MWD), friction coefficient (COF), and seizure load, revealed that Bi_2WO_6 nanosheets outperformed Bi_2Se_3 nanosheets, which in turn exceeded the performance of Bi_2Se_3 nanosheets. However, the hybrid Bi_2Se_3/Bi_2WO_6 showed a substantial improvement in tribological activity due to its hetero lamellar structure, which reduced interlaminar shear strength and effectively prevented restacking and agglomeration of the nanosheets. Elemental dispersion X-ray spectroscopy (EDX) and X-ray photoelectron spectroscopy (XPS) analyses of the worn pathway indicated the presence of metal oxides, such as Bi_2O_3, SeO_2, WO_3, and tungsten nitride in the resulting tribofilm, which synergistically improved the lubrication. The tribological results were validated by atomic force microscopy (AFM) and scanning electron microscopy (SEM) analysis of the wear scar surface.

Keywords: bismuth selenide, tribological properties, paraffin oil, EDX, SEM.

Investigating tribological behavior in the mid-high temperature range of inconel 718 superalloy deposited by wire arc additive manufacturing

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ABSTRACT

The advent of additive manufacturing has recently brought about a significant transformation in the manufacturing landscape. The cost-effective fabrication of large-size components with relatively high deposition rates and lower heat input has gained greater traction than its contemporary additive manufacturing processes. Wire Arc Additive Manufacture (WAAM) is gaining prominence due to its ability to produce large-scale components with minimal capital investment, reduced material waste, and logistical benefits. Inconel 718 nickel alloys are preferred for the WAAM process due to their fatigue, tensile, and corrosion resistance properties. Each layer in WAAM has its own heat cycle history, resulting in various microstructures emerging throughout the layers. The experiment ascertained how grain size and hardness affected the wear characteristics of the IN718 alloy, it was found that alloys with higher hardness and smaller grains had superior wear resistance. This work examined Inconel 718's friction and wear behaviors under various environmental factors. The friction characteristics of Inconel 718 superalloy fluctuate with test temperature, which suggests that rising temperatures speed up oxidation rather than necessarily causing worsening of material wear. The thickness of the oxide layer and material wear increases with contact load. The glaze layer forms at 600°C, lowering friction coefficient and decreasing wear rate. Abrasive wear occurs at low temperatures, suggesting a mechanism for abrasive wear at high temperatures.

Keywords: Inconel 718, superalloy, corrosion resistance, abrasive wear.

Compositionally modulated Ni-W multilayers to alleviate the residual stresses in coatings for superior wear resistance

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ABSTRACT

The presence of tensile residual stresses in the Ni-W alloy coatings generated during the electrodeposition has restricted their industrial deployment. In the present study, the multilayering strategy is employed in developing the Ni-W coatings with the best combination of hardness and residual stresses. Ni-W multilayer coatings composed of alternate soft (~ 2.6 GPa) and hard (~ 8.5 GPa) Ni-W layers with individual layer thickness (λ) ranging from 2.5 μm to 0.05 μm were deposited by using the pulse reverse current electrodeposition. These multilayer coatings have demonstrated a significant reduction in the residual stresses while retaining the high hardness. Deconvoluted XRD analysis shows that the soft Ni-W layers have effectively accommodated the residual stresses generated in the hard Ni-W layers. Ni-W multilayer coating with λ ~0.1 μm has exhibited superior resistance to wear damage compared to its homogeneous counterparts. The improved wear degradation resistance of the multilayer coating was rationalized through assessment of residual stresses and thermal properties.

Keywords: Pulse reverse electrodeposition; Ni-W alloy; Multilayer coatings; Microstructure; Wear.

Tribology of ultra-fine-grained and reinforced Ti6Al4V sliding against ceramics under the influence of interfacial simulated body fluids

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ABSTRACT

Ti6Al4V, a priority material for orthopaedic applications is susceptible to failure due to the generation of wear debris upon prolonged utility leading to implant loosening and infection. Thereby formed wear debris can trigger an immune response leading to inflammation assisting in bone loss and promoting colonization of infectious bacteria. To address this concern, significant improvements are necessary in the mechanical, tribological, and biocompatibility properties of the material. In this work, a relatively new solid-state processing (SSP) technique, namely, friction stir deposition (FSP) is adopted to develop ultra-fine-grained (UFG) and hydroxyapatite (HAp) reinforced Ti6Al4V. The fabricated material (with and without reinforcement) is subjected to tensile testing (strain rate: 0.001s-1). The findings indicate that the addition of hydroxyapatite (HAp) reinforcement to Ti6Al4V results in a concurrent enhancement of both ultimate tensile strength (UTS) and ductility (% elongation). On the other hand, the Ti6Al4V material without HAp reinforcement demonstrates improved UTS without sacrificing ductility. Tribo-testing of the modified material against ceramic under the influence of interfacial simulated body fluids, viz. bovine serum albumin (BSA), Hank's solution (HKS), and phosphate buffer saline (PBS) reveal that the UFG and HAp reinforced Ti6Al4V demonstrate superior tribological properties compared to be base material and the UFG Ti6Al4V without HAp reinforcement. The microstructure of the modified material plays a significant role in activating specific mechanisms that govern the mechanical and tribological responses.

Keywords: Ti6Al4V, Friction stir deposition, Ultra-fine-grained, Hydroxyapatite, Simulated body fluids.

Adsorption mechanism of bio-inspired surfaces for tribological performance: a perspective

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ABSTRACT

Friction, lubrication, and wear at rubbing contact's balance energy loss in engineering applications. Friction is a non-fundamental force invincible from molecular domain to large field of biosphere due to nature consciousness. The surface energy of contact materials, environmental third bodies, and operating conditions regulate energy dissipation control for modulation of engineering constraints. The superhydrophobicity of lotus leaves or self-cleaning mechanism is viable in engineering applications for advancement of science-policy-society domain at the forefront of socioeconomic indicators. The non-stick cooking performance of PTFE substrates over aluminium is observed in daily life in urban life of India. Bio-inspired designing and manufacturing of synthetic PTFE substrates borrowed from "Lotus Effect" may explain the scientific innovation for last few decades.

Keywords; Bionic, Tribology, Surface Texture, Environmental third bodies

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Nanomechanical analysis and wear behaviour of TiB2-Al2O3-Ti nanocomposite coated HSS substrates in contact with EN8 steel counterbody

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ABSTRACT

This article presents the development and wear behaviour analysis of nanocomposite TiB2-Al2O3-Ti coatings with variable concentrations of titanium on high-speed steel (HSS) substrates using multi-target sputtering. The deposition process involved the use of Al2O3, Ti, and TiB2 targets in an Argon plasma at a substrate temperature of 240 °C, with the power density of the Ti target varied to achieve three different TiB2-Al2O3-Ti nanocomposite coatings. The coatings had a thickness of less than 500 nm and were characterized using FESEM, EDS, XRD, and Raman spectroscopy to determine their microstructure, elemental composition, phase analysis, and variation of Ti. The coating thickness and surface roughness were verified using a 3D profilometer. Mechanical analysis was conducted through nanoindentation tests using a Berkovich indenter, while tribological analysis was performed using nano tribological tests against EN8 steel balls of 1.6 mm diameter. The results indicated that the coatings exhibited good hardness and high wear resistance. Wear scar analysis revealed substantial material transfer from the counterball to the coatings. Moreover, an increase in metallic Ti concentration led to improved friction characteristics, as indicated by smaller wear scar diameter and fine wear debris at higher Ti percentage.

Keywords: nanocomposite coatings, wear scar analysis, friction.

Monitoring natural gas engine oil performance and equipment health: enhancing reliability and cost savings

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ABSTRACT

The increasing demand for reliable and efficient power generation in India has sparked a keen interest in exploring alternative energy sources. Natural gas has emerged as a promising option due to its cleaner combustion characteristics compared to traditional fossil fuels. Deploying stationary gas sets in India offers a notable advantage with their flexible capacity ranging from a few hundred kW to 10-20 MW, making them well-suited for distributed power generation and enabling the establishment of multiple smaller power plants across the country. Moreover, the utilization of natural gas as a primary fuel source promotes environmental sustainability in India. Stationary gas sets emit lower greenhouse gases and pollutants compared to conventional coal-fired power plants, contributing to improved air quality and reduced carbon footprint. This aligns with the nation's commitment to mitigating climate change and transitioning towards a greener energy mix. Natural gas engine oils (NGEO) used in these engines require special formulations that differ from diesel and gasoline engine oils. Natural gas engines operate in specific ways: They burn cleaner, resulting in no soot contamination of the crankcase engine oil. They burn gaseous fuel, eliminating fuel dilution concerns and emphasizing the criticality of preventing viscosity increase in the oil. They burn hotter than diesel, with exhaust temperatures ranging from 165°C to 235°C. This higher temperature increases oxidation, nitration, and valve wear in NGEO. They operate at a constant speed, making the engine more prone to retaining deposits and experiencing plug fouling. This paper discusses oil validation techniques that can be employed to monitor NGEO performance and equipment health. Implementing these monitoring techniques helps prevent catastrophic equipment failures, resulting in substantial cost savings in terms of equipment expenses and downtime. Oil condition monitoring, a proven technique, involves drawing samples at predetermined frequencies and analyzing parameters such as kinematic viscosity, viscosity index (VI), oxidation, nitration, and wear elements to assess oil quality. Test results are compared against oil rejection limits and can guide preventive actions such as oil sweetening or conditioning to extend the oil drain interval. Engine endoscopy serves as another valuable tool for determining equipment health and wear. Evaluating engine component health before and after oil charging AND draining offers a method of assessing oil performance. However, challenges may arise during the study, which are thoroughly discussed in this paper. In conclusion, monitoring NGEO performance and equipment health through oil validation techniques is crucial for enhancing the reliability and longevity of natural gas engines in stationary power generation. These techniques provide cost-effective preventive measures, ensuring equipment integrity, reducing expenses, and preventing costly downtime.

Keywords: NEGO, condition monitoring, engine endoscopy etc.

Friction and wear behaviour of Cu-hBN nano composites

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ABSTRACT

The present study is aimed at evaluating the tribological performance of Cu-hBN nanocomposites containing a fixed amount (i.e., 2 wt.%) of hBN with respect to the processing technique as well as the temperature. In order to evaluate the effect of doping on the interfacial bonding between Cu and hBN, composites containing as-received hBN (C1) and Cu-doped hBN (C2) were prepared via spark plasma sintering (SPS), while a third composite (C3) was prepared by pre-sintering in a tube furnace followed by SPS. Dry sliding wear tests have been performed at room temperature (RT) and 400 °C against EN31 steel ball using high-temperature ball on disc rotating tribometer. For comparison, pure Cu specimen (C0) prepared using same procedure was evaluated under similar conditions. The results indicate that the hardness and density get reduced with addition of hBN in Cu matrix. However, C2 has the higher hardness and density than C1 which has been attributed to the better interfacial bonding attained due to doping of Cu in hBN. C3 is softer but denser than C2. Both the average coefficient of friction and the wear rate increased with increasing temperature for all composites except C3 for which the wear rate has been found to decrease with the rise in temperature. Composite C2 has shown the least CoF (0.42-0.45) and wear rate (2.5×10^{-2} -3.0×10^{-2} mm^3/m) which has been attributed to the improved wettability of Cu doped hBN as compared to pristine hBN with the Cu matrix.

Keywords: nanocomposites, Cu-doped hBN, friction, wear, spark plasma sintering,

Corrosion behavior of zirconium alloy in the aqueous solution of LiOH

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ABSTRACT

Zirconium alloys are the key materials for the core components of nuclear reactors due to their low neutron absorption cross-section, corrosion resistance and high strength. Some components are subjected to the environment of coolant water containing LiOH (to maintain the pH of the coolant water at 10.4). Accelerated corrosion tests were conducted on zircaloy-4 at variable concentrations of LiOH in water to vary the pH value of the aqueous solution to observe the effect of pH on the corrosion behavior. EIS and linear polarization studies were conducted at variable pH values of the solution and variable exposure duration. Corroded surfaces were analyzed using a field emission scanning electron microscope (FESEM) and energy dispersive spectroscopy (EDS). Corrosion impedance decreases with increasing the pH of the solution and increases with increasing the exposure duration. Linear polarization analysis shows the decreasing corrosion potential and increasing corrosion current with increasing the pH of the solution. Corrosion potential increases, and corrosion current decreases with increasing the exposure duration. So, the corrosion resistance decreases with increasing the pH of the solution and increases with increasing the exposure duration. EDS maps show the formation of oxide layer on the corroded surface.

Keywords: Zirconium alloy, Corrosion, EIS and Linear polarization.

Tribological studies of Ni-P-graphene oxide and Ni-P-carbon nano tubes composite coatings prepared by electroless deposition process

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ABSTRACT

Ni-P coatings with varying volume fractions of graphene oxide (GO) and carbon nano tubes (CNT) were deposited over mild steel substrate by electroless process. The hardness and wear properties are co-related to understand the response of nanoparticles (GO and CNT) addition into the Ni-P coatings. The hardness of CNT incorporated Ni-P coatings was found higher than that of GO incorporated Ni-P coatings which shows that the hardness is highly susceptible to the size of nanoparticles. Also, the nanosized CNT led to the even dispersion which eventually contributing for the higher hardness as well as excellent wear properties. Further, the hardness and wear properties also dependent of an optimum volume fraction of CNT. Addition of uniformly dispersed 1mg/l CNT into Ni-P coatings leads to 60% increment into the wear resistance when compare to wear resistance of pristine Ni-P coatings. CNT addition beyond the optimum diminishes the hardness as well as wear resistance due to the agglomeration. The particle size of evenly dispersed CNT was found 394.6 nm whereas it was found 538.5nm for GO. Evenly dispersed nanoparticles promote the finer and smoother surface morphology which favors the reduced roughness and ultimately the improved hardness and wear resistance. The coefficient of friction was also decreased for optimum CNT incorporated Ni-P coatings.

Keywords: Ni-P coatings, CNT. GO, hardness, wear.

Investigation on potential of natural fibres as an insulating materials: a step towards sustainability

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ABSTRACT

Energy has always been a main component for all the activities in our daily routines. Energy is consumed in various sectors like the buildings, transportation, mining etc. Building sector has become the world's dominant energy consumer with 40% of the overall energy consumption [1][2]. Most of this consumption comes from heating and air-conditioning systems for thermal comfort of the occupants. This study investigates the potential of natural materials as a thermal insulation for building envelopes, under the programme for implementing a comprehensive sustainable energy strategy. The United Nations indicates that the energy sector must be addressed in any broad atmosphere-protection strategy, through programs in two major areas: increasing energy efficiency and shifting to environmentally sound energy systems. One of the means to reduce energy losses and the strategies towards environmentally sound energy systems are the use of natural insulating materials. During crop harvesting, straw of crops is produced in abundance and has rarely any significant utility. This is usually discarded by mostly burning. In the present work natural material like wheat straw were characterized in terms of their physical and thermal properties using scanning electron microscope (SEM), X-ray diffraction(XRD), and line heat source thermal conductivity measuring approach. Results reveal that thermal conductivity increases with increase in temperature and density. It is found the values of thermal conductivity of wheat straw is between 0.048 to 0.066 W/m.K at the densities ranging from 156 to 300kg/m^3. The XRD pattern shows that it is a polymer showing mixed behaviour consisting both amorphous and crystalline parts. It was found that this material can be classified as moderate insulating materials, having better environmental aspect and compete favourably with conventional insulating materials. As an additional outcome of our research is that their is a definite relationship between heat conducted through stems and independent variables like density and porosity of material medium.

Keywords: Thermal insulation, wheat straw, amorphous and crystalline, SEM, XRD.

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Surface profile and its impact on the performance of elliptical journal bearing

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ABSTRACT

Hydrodynamic journal bearings are widely used in rotating machinery due to innate reliability and durability. It therefore becomes essential to know the parameters that may affect the performance of hydrodynamic journal bearings. Pressure and temperature of oil film are among the key parameters that describe performance of hydrodynamic journal bearing. In the present work experimental results of textured hydrodynamic journal bearing of elliptical shape have been presented. The performance includes generation and development of circumferential temperature and pressure at variable load and speed. The test bearing of Gun metal was fabricated and used as elliptical bearing in performing the experiments. A series of tests were conducted to determine the circumferential temperature and pressure of oil in the elliptical shaped hydrodynamic journal bearing. Impact of dimples of hemispherical shape were introduced to investigate the performance of textured elliptical journal bearing. It has been observed that due to elliptical shape of bearing and formation of two converging zones there will be the film pressure generation in both the converging zones. Experimental results also exhibit that there is an improvement in pressure generation due to the surface texture on the bearing surface.

Keywords: Hydrodynamic journal bearings, surface texture, film pressure generation.

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Mechanical and tribological properties of Ni-BN composite coatings deposited by magnetron sputtering

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ABSTRACT

Nickel Boron nitride (Ni-BN) coatings were deposited on Aluminium-Silicion substrates by Magnetron sputtering method. The effect of BN content on nano hardness, and tribological properties was investigated and discussed. Coatings were deposited using three distinct contents of BN. The surface morphology, composition and phase structure were analysed by X-ray diffraction (XRD), Field emission scanning electron microscopy (FESEM) and energy dispersive spectroscopy (EDS). The Mechanical properties of coatings were evaluated by Hystrion TI premier nanomechanical system. The interfacial wear and friction behaviour was also investigated by observing the wear tracks after the pin-on-disc tests on the MFT-2000 nano tribometer. Results show the nano hardness and elastic modulus of the deposited coatings increase as the Boron nitride content increases. The nano-hardness value increases from its minimum value of 14.22 to 17.56 GPa due to the increase in boron content. Similarly the elastic modulus value increase from 90 to 140 GPa, with increases in Boron nitride content in the Ni-BN matrix. The coefficient of friction of the coatings reduces as the Boron nitride content increases. In addition, the wear resistance of the coating was also improved by increasing the Boron nitride content in the Ni-BN matrix. Ni-BN with the lowest content of Boron nitride showed the most severe wear. The study reveals that Ni-BN films deposited by magnetron sputtering has major potential as a coating for aerospace and ic engine applications.

Keywords: Nickel Boron nitride coatings, Aluminium-Silicion, FESEM, wear, nano hardness.

A study on microalgae oil as a sustainable green-lubricant with tribological and physiochemical characteristics

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ABSTRACT

Lubricants are substances that reduce wear and friction for optimum operation, reducing risks of failures. Most lubricants more than 95% used today are non-renewable petroleum-based which are getting depleted, also releases emissions which are affecting environment and human health. Biolubricants are best alternatives whose main resources are edible/non-edible oils, derived from lipids/carbohydrates like animals, plants, algae, cyanobacteria, microorganisms but everyone is having limitations except Algae. Microalgae oil is sustainable and eco-friendly resource for green lubricants that is essential to the lubricant industry. Microalgae is photoautotroph that requires less resources to grow and cultivates quickly that can be grown several times a year. Microalgae can also be grown in seawater and wastewater and not having dependency on climatic conditions and need for agricultural land because of these reasons production cost of microalgae is also less. Microalgae have great chemical compositions, high lipid content, high content of hydrocarbons, high content of polysaccharides, gelling abilities. Algal have excellent tribological, physiochemical and rheological properties which reduce friction due to high amount of saturated, monounsaturated, polyunsaturated fatty acids because of this microalgae is fit for lubrication. In this study, the lubricating properties of microalgae oil including molecular weight, higher viscosity, oxidation stability, thickening behaviors, reduced friction coefficient, better antiwear, better antiseizure, thermal stability & characteristics, crystallinity and rheology of polysaccharides as sustainable green lubricants are discussed. Microalgae oil is shown to have excellent anti-wear and anti-friction properties, reduced coefficient of friction, decreased surface roughness and wear loss significantly, enhanced lubricant's heat dissipation, decreased wear scar diameter.

Keywords: Friction and wear, surface roughness, biolubricants.

High temperature friction and wear of nimonic C263

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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 undergo periodic repair and replacements due to high temperature erosion and high temperature fretting wear. Erosion and fretting wear resistant coatings are deposited on the blades to avoid its damage. In this study, Ducom UniTest 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.

Keywords: Erosion fretting wear, wear coefficient, XRD, coating.

Experimental analysis on machining of Ti-6Al-4V alloy using WS2 nanoparticle assisted µ-EDM textured tools

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ABSTRACT

Although tool surface texturing can be viewed as a promising method to enhance the machinability aspects of Ti-6Al-4V alloy owing to its significant reduction in contact pressures, rapid debris accumulation in the patterns severely dent its effectiveness particularly at dry machining conditions. Hence, this study focusses on analyzing the impact of an innovative tool texturing technique where dimples (DTT_WS2) and groove (LTT_WS2) patterns are fabricated on tool using WS2 powder mixed dielectric fluid assisted µ-EDM process to observe how efficiently it performs in contrast to conventional µ-EDM textured tools (DTT and LTT) at dry turning conditions. It was identified from the experimental analysis that while the average flank wear, tool chip contact length and specimen roughness machined using LTT_WS2 decreased by 12%, 6% and 14% in contrast to LTT, it reduced by 17%, 7% and 9% in DTT_WS2 in contrast to DTT at 100 m/min respectively. Moreover, adhesion and abrasive wear mechanisms which were predominant in the case of both non textured and normal EDM textured tools were severely reduced in the case of nanoparticle assisted µ-EDM textured tools. This may be attributed to the beneficial tribological properties provided by nanoparticles in terms of its enhanced material removal rates which contributed to improved chip entrapment tendency along with superior lubrication and tool strengthening effects, on account of it getting alloyed across patterns during µ-EDM process.

Keywords: nanoparticle, tool surface texturing, wear, EDM.

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Tribological studies of vegetable oil based bio hydraulic oils

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ABSTRACT

The pursuit of sustainable and environmentally friendly lubricants has become increasingly important in recent years due to growing concerns over climate change and the depletion of fossil fuel resources. 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.

Key words: vegetable oils; tribology; lubrication; friction; sustainability

Development and performance studies of oxygenated diesel fuels

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ABSTRACT

World is moving towards cleaner, greener and energy efficient fuels. The increase in fuel consumption in various industries, especially in road transport sector has created interest for the blending of biofuels in conventional fuel and renewable fuels. Among biofuels ethanol is one of them and preferable choice for blending in gasoline which is a fuel for spark ignition engines and flex fuel vehicles. As such ethanol/methanol cannot be used in compression-ignition diesel engines without engine modifications due to inherent low cetane number and lubricity of alcohols. Therefore, fuel consisting of certain concentrations of alcohols such as methanol / ethanol in diesel blends is being promoted. The lower alcohols (methanol/ethanol) are not miscible in diesel due to their polarity differences. An additive package is essential for the solubility and stability of alcohol (methanol/ethanol) in diesel phase or diesel blends. Since diesel fuel pumps operate at much higher pressure (up to 220MPa in high-pressure diesel fuel pumps) than the gasoline pumps, oxygenated diesel blends must impart adequate lubricity to metallic parts of fuel delivery system and engine. Lubricity is the one of the important property of diesel specifications (IS: 1460-2017) and appropriate dosing of additive package is compulsory to maintain the specifications of oxygenated diesel blends. To tackle the low cetane number, lubricity issue and stability of alcohol-diesel blends, suitable chemistry and dosage of additive package was optimized. In this paper, the lubricity of conventional diesel and diesel blend with methanol up to 15% (v/v), and with ethanol up to 5% (v/v) with & without appropriate Lubricity improver (LI) additive were studied using HFRR (High-Frequency Reciprocating Rig). The details of fuel composition versus critical properties of oxygenated diesel blends will be discussed in the paper.

Keywords: Lubricity improver, HFRR, diesel, oxygenated diesel blends, ethanol, methanol, Cetane Number.

Development of green lubricants using refined base stocks for sustainable developments

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ABSTRACT

Re-refining of used lubricating oil, is an economically attractive recycling method in terms of resources conservation and environment protection. Used lubricating oil undergoes an extensive re-refining process to remove contaminants to produce good quality base oil for use as re-refined base oil for lubricating oils. It allows processing of hazardous material in a safe and effective way to recover high quality oil product form used oil. Used lubricating oil is generally a mixture of different types and grades of used lubricating oils coming from various automotive and industrial applications. Re-refined base oils can be used to produce lubricants such as motor oil, transmission fluid, hydraulic oil and gear oils. Virgin mineral base oils are classified as API Group I, II, and III. Re-refined base oils meeting API group I and II quality are mostly produced by re-refiners. In this paper authors evaluated different types of API GL4 (Gear oil) and API GL5 (Axle oil) based on re-refined base oil to assess the performance of these green lubricants in comparison to virgin base oil based lubricants. This study includes physic-chemical tests, lab performance tests (Rust, corrosion, shear stability and oxidation) and tribological performance test i.e. weld load, wear scar diameter and friction performance by MTM were also evaluated. Test results show similar performance observed in re-refined base oil based lubricant has shown comparative performance w.r.t virgin base oil based products.

Keywords: Re-refined base oils, corrosion, tribological performance, wear.

Combined influence of a liner deformation and couple stresses on the partial bearing aspect ratios

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ABSTRACT

A comparative analysis of two aspect ratios 1.0 and 0.5 are performed to study the stability of a 120° partial arc journal bearing lubricate with a fluid of couple stresses. The modified Reynold's equation is derived for couple stresses and used alongwith elasticity equation to study the impact of deformation in bearing liner on the performance of journal bearing in terms of stability characteristics. The results are presented in terms of attitude angle, somerfeld number, critical mass, whirl frequency and threshold speed. It is concluded that the bearings with high aspect ratio (1.0) are more stable than aspect ratio 0.5 for the fluid of couple stresses and the stability of the bearing is improved by using the couple stress fluid. Threshold speed is reduced with an increase in liners deformation, such that the region of stability is reduced on increasing deformation of bearing liner.

Keywords: Partial arc bearing, stability, liner deformation, aspect ratio, couple stress fluid.

Impact of laser surface texturing (LST) on tribological performance: A comparative study of open and closed shape geometries

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ABSTRACT

Surface texturing is a well-established technique utilized to enhance the tribological properties of materials. In this research, the influence of laser surface texturing (LST) and the effects of different texture geometries, patterns, and dimensions on the coefficient of friction (COF) and wear are investigated. The study focuses on two specific geometries: open and closed shape. AISI 316 steel samples with a diameter of 30 mm were subjected to LST to create the desired textures. Characterization of the textured surfaces was conducted using various techniques, including field emission scanning electron microscopy (FESEM), optical microscopy, 3D profilometry, energy-dispersive X-ray spectroscopy (EDX), and wavelength-dispersive X-ray fluorescence (WDXRF) spectroscopy. Tribological tests were performed using a ball-on-disc type tribometer, with the samples lubricated by PAO 4 base oil, both with and without the addition of MoS2 particles. When MoS2 particles were present, they were dispersed at a concentration of 1 wt. % within the lubricant. The results showed that the incorporation of MoS2 particles significantly reduced the COF values. Moreover, the open shape textures exhibited superior performance compared to the closed textures, as they facilitated better entrapment of MoS2 particles, acting as lubricant reservoirs during the sliding tests. The lower COF and improved friction characteristics of the open shape textures were further highlighted by the reduced wear loss observed during the sliding tests.

Keywords: Surface texturing, Tribological properties, Friction, 3D profilometer, WDXRF.

Fault detection in antifriction bearing using machine learning techniques

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ABSTRACT

Bearings play a critical role in various industries, and their failure can result in significant financial losses, equipment downtime, and safety hazards. Traditional fault detection methods often rely on manual inspection and periodic maintenance, which can be time-consuming, subjective, and inefficient. In this study, machine learning algorithms are employed to develop a robust and automated fault detection system for antifriction bearings. The proposed approach involves the collection of vibration data from sensors installed on the bearings, which are then processed and analyse. This research paper focuses on the application of machine learning techniques for fault detection in antifriction bearings. Traditional fault detection methods often rely on manual inspection and periodic maintenance, which can be time-consuming, subjective, and inefficient. Different machine learning algorithms, such as support vector machines, decision trees, random forests, k-nearest neighbours, and logistics regression are trained and evaluated using labelled datasets of normal and faulty bearing conditions. The proposed approach shows promising potential for real-time monitoring and early fault detection, enabling proactive maintenance and minimizing unexpected breakdowns. Nine statistical features are extracted from the vibration data, and these are fed to the models, and the later data are trained and tested. The trained Random Forest model can differentiate the faulty bearing with a testing accuracy of more than 97%.

Keywords: Machine learning, algorithms, tribology, antifriction bearing.

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Investigation of Tribological Performance of AZ31B Mg Alloy using Lanthanum Oxide (La_2O_3) Nano-Particle based Lubricant

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ABSTRACT

Magnesium alloys have gained growing attention for their application in various industries, including automobile manufacturing, aerospace structures, electronics, and consumer goods. This interest is primarily due to their low density, high strength-to-weight ratio, excellent machinability, and good castability. In this study, the impact of lanthanum oxide (La_2O_3) nano-particles on the tribological characteristics of the contact between magnesium alloy (AZ31B) and steel was investigated. To assess these properties, a reciprocating sliding ball-on-disc tribometer was employed. The lanthanum oxide (La_2O_3) nano-particles were prepared through a facile wet stirring process and incorporated as the dispersed phase in the Polyalphaolefin oil (PAO-4). Various characterization techniques, including Field Emission Scanning Microscopy (FE-SEM), X-ray diffraction (XRD), Energy Dispersive X-Ray spectroscopy, and Raman spectroscopy, were employed to examine the morphological and crystal structural properties of the prepared nano-particles. In addition, this study also evaluated the mechanical properties of the AZ31B, including yield strength, ultimate tensile strength, percentage of elongation, impact resistance, and hardness. Tribological tests were carried out at room temperature under both dry and lubricated conditions. FESEM and EDS techniques were utilized to examine the worn-out surface after conducting the tribological tests. The results of the tribological tests revealed a significant reduction in both the friction coefficient and wear when utilizing nano-particles. The utilization of lanthanum oxide (La_2O_3) nano-particles has demonstrated its effectiveness in enhancing the tribological performance of magnesium alloy (AZ31B), making it more suitable for a range of industrial applications.

Keywords: Magnesium alloy, lanthanum oxide (La_2O_3) nano particles, Friction and wear, Mechanical properties

Performance and tribological study of electromechanical brake with magnetorheological fluid and magnetic powder

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ABSTRACT

Brakes, which are the safety component of any automobile used to control the motion of the vehicle as per the driver's choice. In conventional brakes, friction lining materials are used, which affect the health of human beings and pollute the environment. Hence, there is a need to look for new types of brake systems. In the present work, a new type of electromechanical drum brake is designed that does not use friction lining materials for brake application. It can use magnetorheological (MR) fluid as well as magnetic powder (MP) for brake application. The presented brake has been designed to operate in hybrid mode i.e., shear plus compression mode. These brakes face problems like leakage of MR fluid in MR brakes and low response time for braking in MP brakes. In addition to the design of the new brake, the performance of new brake has been tested with MR fluid and magnetic powder separately on a full-scale brake inertia dynamometer. The performance test results have been compared for both MR fluid and magnetic powder and compared with conventional friction brake. In addition to the performance study, the effect of MR fluid and magnetic powder on brake shoe surface properties has been studied.

Keywords: Electromechanical drum brake, MP brake, performance study, surface properties

A study of tribological behaviors of nano additives used in SAE 10W40 base oil

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ABSTRACT

In the recent era, the focus or effort is on the improvement of the lubricating oil's tribological and rheological properties. Various nano-additives and hybrid nano-additives are added to the base oil to improve the performance of the oil. The main objective of the study of this research is to provide an overview of the tribological behavior of different nano-additives which are added in commercially available SAE 10W40 engine oil. The papers considered for this study includes several nano-additives like molybdenum disulfide (MoS2), Hybrid MoS2 and carbon nanomaterials (MoS2/CNMs), zinc oxide (ZnO), multiwalled carbon nanotubes (MWCNTs), hybrid ZnO/MWCNT, magnesium oxide (MgO) and hybrid Al2O3/graphene. It was found that these research works carried out tribological experiments to evaluate the performance of engine oil (SAE 10W40). The friction coefficients, tribological and rheological properties and wear parameters were performed and analyzed using a ball-on-three-pins tribometer, ball-on-disk tribometer and 3D optical profilometer. The tribological experimental results showed that the non-additives in the engine oil remarkably improved the friction reduction and higher anti-wear capability than the pure oil, and effectively lubricated the mechanical applications. The metal surfaces morphology and chemical compositions were examined by scanning electron microscope, Raman spectroscopy, 3D optical profilometer and X-ray photoelectron spectroscopy (XPS).

Keywords: Tribology and rheological properties, 10W40, nanoadditives.

Tribological characterization of wire arc additive manufactured SS308L component

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ABSTRACT

The majority of components are damaged by wear in operating condition, so the improvement of such components in tribological aspects is required. In this paper wear analysis has been done for a thin wall of stainless steel 308L that was fabricated using wire arc additive manufacturing (WAAM). Dry sliding wear experiments were analyzed regarding load using an unlubricated ball-on-disc tribometer. The results of the wear analysis showed that while the most wear was seen at greater loads and the lowest wear was found at lower loads. Through X-ray diffraction (XRD) investigation of wear debris, martensite was found to be the dominating phase. Austenite changes into martensite as a result of the AM- Austenitic Stainless Steel (ASS) wear process. The observed changes can be attributed to ASS's metastability when it undergoes plastic deformation. The plastic deformation of sliding surfaces is more pronounced under high loads. As the load is increased, the amount of ferrite (%) reduces because of the increased plastic deformation, which causes austenite to change into martensite. Comparing the WAAMed alloy to the wrought alloy, the experimental results likewise showed an increase in hardness and a notable improvement in wear resistance.

Keywords: Wear characteristics; wire arc additive manufacturing; SS308L Steel; Microstructural evaluation

Tribology performance of high oleic acid vegetable oil as biolubricant blended with ZDDP additive

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ABSTRACT

The growing sale of automotive vehicles and the industrial revolution causes a rise in lubricant consumption to reduce frictional power losses. The used lubricants discarded in the environment are non-biodegradable and cause environmental concerns, hence the development of biodegradable lubricants is essential for the green environment. Bio-lubricants are projected to reduce the world's reliance on imported petroleum products. The biolubricants were synthesized from high oleic acid vegetable oil such as olive oil through base catalyst transesterification of the olive fatty acid methyl ester with Trimethylolpropane in the presence of sodium methoxide catalyst. Olive oil contains 68.7% oleic acid, which aids in the formation of an oil oxide film on the metal surface. The olive biolubricant was blended with ZDDP (Zinc di-thiophosphate) additive with 3% and 5% concentrations. The tribological performance of the synthesized olive biolubricant with ZDDP was assessed on a pin-on-disc tribometer under various operation conditions and results were compared with veedol oil SAE 20W40. According to the findings, adding ZDDP to olive biolubricant minimizes friction and wear on rubbing metal surfaces. The rheological and physicochemical parameters were evaluated and determined to be within acceptable limits. The coefficient of friction was reduced by 89% with a 3% blend of ZDDP in olive biolubricant and reduced by 47% with a 5% blend of ZDDP in olive biolubricant. In terms of performance characteristics, an olive biolubricant containing 3% ZDDP was discovered to be the best mix for piston-cylinder assembly. The study indicated that olive oil has the potential to be used as an industrial and automotive lubricant with a tiny amount of ZDDP additive.

Keywords: biodegradable lubricants, rheological and physicochemical parameters, ZDDP.

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Thermohydrodynamic analysis of gas foil journal bearings using EN42J spring steel as foil material

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ABSTRACT

The most effective replacement for traditional solid-contact bearings and other types of hydrodynamic bearings are gas foil bearings (GFB).These bearings are commonly used in high-speed rotating machinery to reduce friction, wear, and power losses, leading to improved efficiency and performance [1]. GFBs typically use thin metallic foils (of thickness 100 □m-150 □m) as the bearing surfaces to support the rotating shaft without the need for physical contact. The choice of foil materials is critical as it directly affects the bearing's performance, durability, and reliability under various operating conditions. Several materials are commonly used as foil materials in gas foil bearings are Inconel [2], beryllium bronze [3], stainless steel [4] etc. One such material is EN42J spring steel. EN42J spring steel is known for its high tensile strength and excellent mechanical properties. This high strength allows it to withstand the forces and pressures experienced in gas foil bearings, ensuring long-lasting performance in turbomachinery. Forming EN42J spring steel generally requires lower processing temperatures compared to super alloys like Inconel, which typically require elevated temperatures for forming and shaping. Ease of machinability, reduced material waste and cost effectiveness are some of the major advantages of EN42J spring steel. The present article examines the hydrodynamics and thermohydrodynamics of gas foil journal bearings under slip-flow conditions. It uses a mathematical model, evaluating viscosity and density, and solving energy equations using finite difference methods. Conclusions are drawn regarding the benefits of using EN24J spring steel as foil material.

Keywords: EN42J spring steel, thermohydrodynamic analysis, energy equations

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Enhancing the scratch and tribochemical wear resistance of silica glass surfaces with graphene

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ABSTRACT

The brittleness of glasses renders them vulnerable to contact-induced damage during their manufacturing, transportation, and service life. Scratches, in particular, leave a longer trace of defects which later act as sites of sub-critical crack nucleation and chemical attack [1]. The formation of such surface defects on glasses is attributed to the asymmetric contact stress fields caused by the sliding friction between the glass and the rigid countersurface [2]. This warrants the investigation of coatings that not only alleviate the friction, thereby hindering the nucleation of superficial flaws, but also impart resistance against chemically reactive species. To this extent, we systematically study two-dimensional graphene as a coating material for silica glass surfaces. Thin graphene sheets, deposited on silica via thermo-mechanical exfoliation from a HOPG crystal, were characterized with Micro-Raman and atomic force microscopy (AFM) to evaluate their nature, thickness, and lateral size distribution. The nano scratch tests of graphene-glass surfaces carried out with AFM reveal a dramatic (~98%) drop in friction down to the superlubricity regime, consequentially resulting in lower wear post-scratching. Scratch tests in aqueous conditions also demonstrated minimal tribochemical wear of glass owing to the hydrophobicity and chemical barrier nature of graphene preventing the dissolution reactions. Furthermore, the atomistic simulations unravel the stress-shielding and deformation mechanisms of the graphene-glass system that aids in lowering the plastic damage. Altogether, the experimental and simulation results highlight the potential of two-dimensional graphene coatings in enhancing the scratch as well as tribochemical wear of glasses.

Keywords: Atomistic simulation**,** AFM, 2D graphene coating, tribochemical wear.

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Design and development of IOT based hydrostatic journal bearing test rig

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ABSTRACT

This paper presents the design and development of an IoT-based hydrostatic journal bearing test rig, focusing on the application of sensor fusion technology and the measurement of the fluid film stiffness coefficient. The test rig is equipped with various sensors to collect comprehensive data during bearing operation. Sensor fusion technology integrates data from multiple sensors, enabling a holistic analysis of the bearing's performance. Google Firebase is utilized as a data recording platform for secure and efficient storage of the signals and measurement data. The measurement of the fluid film stiffness coefficient provides insights into the bearing's load-carrying capacity and stability. The IoT-based hydrostatic journal bearing test rig incorporates sensor fusion technology to capture and analyze the behavior of the bearing. Various sensors, including temperature, pressure, speed, and displacement sensors, collect data during operation. By integrating data from multiple sensors, a comprehensive understanding of the bearing's performance is achieved. The data is recorded and stored using Google Firebase, ensuring scalability and real-time access to the recorded signals and measurements. Additionally, the measurement of the fluid film stiffness coefficient offers valuable information about the bearing's ability to support the applied load and maintain proper lubrication. This research contributes to the optimization of hydrostatic journal bearings, enhancing their reliability, efficiency, and lifespan in industrial applications.

Keywords: Hydrostatic Journal Bearing, Fluid film thickness, IOT, Measurement

Experimental Study on 2D Nanoparticle Additions on Fully Formatted Commercial Gear Lubricant Tribological Performance using a Four Ball Tester

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ABSTRACT

In order to reduce wear, friction, and the influence of surface roughness fluctuations, this study aims to examine the effects of introducing 2D nanoparticles as lubricant additives. Tribological tests were conducted using a four-ball tribometer and commercially available super-finished chromium-coated spheres to assess the effects of graphene, reduced graphene oxide (rGO), molybdenum dioxide (MoS2), and hexagonal boron nitride (hBN) on wear and friction. Morphological and elemental characterizations of the nanoparticles were performed using state-of-the-art techniques such as field-emission scanning electron microscopy (FESEM), electron dispersive spectroscopy (EDS), and transmission electron microscopy (TEM). To fine-tune the experimental setup and examine various variables, the Taguchi method was used as the design of the experiment. Each of the four nanoparticles in this approach had three possible values, for a total of nine possible trials (L9). In this investigation, gear lubricant mixed with chosen nanoparticles was prepared by magnetic steering and ultrasonication. The zeta potential was used to evaluate the dispersibility of samples. For all of the specimens, we determined their volume-to-volume ratio (%V/V). In order to optimise sonication parameters (time and power), the samples with the highest nanoparticle volume concentration were chosen as a reference. According to the findings, the gear lubricant's performance was much improved by using a mixture of heterogeneous nanoparticles. In particular, the wear volume was reduced by 78% and the friction coefficient by 52% as a result of these improvements. The fact that the lubricant's characteristics have been successfully enhanced bodes well for potential applications in a wide range of gear systems. This research used improved sonication conditions to simultaneously mix a number of nanoparticles to improve dispersibility and lessen sedimentation in gear lubricant. Additionally, the 2D nanoparticles as additions show notable enhancements in tribological performance for tribo-pairs, proving the four-ball tester's viability for lubricant characterization.

Keywords: Taguchi method, four-ball tester, Gear oil, 2D nano particles, Graphene, rGO, MoS2, hBN, Friction, Wear.

Enhancing Tribological Performance of AISI A2 Steel through Laser Surface Texturing: Exploring Nature-Inspired Patterns

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ABSTRACT

Surface treatment methods have been widely employed to improve the tribological performance of various engineering materials. This study focuses on investigating the effects of laser surface texturing (LST) on AISI A2 steel surfaces. Specifically, different nature-inspired textures, such as human fingerprints, snake skin patterns, and shark skin patterns, were synthesized on polished AISI A2 substrates using a fibre laser with a wavelength of 1064 nm. By maintaining constant laser power, beam diameter, scanning speed, and laser frequency, the shape of the textures was selectively modified to generate distinct patterns. The textured surfaces underwent evaluation of their coefficient of friction (COF) and wear mechanism under various loads against an EN-31 counter body. To examine the surface morphology and elemental composition prior to sliding tests, as well as to analyze the wear tracks following the sliding tests, the textured surfaces were characterized using field emission electron microscopy (FESEM) and energy-dispersive X-ray spectroscopy (EDS). Tribological tests were conducted using a ball-on-disk tribometer under dry sliding conditions. The experimental results reveal that the textured surfaces exhibit effective debris-trapping capabilities, leading to a substantial reduction in the coefficient of friction. Furthermore, the geometry of the textures plays a crucial role in determining the wear mechanism and dynamics of wear debris at the sliding interface.This comprehensive approach facilitated a thorough evaluation of the surface properties and tribological behavior of the textured surfaces. The findings strongly suggest that LSTof nature inspired textures can effectively improve the tribological performance of AISI A2 steel by promoting favorable wear mechanisms and influencing the dynamics of wear debris.

Keywords: LST, coefficient of friction, FESEM, EN-31

A novel study of zinctitanate nano additives and its synergy with phosphonium ionic liquid for potential in lubricants

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ABSTRACT

The relentless pursuit of environment benign lubricant aspires to lower/replace SAPS compounds (Sulphated Ash, Phosphorus, Sulphur) which negatively impact the emission after-treatment system of automotive vehicles by undermining the catalytic convertors. This has been a strong motivation to replace/minimize ZDDP from engine oils. This novel study explored Zinctitanate (ZnTiO3) nanoparticles (APS <100nm) for potential in lubricant formulation. A series of nano-oils were formulated by varying Zinctitanate nanoparticles concentration (0.25-1 wt.%) along with a commercial dispersant PIBSA (1wt% fixed concentration) in PAO-6 (API group IV) base oil. Colloidal stability of the Zinctitanate nanoparticles was studied using DLS analysis and visual inspection at regular intervals. Zinctitanate outperformed several other nanoparticles (Boehmite, CuO, Al2O3, ZnO, SiO2, ZnO, and hBN) in dispersion stability (majority dispersed even after 225 days), which could be attributed to physicochemical properties of Zinctitanate nanoparticles and plausible steric repulsion provided by the dispersant. Antifriction, antiwear, and extreme pressure performance of the formulated nanolubricants were assessed using four ball tribometer. All concentrations of Zinctitanate nanoparticles improved tribological performance and the concentration of 1wt% gave excellent antiwear (26-53%), antifriction (14-18%), and extreme pressure (65%) enhancement compared to the base oil. Further, synergy with phosphonium phosphate ionic liquid were studied and they outperformed commercial ZDDP additive under similar working conditions. Surface characterization (SEM, EDS, XPS) results confirm the formation of protective transfer film (at least 100nm thick) composed of FeTiO3 and ZnO due to disintegration under tribostress and subsequent tribochemical reaction with the nascent steel surface.

Keywords: Zinctitanate, nanolubricants, AW additives, ionic liquid, colloidal stability, EP additives, synergy

Determination of friction transition under high acceleration

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ABSTRACT

Tribology, or the study of friction, wear, and lubrication, is an important field in engineering that greatly impacts the performance and reliability of different systems. The tribological behaviour of materials under high acceleration sliding conditions is less known, and these situations are applicable to crashing. The present study investigates the friction behaviuor of materials with sudden sliding. A series of tribological tests were performed in this study using an Impact tribometer. The test samples include polymers, fabric, seatbelt elastomers, and viscoelastic materials. The effects of normal load, sliding velocity, and contact parameters on the friction coefficient were investigated. Contact stiffness in the mentioned case plays an important role in determining the friction coefficient. The present study advances our understanding of the friction transition mechanism at sudden sliding with high acceleration. The findings will help to develop more efficient and reliable systems that use soft materials in high acceleration sliding environments.

Keywords: Friction, soft materials, high acceleration, contact stiffness, contact geometry

An experimental investigation on tribological study of lapped titanium alloys manufactured by 3D printing and casting process with different carbide balls

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ABSTRACT

Titanium alloys are manufactured by additive manufacturing (AM) and casting process. The choice between AM and casted titanium alloys depends on the specific requirements of the application. Compared to casting, AM/3D printing allows for the precise control of microstructure, resulting in fine-grained structures with improved mechanical properties. It offers greater design freedom, enabling the production of complex geometries and customized components. However, AM titanium alloys show the higher surface roughness. This surface roughness data is crucial for evaluating the friction, and wear properties of surfaces. Rough surfaces have larger contact areas, leading to increased frictional forces. Irregularities on rough surfaces act as stress concentrators, accelerating material removal and wear rates. Therefore, finished surfaces obtained from lapping process are used in wear experiments. In this study, wear tests were performed using reciprocating sliding tribometer on the AM titanium alloys and compared to casted titanium alloys against the various hard counter bodies. The experiments were conducted with a constant load of 5 N, frequency of 10 Hz, and stroke length of 1 mm for 30 min. The coefficient of friction values on AM titanium alloys against the boron carbide, silicon carbide, tungsten carbide, and titanium carbide are 0.32, 0.31, 0.49, and 0.38 respectively. Compared to AM titanium alloys, lower coefficient of friction was observed on the casted titanium alloys against the hard counter bodies except the silicon carbide. Lowest and highest specific wear rates were observed on casted titanium alloy against the silicon carbide and AM titanium alloy against the tungsten carbide.

Keywords: Additive manufacturing, titanium alloy, coefficient of friction, wear

The effect of multi-walled carbon nanotubes on the crystalline structure and wear resistance of reinforced hydroxyapatite composite coatings for orthopedic applications

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ABSTRACT

For load-bearing orthopedic implants, metallic substrates coated with hydroxyapatite (HA) are commonly used. The HA coating's poor crystallinity, fracture toughness, and wear resistance expedite failure of the implant and bioresorption, resulting in poor adhesion between the coating and substrate. Therefore, using the plasma spraying process, an effort is made to improve the crystallinity, fracture toughness, and wear resistance of the HA coating in the present investigation. To acquire desirable properties Plasma spray coating was used to coat titanium grade 2 substrates with hydroxyapatite and hydroxyapatite reinforced with 4% (by wt.) multiwalled carbon nanotubes (MCNT). X-ray diffraction was used to characterize every coated substrate. These coated substrates wear behavior was investigated using simulated bodily fluid (SBF), which has a pH range of 7.20 to 7.40. The outcomes show that adding 4% (by wt.) MCNT to the substrate causes the formation of a suitable crystalline and desired dense bio-active hydroxyapatite coating. This improvement is by virtue of inherent mechanical properties and the crack bridging effect offered by MCNT. The addition of MCNT also helped in restricting crack propagation in the coatings.

Keywords: Hydroxyapatite coating, wear resistance, simulated bodily fluid, plasma spray coating

Fabrication of mini rough terrain robotic vehicle

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ABSTRACT

Mini rough terrain robotic vehicle is developed by the working principle of Rocker-Bogie mechanism. This mechanism has 6 legs with 6 wheels and have no springs and stub axles, it doesn't have any kind of steering mechanism. This robotic vehicle climbs over obstacles such as rocks that are twice the size of the wheels. This terrain robot is designed for low speed and high torque. This vehicle is prepared by using tribological CPVC pipes, 6 gear motors and wheels, Arduino UNO, Motor driver module, Bluetooth module. This robotic vehicle is applicable for multi-purpose use such as mobile control robotic vehicle, Fire detection robot, Army application, tribological applications, etc.

Keywords: Robotic vehicle, rocker-bogie mechanism, tribological properties

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Discovery of tribological materials by machine learning approaches

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ABSTRACT

Machine learning aided material discovery and there is an increase in demand for newer materials. Research is in infancy for the discovery, manufacture and deploying of advanced materials. The lack of material, property information leads to wrong results even under ideal conditions [1]. Since the availability of large scale data and fast computational tools can help to reduce the automated discovery of materials at lower costs [3]. Various machine learning approaches have been put forward by different researchers for understanding the material stability. Material researchers are designing materials for the changing parameters but more research has to be taken to understand the stability prediction driven by suitable machine learning algorithms [2]. Although the simulations of known materials are available, the stability prediction of the unknown materials have to be taken into consideration for the future. In this work we have analyzed the materials of the different alloys by having different combinations. The motivation is to design and develop materials with improved mechanical strength, ductility and resistance to wear corrosion at high temperatures. Machine Learning aided material discovery will help in identifying the right selection for different applications.

Keywords: Machine learning approaches, wear corrosion, mechanical properties

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Unveiling wear mechanisms and mapping plots of Mg-Bi-Zn-Ca foam during dry sliding

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ABSTRACT

Mg-Bi alloy system is attractive class of light weight material to fabricate ductile Mg based alloy. Closed-cell Mg alloy foam has excellent tribological performance in ultra-light tribological applications. In present investigation, wear mechanisms of Mg-Bi-Zn-Ca closed-cell form were carried out to study wear properties at different tribological parameters. Closed-cell Mg-2Zn-2Ca alloy foam was fabricated by melt processing route using dolomite and MgCO3 mixture as a blowing agent. Bismuth (Bi) was added by 2 wt.% and 4 wt% during stirring. In Mg based alloys, Zn improves mechanical properties as well as biocompatibility and Ca used as grain refining element as well as enhance the viscosity of melt during foaming procedure [1]. Bi improves the ductility in Mg based alloys. Dry sliding wear testing was carried out on pin-on-disc friction and wear monitor. Normal load and sliding speed were varied from 5N-100N and 2-4 m/s respectively at 1000 m sliding distance [2]. Microstructure analysis by optical microscopy and hardness tests were conducted to study the formation of Mg-Bi intermetallic phases and its effect on surface properties during sliding motion of Mg-Bi-Zn-Ca closed-cell foam. Due to porous surface of foam, wear rate was decreased by filling porosities by wear debris of oxide and flakes. Wear mapping plots were developed to identify wear mechanisms which were mainly abrasive, oxidation, delamination and plastic deformation wear. Addition of Bi in Mg based alloy foam showing promising material for light-weight bioresorbable bone implant, automotive and aerospace applications.

Keywords: Wear mechanism, Bi-Zn-Ca closed cell foam, friction

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Tactile friction under boundary lubrication: effect of surface and molecular properties

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ABSTRACT

While holding any object, there is an active interaction between our fingertips and the object's surface. Both the normal and the frictional load applied by the human fingers play an essential role in this tactile exploration. The system under study can be generalized, and the study's goal is to investigate friction between a deformable patterned soft substrate (Elastic modulus ≈105 -106 Pa [1]) and a stiffer substrate in the presence of boundary lubrication. Coefficient of friction (COF) values were calculated using the human finger for different lubricating solutions and different substrates. All the measurements were made on an in-house developed strain gauge-based force sensor, capable of measuring both the normal and the frictional force simultaneously and independently. The results after post processing [2] indicate that adding a small quantity of lubricating solution between the finger and the substrate drastically reduces friction. COF values plummeted from 1 to 0.65 for deionized water to as low as 0.1 for Sodium hydroxide (Soda) solution. Surfactant solutions like Sodium dodecyl sulphate (SDS) facilitates boundary lubrication[3] and gives COF values of about 0.4, and even lower for different concentrations. The COF is observed to change with the concentration and saturates beyond the critical micellar concentration for SDS. The role of human skin, owing to its low elastic modulus and affinity for specific interactions with different molecules, cannot be understated in determining tactile friction.

Keywords: Coefficient of friction, Sodium dodecyl sulphate, lubricants

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Wear mechanisms in total knee implants

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ABSTRACT

Total knee replacement (TKR) is an effective orthopaedic surgical procedure to confront osteoarthritis and restore bone joint mobility, relieve pain, and enhance the quality of life. One of the most significant problems is osteolysis around total knee arthroplasty which causes implant failure and leads to revision surgery. The development of osteolysis is often related to the wear of the polyethylene-bearing surface with the production of biologically active particulate debris. Wear is affected by several factors which can be patient, technique, or implant-associated. Patient factors include age, size, and activity level. The surgical technique must focus on reducing wear by focusing on correct implant alignment and restoring the mechanical axis of the joint. Implant factors in knee arthroplasty include component design (both bearing surface and backside) and polyethylene insert characteristics. These include the structure and thickness of the insert. The structure is closely related to the manufacturing processes used as well as the post-manufacturing sterilization and packaging. Wear in orthopaedic implants occurs in four modes depending on the location where wear is occurring. Mode 1 wear occurs at the articulating surfaces while Mode 2 wear occurs between an articulating primary bearing surface and a surface that was never intended to be a bearing surface. Whereas Mode 3 wear occurs between articulating surfaces in the presence of third-body components. Mode 4 wear occurs between the back of a polyethylene insert and the metallic tray of a tibial component. The wear mechanisms involved in knee implant failures are adhesive, abrasion, third-body wear, fatigue wear, and corrosive wear. The wear debris released due to these wear mechanisms from the articulating surfaces reacts with the surrounding tissues. When the wear debris reaches the prosthetic bone, it triggers osteolysis which leads to implant failure. Severe wear leads to catastrophic failure of the implant. Therefore, it is important to understand the mechanism behind implant wear to reduce them and meet the current life expectancy of the implant.

Keywords: Backside wear, Polyethylene wear, Total knee arthroplasty/replacement, Wear mechanism,

Fault diagnosis in conical journal bearing using vibration analysis

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ABSTRACT

Journal consists of a shaft or journal that freely rotates inside a metal sleeve or shell that provides support. They are widely used in applications where high speeds are essential, such as IC engines and centrifugal pumps. Bearing wear and corrosion are one of the most common causes of journal bearing failure in an industry, which results in significant safety risks and financial loss. Therefore, in order to identify these defects at an earlier stage, a suitable condition-monitoring technique must be chosen so that catastrophic failures can be avoided and monetary loss can be prevented. This paper presents a conical journal-bearing fault detection methodology based on vibration analysis. For the purpose of analyzing conical journal-bearing flaws like wear, holes, grooves, looseness, etc., a journal-bearing test rig is developed. The frequency vs amplitude plot of healthy and faulty bearings is compared after experimental data for healthy and unhealthy bearings is acquired using FFT Analyzer. The distinctive vibration characteristics of the journal-bearing defect are at 6X of the operating frequency, and they remain constant for various operating speeds and defect sizes. This unique feature is dependent on the contact angle between the bearing and the journal. It is observed that, due to the defect, fluid film thickness decreases by 37%. Also, the fluid film thickness decreases as the defect size increases. The findings are matching well with the conclusions reported in the literature.

Keywords: Wear, corrosion, journal bearing, fluid film thichness

Performances analysis of bearing with surface waviness operating with lubricant additives

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ABSTRACT

The present study investigated the effect of surface waviness on the dynamic and stability performances of journal bearing operating with copper oxide (CuO) and cerium oxide (CeO2) as lubricant additives. The dynamic performance parameters of bearings with surface waviness and nano additives in lubricant are calculated using the non-dimensional form of the Reynolds equation and finite element method. Dynamic performance parameters like stiffness, damping coefficients, and threshold speed are calculated at different waviness values in the circumferential, axial, and both directions at various wave amplitudes with variable viscosity of lubricant due to the inclusion of nano additives. The viscosity equation developed from the results of experiments with SAE 15W-40 oil provides a relationship between the relative viscosity, temperature, and concentration of nano additives in lubricant in the temperature range of 30-90 degrees Celsius. According to the calculated results, the effect of waviness on the bearing surface increases dynamic coefficients and threshold speed and the maximum enhancement in stability threshold speed is observed with waviness in the circumferential direction with three waves and 0.5% concentration of CuO in lubricant at 900C as compared with waviness in the axial direction or in both directions. In addition, as the wave amplitude increased, the stability of the bearing improved. The optimum surface waviness parameters and nanoparticles as additives in lubricants have been determined to get the maximum dynamic performance and stability and the current findings will be beneficial for designers to improve the performance of hydrodynamic journal bearings.

Keywords: Hydrodynamic journal bearings, additives, damping coefficients

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High temperature tribological studies using hybrid nano lubricants containing ZDDP and silica nanoparticles

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ABSTRACT

This research presents a thorough examination of the tribological characteristics of a high-temperature hybrid lubricant composed of silica nanoparticles and zinc dialkyl dithiophosphate (ZDDP). Analysis of the lubricant's tribological behaviour at both the macroscopic and nanoscale levels sheds light on its viability as a high-temperature lubricant. Tribological tests were performed at the macroscale level using a reciprocating ball-on-flat configuration at high loads and temperatures. The hybrid lubricant's coefficient of friction and wear performance was measured and compared to those of the neat base oil. The results show that the friction-reducing and anti-wear properties of the ZDDP-based lubricant are greatly enhanced by adding silica nanoparticles, especially at high temperatures. The hybrid lubricant's improved tribological properties come from the complementary interactions between the ZDDP additives and the silica nanoparticles. Atomic force microscopy (AFM) was used to measure nanoscale friction forces and wear behaviour to understand the underlying mechanisms at the nanoscale better. The analysis by AFM shows that the hybrid lubricant effectively reduces friction and wear by forming a robust tribofilm on the sliding surfaces made up of ZDDP-derived species and silica nanoparticles. The results of this research offer essential information for developing and improving hybrid lubricants used in high-temperature settings. To improve lubricants' tribological performance in harsh environments, a promising strategy is to combine silica nanoparticles with ZDDP additives.

Keywords: Tribological characteristics, high-temperature lubricant, nanoscale friction

Evaluation of microstructure and wear behavior of materials for selection of material of side guide liners of HSM

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ABSTRACT

The present work deals with the microstructure wear behavior of different types of prospective materials for side guide liners of the coiler section of Hot Strip Mill (HSM). Materials used for this study were hot rolled low carbon steels, forged medium carbon steel and Cr-Mo alloyed medium carbon steels. Wear tests were also performed under room temperature against heat treated 5% Chromium tool steel disc by using a Friction and Wear testing machine with a pressure of 4 bars at a constant rolling speed of 100 rpm for 15 hrs test duration. Samples were also investigated by using Optical microscopy, Scanning Electron Microscopy (SEM) with Energy Dispersive Spectrometer (EDS) to correlate the wear behavior of the materials by microstructural analysis and select suitable materials for plant trials. It was found from the investigation that the matrix microstructure, amount, and distribution of different phases/ carbides play an important role in the wear performance of the materials. Under dry condition, the amount of wear with the low carbon steel, medium carbon steel, and Cr-Mo alloyed medium carbon steel is lower by over 10%, 58%, and 62% respectively from that with the existing liner material. Plant trials at HSM reveal that the medium carbon steel liner exhibited the best techno-economics by showing a reduction in wear by over 58% compared to that of existing liner material.

Keywords: wear, hot strip mill, tribological behaviour.

Experimental investigation of tribological properties of callophyllum inophyllum bio-lubricant oil modified with nano sized molybdenum disulphide

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ABSTRACT

The aim is to study the tribological properties of bio-lubricant Callophyllum Inophyllum (CI) oil modified by dispersing 0, 0.2%, 0.3%, 0.4% and 0.5% nano sized molybdenum disulphide (MoS_2) added to base oil. The test was conducted using a four ball tribotester according to the ASTM D-4172. CI oil has been chosen because of its high viscosity and ease of availability. MoS_2 nano-particles were used in CI oil on weight percentage basis. A certain amount of concentration of the friction modifier has been found to significantly improve tribological characteristics of the base oil. Rheological tests were carried out by using Anton paar MCR 102 rheometer in order to access its flow behaviour of bio lubricant. The potential benefits of adding nano compounds like MoS_2 to lubricating oils to improve their rheological qualities are astounding. Using an energy dispersive system (EDS) and a Field emission scanning electron microscope (FESEM), the surface characteristics of the balls under test were examined. In comparison to the virgin CI oil, the minimum wear scar diameter was reduced by 10% at 0.04% of nano-additive reinforcement. The outcomes showed that their addition significantly reduced the test balls wear. The Raman analysis revealed that the nano additives were adsorbed on the wear scar surface thereby confirming the development of tribolayer.

Keywords: Bio-lubricant, callophyllum inophyllum, molybdenum disulphide, wear, nano-additive, tribolayer.

Sliding wear of copper impregnated carbo-graphite under different conditions

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ABSTRACT

The present study aims to assess the effect of the copper impregnation on the friction and wear behaviour of carbo-graphite at room temperature (RT) and 120 °C under dry and lubricated conditions by carrying out tests under a constant normal load of 20 N and a sliding speed of 3 m/s using a pin-on-disc tribometer sliding against EN31 steel. The results demonstrate that plain carbo-graphite (CG) exhibits a lower coefficient of friction (0.301 and 0.257) compared to 0.337 and 0.441 for copper-impregnated carbo-graphite (Cu-CG) at room temperature (RT) and 120 °C under dry conditions due to the presence of a transfer layer of graphite which provides easy shearing capability at the sliding interface. Additionally, Cu-CG exhibits a lower wear rate (0.23 x 10-5 and 0.87 x 10-5 mm3/Nm) compared to CG (3.01 x 10-5 and 4.08 x 10-5 mm3/Nm) at RT and 120 °C, which has been attributed to the higher hardness of Cu-CG. However, under lubricated conditions, Cu-CG exhibits the lower coefficient of friction (0.0218 and 0.0549) and wear rate (0.66 x 10-5 and 0.21 x 10-5 mm3/Nm) compared to CG at RT and 120 °C. These improved friction and wear performance of Cu-CG under lubrication has been ascribed to the copper impregnation, which enhances the mechanical properties, reduces the content of open pores and enables the liquid constrained between surface asperities to hold higher pressure.

Keywords: Seals, Carbo-graphite, Impregnation, Solid-lubrication, Friction, Wear.

Micro indentation behavior of electroplated Cr layers

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ABSTRACT

Wear of engineering components is an important degradation process. The consequence of this is the loss of material and performance of components resulting in decrease in service life of the components. Electroplated chromium coatings can be considered to be potential layer for this purpose to improve the performance and service life of components. Efforts are being made to replace the conventional chromium electroplating based on hexavalent chromium with the electroplating process based on trivalent chromium bath. This is due to environmental regulations imposed and the need to phase out the hexavalent chromium deposition process. In this work, an attempt is made to evaluate the microstructural features and Micro indentation response of chromium electroplated deposited by trivalent Cr and hexavalent chromium bath. These coatings will be characterized in as-coated condition and also in heat treated condition given for hydrogen relief. In view of the above discussion present investigation has been undertaken to understand the deformation behaviour of Cr plating both as hard chrome and as high efficiency Cr plating. The influence of heat treatment on the deformation Behaviour is also evaluated. The mechanical properties will then be correlated with the coating microstructure. The results of this investigation will be presented in detail.

Keywords: wear, electroplated chromium coatings, mechanical properties.

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Tribological evolution of AISI52100 bearing steel, brass, and copper surface under dry and lubricated with eco-friendly mahua oil

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ABSTRACT

The world energy crisis and the depletion of fossil fuels at an enormous rate are the major concerns to look for an alternative source of energy. Almost 1/3rd of the fuel energy used by vehicles (passenger cars and heavy-duty) is utilized to reduce frictional losses. A threefold increase in fuel efficiency in automobiles may result from a reduction in friction losses. These friction losses can be minimized by interposing a thin layer of low-shear strength of gas, liquid, and solid material which are well-known as lubricants. Lubricant consumption is approximately 45 million metric tons worldwide per year, with a 2.1% increase in demand since 2012. These lubricants are mainly formulated with mineral oils and chemical additives which severely damage the environment. Mineral oils have many positive attributes; however, they are non-renewable, unsustainable, and major polluters of the environment during their life cycle. The major problems with conventional lubricants are related to drainage and disposal which severely damage the aquatic ecosystem. This research work aims to investigate the tribological characteristics of Mahua oil (MO) under deferent contact material such as (AISI52100 Bearing Steel, Brass, and Copper). These materials are mainly used in deferent engineering application such as valve train, piston assembly, crankshaft, auxiliary parts, and brakes. To understand the lubrication mechanism and performance of mahua oil under deferent loading condition has been conducted.

Keywords: sustainability, tribology, Mahua oil, AISI52100 Bearing Steel, Brass, and Copper.

Fascinating science of nature inspired — nano/water interface for atmospheric water harvesting, self-cleaning, and water treatment

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ABSTRACT

Across the globe, the freshwater scarcity crisis has accumulated into a colossal crisis that requires innovative solutions to ensure the sustainability of the Earth. Nature has always been an intriguing source of inspiration for resolving pressing challenges. The idea of engineering multifunctional surfaces inspired by nature is a promising approach to addressing various water-related issues. In this work, we present nature-inspired multifunctional surfaces with application in atmospheric water capturing, self-cleaning, and oil/water separation [1-3]. Fishing fresh water from the atmosphere can provide an alternative source for agriculture and household activities, especially in arid regions. Similarly, the idea of self-cleaning in nature could be used to emulate the surfaces that could save thousands of gallons of water which is particularly important in regions where water resources are scarce. Furthermore, separating water from oil mixtures can help clean natural bodies of water, preserve aquatic species, and reduce the cost of pre-filtering for desalination. The use of these multifunctional surfaces can also have other environmental benefits, as they typically operate based on the laws of physics at solid/liquid interface, avoiding the use of toxic chemicals and tedious procedures that could lead to indirect pollution and toxicity. Nonetheless, there is still a need for more research to develop superior, yet scalable hierarchical multifunctional surfaces that can effectively capture, and conserve freshwater resources. Investing in research and innovation in this area can have a significant impact on preserving the sustainability of the Earth and ensuring that growing populations have access to clean water.

Keywords: Nature Inspired, Water Crisis, Nano/Water Interface

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Wear resistant rails for Indian railways

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ABSTRACT

Indian railway has ambitious plan to run 100t wagons on its route. The rails for such route should have better Tensile Strength and Hardness than the existing rails for better life. Residual stress in rails reduces the load bearing capacity of rails which is a major point of concern for both the manufacturers and users. Residual stresses in rails are generated through manufacturing process. The natures of residual stress in rail are tensile and compressive at different location of its cross section. Tensile stresses are normally found at foot centre and head of the rail while compressive stresses are found in web. Compressive residual stresses are not harmful, whereas, tensile stresses are undesirable for foot fatigue life. Every rail manufacturer has tried in its own way to minimise the residual stress. The maximum residual stress at foot centre of the rail has been allowed up to 250 MPa as per latest revision of IRS-T12-2009 specification. Indian Railway has also studied the suitability of 880 grade, 60kg rails for 25t axle load operation. Research Design and Standards Organisation (RDSO), Lucknow, Ministry of Railways has considered higher values of residual stress and minimum value of yield strength which has resulted in unsuitability of this rail. International Heavy Haul Association (IHHA) also issues guidelines for selection of rails on the basis of wear and axle load. INNOTRACK project has also provided guidelines for rail selection on the basis of wear and rolling contact fatigue of rails. This study deals with the efforts taken for reduction in residual stress in rails and selection of yield strength value in stress calculation for 25t axle load operation under the Indian condition. A revised calculation under the methodology of Indian Railways is also proposed. A review of rail selection on the basis of wear and rolling contact fatigue in rail is also discussed.

Keywords: Axle load, residual stress, straightening, wear, rolling contact fatigue

Friction and wear analysis of Al-5052/NiTi surface composites fabricated via friction stir processing

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ABSTRACT

This paper presents a comprehensive analysis of wear behaviour of Al 5052-H32 alloy reinforced with Nitinol (NiTi) shape memory alloy using multi-pass friction stir processing (FSP). Four pass FSP was performed to improve the dispersion of NiTi particles in the base material. The processed specimens were subjected to wear testing under varying operating conditions. The results reveal that the addition of NiTi reinforcement significantly enhances the wear resistance of the alloy. The wear rate decreases with increasing NiTi content, indicating improved material durability. The microstructural analysis further elucidates the distribution and interaction of NiTi particles within the aluminum matrix, contributing to the observed wear behavior. Additionally, the friction characteristics of the reinforced alloy were investigated using a friction test apparatus. The coefficient of friction was determined under different loads and sliding velocities. The results demonstrated that the incorporation of NiTi reinforcement leads to a reduction in the coefficient of friction, suggesting improved tribological properties. The research findings can be applied to various engineering applications, such as automotive and aerospace industries, where enhanced wear resistance and reduced friction are desirable. The results also contribute to the understanding of the fundamental mechanisms underlying the interaction between NiTi and aluminum, paving the way for further advancements in materials processing and tribology.

Keywords: Wear analysis, Tribology, Shape memory alloy, Friction stir processing, Aluminum Metal Matrix Composites (AMMCs).

Microstructural evolutions during wear test of low-carbon steels

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ABSTRACT

The emerging trends in additive manufacturing (AM) facilitates new technologies to come up with some advanced features like low fabrication cost, rapid production, large product volume, and excellent mechanical properties. In such scenarios, wire arc additive manufacturing (WAAM) excels more than laser and electron beam-based AM systems, although it has moderate dimensional tolerances. This experimental investigation promotes multilayered fabrication through an advanced WAAM process known as non-transferred WAAM. The prime objective of this work is to study the microstructural evolutions during wear testing using a ball-on-plate tester. The grain flow direction in the worn-out region has been changed compared to the unaffected region, which aligned along the abrasion direction. Some oxide inclusions are also evident in the worn-out region that, signify the occurrences of oxidation due to the frictional heat generation. The formation of an oxide layer in the worn-out region is also identified by employing energy dispersive spectroscopy (EDS) and Raman spectroscopy analysis. There is a minimal variation in the wear rate among three different deposit sections as 0.002118 (Top), 0.002434 (Middle), and 0.002997 mm3/N.m. It indicates the formability and uniformity of the multilayered component fabricated through non-transferred WAAM. The non-transferred nature of this system makes it available for other manufacturing processes, like conventional welding and metal casting.

Keywords: Additive manufacturing, wear, WAAM, EDS

Tribological and corrosion performance of Al6082/SiC-CeO2 hybrid surface nano-composites

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ABSTRACT

This study presents a comprehensive analysis of wear and corrosion performance of Al-Mg-Si-based nanocomposites. Friction stir processing (FSP) was utilized for the fabrication of Al6082-based nano-composites by incorporating hybrid SiC-CeO2 reinforcement particles. The effect of number of FSP passes on reinforcement dispersion was studied via microstructural evolution and further their effects on wear and corrosion characteristics was analysed. Microstructural investigations revealed a homogeneous distribution of reinforcement particles inside the base matrix. Further, results reflected that the wear and corrosion rate decreases with increasing the FSP passes indicating improved material durability. The results of tribological and mechanical properties of this study strongly corroborates with the microstructural evolution. The research findings can be applied to various engineering applications, such as automotive and aerospace industries, where enhanced wear resistance and reduced friction are desirable.

Keywords: Wear; Corrosion resistance; Friction stir processing; Al 6082; Nano-composites.

Chemical transesterification of soybean oil as a feedstock for stable biodiesel and biolubricant production by using Zn-Al hydrotalcite as a catalyst and perform tribological assessment

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ABSTRACT

Trimethylolpropane fatty acid triester (TFATE) is a potential biolubricant that could substitute mineral-based lubricants in an environmentally responsible way. Double transesterification from vegetable oils would play a key role in the development of biodiesel and biolubricants. However, there are difficulties associated with high-pressure maintenance, energy consumption, and substrate saponification caused by strong homogeneous alkaline catalysts. In this research, develop a novel method for using Zn-Al hydrotalcite as heterogeneous catalysts in the production of fatty acid alkyl esters and TFATE-based biolubricants (biodiesel & biolubricants) from vegetable oils through a double transesterification with methanol and trimethylolpropane (TMP), respectively. As a result, high yields of biolubricant were formed under the following chemical conditions for the latter; alcohol to FAME ratio is 4:1; the concentration of the catalyst is 5 wt%; and the temperature is 140 °C. By using XRD, FT-IR, TGA, and SEM-EDX study, the Zn-Al hydrotalcite was examined. The resulted product was analyzed by using 1H NMR, FT-IR, and Gas chromatography techniques. Moreover, physicochemical, along with tribological properties were also evaluated. The developed biolubricant's tribological characteristics indicated the lowest coefficient of friction.

Keywords: TFATE, biolubricants, SEM, EDX

Impact dynamics of elastic-plastic contact: A theoretical and experimental study to estimate the energy loss of spherical ball on a flat surface

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ABSTRACT

Erosive wear resulting from the impact of particles on the surface is important in various areas ranging from collision of celestial bodies, aerospace industry, turbines to tribological contact between the asperities of interacting surfaces. Study of the dynamics of the particle impact on the solid surfaces is crucial to understand the deformation mechanism of the erosive wear. In the present work, we have used high-speed imaging to study the low-velocity normal and oblique impact of an elastic spherical ball against an elastic-plastic substrate. A simple theoretical model, based on the quasi-static contact mechanics, is developed to estimate the energy dissipation during the elastic-plastic contact interaction in the impact process. The experimental studies using high-speed imaging are carried out with the spherical balls of different materials and varying sizes to estimate the energy loss due to plastic deformation. From the SEM micrographs of impact crater, the residual contact radius is obtained, which is used in the present contact model to estimate the energy loss. Subsequently, using the image-processing algorithm, developed in-house, the coefficient of restitution (COR) is determined. The present elastic-plastic contact model is validated by comparing the COR values obtained from the experiments. The results are found to be in good agreement. The present model can be used to estimate the dynamic hardness and also to understand the evolution of the contact pressure during the impact process.

Keywords: Erosive wear, tribological contact, COR, dynamic hardness.

Biolubrication and its enhancement through biomaterials

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ABSTRACT

Biolubrication occurs during sliding movements in the eye, mouth, knee and hip joint as well as in genitourinary and circulatory tracts, which is essential function of health and a critical issue for medical device, implant success in clinical performance. Human body has developed specialized tissues and lubricant fluid to facilitate ultra-low friction during normal human function e.g. blinking, walking, running, speech, mastication and swallowing. Human being take these functions for granted unless due to old age or disease the friction increases and problems like dry eyes, dry mouth and arthritis set in. Often these friction related chronic diseases do not have a treatment, only the pain or irritation can be relieved. Artificial saliva, artificial tears and viscosupplementation fluids are administered to relieve the symptoms, although there are at present very inefficient. The main reason for the failure is because the natural lubrication system is overwhelmed with exogeneous man made compounds, predominantly viscosity enhancers, which do not stay in place for long. In this talk I would like to explain our novel approach to work synergistically with the impaired natural lubrication system. Biomolecules inspired by mucoadhesive adhesive molecules1–3 and cationic macro molecules produced through recombinant4 route are successfully employed by us to restore the impaired biolubrication for dry mouth and arthritis as model systems. Furthermore to test the efficacy of our biomolecules, I will also explain the ex vivo test systems5 we have developed. These ex vivo systems play an important role for pre selection of molecules before taking to preclinical animal or human testing.

Keywords: friction; macromolecules; mucoadhesive; Dopamine; Chitosan

Intelligent web application to detect antifriction bearing defects using vibration analysis and machine learning for industry 4.0

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ABSTRACT

Anti-Friction Bearings (AFBs) are one of the important components of rotating machinery. AFBs failure causes the machines to break down, resulting in loss of production time, risk to workers health /safety and financial loss. In order to identify the type of fault in AFBs, an end-to-end solution in the form of a web application is developed. Vibration data from accelerometers is gathered online and experimentally for healthy condition and faulty condition. The faults considered in this study are defects at the outer raceway and defects at the inner raceway. After segmenting the data over two shaft revolutions, thirteen statistical features are calculated for noise elimination. The most influencing features are chosen using Principal Component Analysis (PCA). The training set is used to train four different types of classifiers: Decision Tree (DT), Random Forest (RF), K-Nearest Neighbors (KNN), and Support Vector Machine (SVM). Following hyperparameter tuning, performance is assessed on the testing set. It is concluded that SVM gives the highest accuracy of 97.64%. Therefore, SVM was chosen to develop the python code. HyperText Markup Language (HTML) and Cascading Style Sheets (CSS) are used to create web page. Flask is used to create an application with the best performance model. AWS's Amazon Elastic Compute Cloud (Amazon EC2) instance is used to deploy the application. The developed application is able to detect defects in any rolling element bearing.

Keywords: Anti-Friction Bearings, PCA, SVM, KNN

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Catheter Friction and Stribeck-Like Characteristics under Varying Speeds and Loads

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ABSTRACT

Catheters are widely used in surgical procedures and disease management. The surfaces are coated with hydrophilic, lubricious materials that reduce patient discomfort and tissue inflammation. In this study we evaluate the friction of several commercial catheters under varying loads and speeds using a novel setup. In this setup, the catheter was gripped using a special holder and tested against silicone rubber with a Shore hardness of 60. Loads were varied from 0.2 to 1 N corresponding to several kPa contact pressure. Speeds were varied from 0.001 to 0.1 m/sec to investigate possible 'Stribeck-like' behaviour for soft contacts. Furthermore, to understand the bulk stiffness of the catheter on friction, catheters were tested with and without inserts. This novel test configuration opens the possibility of evaluating both surface coatings and bulk stiffness effects of catheters on measured friction. With load variation, certain catheters showed a transition from adhesion to deformation regime of friction. Increasing the bulk stiffness of the catheter resulted in lower friction. Under speed variation, certain catheters offered better lubricity compared to others. In certain regimes of load and speed, the lubricious catheters even demonstrated 'superlubricity' with a COF < 0.01.

Keywords: Catheters, lubricants, COF, coatings.

Nanoindentation and tribological behaviour of copper-nickel alloy synthesized by powder metallurgy

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ABSTRACT

In this study, a synthesis process involving mechanical milling and vacuum tube sintering was employed to fabricate the copper-nickel (10, 20 and 30 wt%) alloy. Microstructural analysis using field emission scanning electron microscope (FESEM), and energy-dispersive spectroscopy (EDS) revealed a uniform dispersion of copper and nickel within the alloy. Hardness properties were investigated using micro indentation and nanoindentation techniques at different local regions of the alloy. The experimental results demonstrated that the increasing wt% of nickel effectively enhanced the hardness and elastic modulus of the alloy. Additionally, tribological properties were evaluated under varying normal loads. The wear rates of Cu-(30 wt%) Ni alloy were low compared to other fabricated alloys, revealing significant strengthening by the increasing wt% of nickel.

Keywords: Cu–Ni alloy, Mechanical milling and vacuum tube sintering, micro-indentation and nano-indentation, Friction and wear.

Design and analysis of green brake pad materials for the enhancement of tribological properties and environmental sustainability

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ABSTRACT

This study's objective is to evaluate the effectiveness of environmentally sustainable friction brake pad materials. Brake pads are a crucial part of cars and generate hazardous chemicals that significantly contribute to air and water pollution. Utilizing environmentally friendly brake pad materials can lessen the harm that transportation has on the environment. Through a variety of tests, including wear, thermal conductivity, and coefficient of friction tests, the performance of green friction brake pad materials was examined in this study. The performance of the green brake pad materials was evaluated in comparison to conventional brake pad materials. According to the findings, standard brake pad materials did not perform as well as green friction brake pad materials in terms of wear resistance and heat conductivity, but the difference was not great enough to have an impact on overall performance. The study illustrated that using green friction brake pad materials instead of conventional brake pad materials may significantly lessen the impact of automobiles on the environment. Utilizing environmentally friendly brake pad materials helps lessen air and water pollution and promote a more sustainable future. To increase the efficiency and cost-effectiveness of green brake pad materials, additional research is required.

Keywords: Friction brake pad, wear, wear resistance,

Synergistic effect of laser surface texturing and CrCN coating on the friction between piston ring and cylinder liner interface

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ABSTRACT

The friction loss between piston rings and cylinder liner interface is a major contributor of energy losses in the internal combustion (IC) engines, and it accounts for 4–15% of the overall energy losses. To overcome from this frictional loss numerous techniques have been employed like surface texturing, coatings, lubrication etc. on the piston ring and cylinder liner interface. However, the combined effect of these techniques has not been studied in depth. In this present work, analysis of the combined effect of surface texturing and the surface coating applied to the piston ring to reduce coefficient of friction (COF) at piston ring and cylinder liner interface has been studied. The CrCN Coating is applied to the piston ring through DC magnetron sputtering technique, and the circular dimple textured to the piston ring through laser surface texturing technique. The coated sample, textured sample and the coating over the textured sample are compared for the frictional analysis under the boundary lubrication regime. The tribo testing is simulated using the reciprocating engine tribometer rig.

Keywords: Friction, Tribology, Surface coatings, Texturing, Piston ring /liner, Engine

Investigating tribological performance of surface laser textured AA 5052 under dry and lubricated sliding conditions

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ABSTRACT

Aluminium alloy 5052 (AA 5052) holds significant importance in various tribological applications due to its favourable mechanical properties, corrosion resistance, and lightweight nature. However, there are ongoing challenges in improving its tribological performance. Surface texturing has emerged as a promising technique to address these challenges by modifying the surface topography, which can influence friction, wear, and lubrication mechanisms. This study aims to investigate the effects of surface laser texturing on AA 5052, with the goal of enhancing its tribological properties. Three distinct surface textures, namely circular, triangular, and square shapes, were evaluated through a series of tribological tests. The tests were conducted on a ball on disc tribometer under different conditions: dry conditions, lubricated conditions using PAO4 oil, and PAO4 oil with the addition of graphene nanoplatelets (GNP) additive. This study analyses synergetic effect of surface texturing and lubrication on the friction and wear behaviour of AA 5052. Moreover, different surface characterization techniques like Optical microscopy, 3D profilometry, field emission scanning electron microscopy (FESEM), Raman spectroscopy and energy-dispersive X-ray spectroscopy (EDS) were used to analyse the surface before and after the tests, and to understand the prevalent wear mechanisms and formation of various compounds during sliding. The objective of this study is to contribute to the understanding of the tribological behaviour of AA 5052 and the effectiveness of surface texturing for improving tribological properties. The findings of this study have implications for industries requiring durable and high-performance materials such as automotive, aerospace, and manufacturing.

Keywords: AA 5052, Surface laser texturing, PAO4, GNP

Role of metallurgical phases on the tribological behavior of HVOF sprayed HEA coatings

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ABSTRACT

Nowadays, a group of alloys, namely high entropy alloys (HEA) is getting much attention, because of their excellent properties. However, the fabrication of HEAs requires multistage techniques, especially milling, sieving, compaction, sintering, inert media, etc. These processes are laborious, costly, time-oriented, and unsuitable for commercial application. This study adopted a single-stage process-based HVOF thermal spray to develop HEA coating on SS304L substrates. The tribological behavior of the deposited HEA coating was explored under different milling time durations (5h, 10h, and 15h, respectively). The effect of feedstock preparation, microstructure, surface chemistry, mechanical and metallurgical properties on wear resistance was also investigated. The microstructure and composition of both coating and feedstock were evaluated by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) analysis. Finally, the phase distribution was correlated by X-ray diffraction (XRD) analysis. The results showed that 15h milled powder coating indicated better tribological properties than the base substrate and 5h,10h milled powder coating. A chemically stable Body Centered Cubic (BCC) solid solution phase was generated within the 15h milled powder-coated system, which resulted in superior tribological properties.

Keywords: High entropy alloy, SS304L, tribological behaviour, powder coating, XRD, EDS.

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Multi-objective multi-stage optimization of wind turbine gearbox (WTG) with the inclusion of scuffing constraint

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ABSTRACT

A novel multi-objective multi-stage optimization problem is carried out by using Non-Dominated Sorting Genetic Algorithm (NSGA-II) for Wind Turbine Gearbox (WTG). NSGA-II is an optimization algorithm known for its diversity and convergence rate. Solutions attained from the Pareto fronts are used for further analysis. Two conflicting objective functions are considered for the design aspect: a) Minimization of weight. b) Minimization of power loss. In addition, various regular mechanical design constraints and tribology constraint, i.e., scuffing, are applied during the analysis for unmodified involute gear tooth profile with the consideration of 2-stage planetary gear trains and 1-stage of helical gear pair (pph) model as per AGMA standard [1–4]. Most influencing design variables, such as module, face width, number of teeth, etc., are considered. Further, simulations are done between ISO VG 460 Mineral oil and ISO VG PAO 460 synthetic-based oil to find the best oil through the Pareto front. An analysis is also done by varying gear ratios and power capacity for ISO VG PAO 460 oil. Also, results for multi-objective multi-stage WTG with scuffing constraint are compared with multi-objective multi-stage WTG without scuffing, and results indicate that significant amount of power reduction is seen when simulations are done with scuffing constraint.

Keywords: Wind turbine gearbox, synthetic base oil, NSGA-II.

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Influence of wear on the threshold speed of hole entry hybrid conical journal bearing compensated with capillary restrictor

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ABSTRACT

Now days, Hybrid journal bearing are used mostly to take advantages of both hydrostatic and hydrodynamic actions simultaneously. Also, they have significant advantages of carrying radial and axial load simultaneously. As they are used for high speed application, they may be subjected to change in speed during their long duration of service life. These bearing are also subjected to wear, so this paper presents an analytical approach is to study the effect of wear on the threshold speed of hole entry hybrid conical journal bearing compensated with capillary restrictor. The modified Reynolds equation governing the laminar flow of isoviscous incompressible lubricant in the clearance space of conical journal and bearing is solved by Finite Element Method. Numerically simulated results indicate that appreciable change in the threshold speed of worn hybrid conical journal bearing as compared to unworn bearing of same configuration.

Keywords: Hybrid journal bearing, FEM, wear, isoviscous.

Nanomechanical and nanotribological behavior of biocompatible tantalum nitride (TaN) coating for biomedical applications deposited on Ti6Al7Nb alloy

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ABSTRACT

In this study, TaN coating was deposited on biomedical grade Ti6Al7Nb alloy with the help of radio frequency (RF) magnetron sputtering for biomedical applications. Grazing incidence X-Ray diffraction (GIXRD), Field emission scanning electron microscopy (FESEM), and Energy dispersive spectroscopy (EDS) were employed to investigate the structural, surface morphology and composition. GIXRD results confirmed the polycrystalline structure of TaN with cubic-NaCl like structure and texture growth along (111) basal plane. The effect of load on Young's modulus and hardness was studied using nanoindentation tests at loads ranging from 1200-1600 µN. The results demonstrated that hardness and Young's modulus of TaN coating decrease as the indentation load increases due to indentation size effect. A scratch test was performed at 0-600 mN progressive loading condition to find critical loads corresponding to cohesion and adhesion failure of the coating. The scratch results of the coating demonstrated that cohesion failure occurs due to cracking and adhesion failure after severe chipping. To determine the average coefficient and wear rate of TaN coating nanotribological tests were conducted at 1 N against two different counter bodies (steel and ceramic ball). The average COF values were found 0.052 and 0.041 against steel and ceramic, respectively and associated wear rate values were 1.21×10-4 and 2.75×10-4 mm3/N.m. Abrasive marks, cracking and oxidation were observed as main wear mechanism. Ta2O5 was formed against the steel ball and confirmed with the Raman spectroscopy.

Keywords: Magnetron sputtering, TaN coating, Nanomechanical, Nanotribology

Tribology for sustainability with energy-efficient hydraulic

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ABSTRACT

Hydraulic fluid is used in a wide variety of hydraulic machinery ranging from construction /mining equipment to machine tools and other equipment extensively used in various industries. In order to generate hydraulic pressure, a huge amount of fuel power/electricity is required as an input for drive unit. Equipment owners have become increasingly aware of the total cost of ownership, which has led to a rise in demand for machines that require low maintenance, have high reliability, high accuracy, short cycle times and consume lesser energy. Being aware of the role that lubricants could play in a sustainable future, we at BPCL have developed an energy-efficient hydraulic fluid aimed at reducing the overall carbon footprint in line with global energy transition scenario. Depending on the type of application, an efficiency increase of up to two digits is possible with this energy-efficient hydraulic fluid. In comparison to conventional hydraulic fluids, energy-efficient hydraulic fluids can save up to 10% of fuel consumed in construction or mining equipment and up to 2% of energy consumed in stationary manufacturing equipment. The energy-efficient hydraulic fluid is formulated with severely hydrotreated high Viscosity Index (VI) base oils and a specific efficiency-boosting performance polymer with exceptionally high shear stability. This results in an energy-efficient hydraulic oil with high VI, directly contributing to a lower traction coefficient, reduced shear loss, high efficiency, and high thermal and oxidative stability with a higher level of protection versus a standard mono-grade/ multigrade fluid. Consequently, the fluid translates to shorter warm-up times, optimum viscosity at working temperature and low friction properties help reduce frictional losses. With the use of this fluid, hydraulic equipment runs more efficiently and can reduce its energy requirements by anywhere between 2% and 10%. The gain in energy efficiency with the use of this energy-efficient hydraulic oil results in a reduction of GHG emissions by 10%. Moreover, the use of re-refined base oil in the formulation has the potential to support circular economy and have resulted a further reduction in the carbon footprint by 5%, without compromising on the benefits as stated above. In addition, by eliminating the use of traditional Zinc-based additives and adopting an advanced Zinc-free additive technology, the product delivers more than double the service life of those formulated with conventional additives thus enabling effective utilization of energy resources. This hydraulic fluid holds immense potential in the future as a sustainable solution for aiding the energy transition.

Keywords: Hydraulic fluid, Energy-efficiency, Re-refined base oil, Viscosity Index, Energy Transition, Circular Economy, Sustainability, Tribology for Sustainability, Friction.

Effect of combined (radial-axial-angular direction) misalignment on sliding wear of spur gears: A comprehensive study

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ABSTRACT

This study investigates the accelerated failures of gears, which are frequently attributed to misalignment-induced geometric stress concentration. The mathematical model to account the effect of misalignment in radial, axial, angular, and combined (radial-axial-angular) orientations on the sliding wear of the driver gear (pinion) is derived. To evaluate sliding wear, the 'slicing of the gear' technique is used in conjunction with a modified version of Archard's wear equation. A MATLAB script is created to solve and analyze the wear profile. The model's accuracy is validated against established literature and experimental findings. In addition, a parametric study is conducted to determine the impact of design parameters such as module, pressure angle, gear ratio, and pinion tooth count on the wear of a combined misaligned gear pair. The study's results disclose several important observations. Increasing radial misalignment reduces the contact ratio, resulting in increased pressure and sliding wear in the single-tooth contact zone, and vice versa. Similarly, an increase in axial misalignment decreases the contact zone, resulting in an increase in contact pressure and sliding wear throughout the mesh cycle. In addition, an increase in angular misalignment decreases the contact zone and contact ratio, resulting in an increase in contact pressure and a non-linear wear distribution along the tooth flank. This also results in increased wear in the transition zones between single and double tooth contact. Notably, combined misalignment has the most severe effects of all misalignment types, resulting in higher contact pressure, non-linear wear distribution along the tooth flank, and increased wear in the transition zones between single and double tooth contact. While previous research has reported on the contact pressure and sliding wear of perfectly aligned and misaligned gear pairs, this work fills that gap by further considering the impact of combined misalignment and variations in the contact ratio. Improving gear dependability and performance relies on having a thorough understanding of the wear behaviour of misaligned gears, which is provided by this analysis.

Keywords: Radial misalignment, axial misalignment, angular misalignment, sliding wear of gear, slicing of gear tooth, contact ratio, contact pressure.

Microstructure evolution and tribological properties of Ti-6Al-4V metal matrix composites synthesized by spark plasma sintering

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ABSTRACT

Despite of being higher strengths-to-weight ratios of Ti-6Al-4V –GV alloys, their poor wear behavior prevents them from being widely used in a variety of medical applications. One approach to resolve this issue is to increase the wear resistance ability of Ti-6Al-4V alloys by incorporating suitable discontinuous reinforcing phases. In this probe, Ti6Al4V alloy composites with different TiC nano-reinforcement were synthesized using the advanced spark plasma sintering (SPS) process. The resulting sintered compact was found to have a nano-hardness of 9.89 GPa for 2.5 wt% TiC reinforced TMCs, with significantly better wear resistance than the source alloy matrix (8.2 GPa). Moreover, when the fretting wear slid across SS316L balls (counter disc material), a reduction in wear volume of 20-22% was noticed. The fretting wear behavior of the Ti6Al4V/TiC composites with various wt% of TiC content were observed to contribute significantly in the wear mechanism. Especially at high wt% of TiC content, the formation of a Tribo-oxide treatment significantly reduced the wear volume of the composites. This result was attributable to the existence of a strong oxide layer and a diffused zone, which improved the composites wear resistance ability while also reducing the abrasive effects of TiC Nano particles and the substantial plastic deformation of the Ti-6Al-4V matrix.

Keywords: Titanium Matrix Composites, Microstructure, Wear mechanism, Spark plasma sintering.

Friction and wear properties of GO/Fe_2O_3 hybrid nanoparticles as lubricant additives in PAO-4 oil for steel on steel point contacts

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ABSTRACT

Nanoparticles play a significant role in lubrication, effectively reducing friction and wear through various mechanisms such as mending effect, rolling effect, and protective film formation. Furthermore, the combination of two or more nanoparticles can lead to the development of new materials that exhibit enhanced performance and increased multifunctionality. In the present work, graphene oxide and iron oxide (GO/Fe_2O_3) based hybrid nanocomposite particles were used as an additive in Polyalphaolefin (PAO-4). The GO/Fe_2O_3 nanocomposite particles were prepared by a sonochemical method. Field Emission Scanning Electron Microscopy (FE-SEM), X-ray diffraction (XRD), and Energy Dispersive X-ray spectroscopy characterization techniques were used to analyze the morphological and chemical properties of prepared nanocomposite particles. The nanolubricant was prepared by dispersing 0.5 wt.% GO and GO/Fe_2O_3 NPs in base PAO-4 oil. To ensure the effective dispersion of hybrid nanoparticles within the base oil, both an ultrasonicator and a homogenizer were utilized. The rheological properties of the developed nanolubricants were assessed using a modular compact rheometer at 40°C and 100 °C. Furthermore, all tribological tests for the prepared lubricant were performed at a universal tribometer under different load conditions (5, 15, 25 N). The experimental findings demonstrated that the hybrid GO/Fe_2O_3 nano additive enhanced the tribological performance. Notably, the nanolubricant based on GO and GO/Fe_2O_3 nanoparticles exhibited exceptional COF and wear properties when compared to PAO-4. Raman spectroscopy analysis revealed the presence of a protective GO/Fe_2O_3 tribofilm on the worm surface, contributing to a reduction in the coefficient of friction (COF) and wear. Overall, the GO/Fe_2O_3-based nanolubricants demonstrated superior tribological performance.

Keywords: Hybrid nanocomposite particles, Ultrasonication synthesis, Friction and wear, Nanolubrication.

High entropy alloys on hydrogen storage perspective. A review

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ABSTRACT

Energy is a necessary component of our everyday life, enabling tasks like computing, cleaning, cooking, and travelling. However, owing to population expansion and economic progress, the world's energy need is continually rising. Around 90% of this demand is now met by fossil fuels, but since they are non-renewable and contribute to greenhouse gas emissions, their supply is quickly running out and they pose long-term threats to both human health and the environment. Thus, the creation of alternate energy sources is critical. As safe, non-toxic, and renewable alternatives, hydrogen fuels have drawn a lot of attention, especially as alternatives to petroleum-derived fuels in cars. However, creating effective hydrogen storage devices, particularly for on-board applications, is the main problem. It is possible to store hydrogen as a gas, liquid, or solid, and much research has gone into developing secure, economical, and environmentally friendly hydrogen storage options with high energy densities. When compared to high-pressure compression and liquefaction methods, solid-state hydrogen storage, especially employing metal hydrides, looks to be the most practical option. In-depth study has been devoted to the synthesis of inexpensive metal hydrides with desirable characteristics, such as low absorption/desorption temperatures, high gravimetric and volumetric hydrogen storage densities, resistance to oxidation, good reversibility and cyclic ability, fast kinetics and reactivity, and moderate thermodynamics. As prospective chemical components for solid-state hydrogen storage, metal hydrides show promise, spurring the creation of cutting-edge materials for effective energy storage systems.

Keywords: Fossil fuels, solid state hydrogen storage, tribology.

Surface characteristics of the 3D printed PEEK under adhesive wear conditions

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ABSTRACT

Additive manufacturing has revolutionized the fabrication of parts and components by enabling on-demand production with fewer lead times. In structural applications such as gears, sleeves, and bushes, semicrystalline polymers like polyetheretherketone (PEEK) are preferred due to their excellent mechanical properties. However, the performance of PEEK is governed by its tribological properties in some applications, which are significantly influenced by the contact surface of the material with other polymers or metals. When it comes to additively manufactured parts, the surface properties of PEEK samples play a crucial role in determining their friction and wear behaviour, which can differ from conventionally manufactured samples. The contact surface, roughness, and porosity of additively manufactured PEEK samples are significant factors to consider when these parts come into contact with metals under dry sliding conditions. The presence of different contacts and asperities on the surface of the samples leads to variations in the wear response. This implies that the tribological behaviour of additively manufactured PEEK parts may deviate from that of traditionally manufactured parts due to the characteristics of the additive manufacturing process. Comprehensive experimental investigations are required to understand and analyze additively manufactured PEEK's friction and wear characteristics. The experiments involve studying the wear rate, coefficient of friction, and surface morphology of the samples under dry sliding conditions. The results indicate the significant influence of contact surface formed due to additive manufacturing on the wear process.

Keywords: PEEK, semicrystalline polymers, additive manufacturing, friction and wear.

Towards sustainable lubrication: evaluating the effectiveness of additive-blended mustard oil-based grease

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ABSTRACT

Nano-materials offer the potential scope for increasing numerous novel applications when engineered to deliver availably functional properties. The nanosized additives when added to biodegradable oils improve their tribological performance and contribute to energy saving and sustainability. The study aimed at the comprehensive analysis on lubricative characteristics of virgin and additive blended mustard oil-based grease. The influence of additives on the greases, friction reduction, wear protection and load carrying capacity were observed. Lubricating abilities were tested using ASTM 2266, four ball test to evaluate the performance of both the greases. The grease was prepared with mustard oil as a basis and sodium thickener as an additive. Addition of graphene nano particles to virgin mustard oil-based grease escalated the viscosity of the grease as studied on Anton Paars rheometer. Wear examinations were performed on steel balls using an optical microscope and scanning electron microscopy, and the results were consistent. Also, addition of 0.25% of graphene nano particles reduced the coefficient of friction substantially. The incorporation of components complements the overall lubrication overall performance of the mustard oil-based grease, making it a promising choice for various industrial applications. those findings make contributions to the expertise of the lubrication behavior of mustard oil-based greases and spotlight the benefits of incorporating additives to beautify their lubrication characteristics.

Keywords: Biodegradable oils, wear, graphene, nano particles.

Tribo-SE performance of HVOF sprayed tungsten carbide-cobalt-chromium powder on few slurry handling and hydro-turbine steels

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ABSTRACT

Hydro-power plants being employed next to rivers, are one of the industries as primary renewable energy resource for electricity generation in several countries. Such industries embrace numerous associated fully or partially submerged underwater components/parts of hydro-turbines. These hydro-turbine components/parts formed of different materials encounter damage in the form of wear loss due to slurry erosion (SE). Exploration of tribo-analysis of SE performance of hydro-turbine materials in original or in modified (coated, heat treated or thermo-mechanical processed, etc.) conditions being utilized for confronting the SE wear is imperative for sustaining the life and intended service of different hydro-turbine components/parts. In past, numerous authors have aligned their areas of research in this direction. Similar kinds of earlier studies [1,2] can be realized for reviewing the efforts inclined to SE investigations, attempted by several researchers. In this study, comparative SE performances of few slurry handling steels; ferritic stainless steel (FSS/ SS-409), and austenitic stainless steels (ASS/ SS-304 and SS-316) in original as well as in coated states have been probed in SE pot tester. Among these steels, SS-304 is widely used in slurry pipelines of thermal power and other plants and other steels; SS-409 and SS-316 have high temperature/ highly corrosion resistant and hydro-turbines/hydro-machineries applications, respectively. This study investigated the SE performance of different steels being employed in slurry pipelines and hydro-turbines for comparative analysis. Substrates of these different kinds (FSS, ASS) of steels were coated of tungsten carbide-cobalt-chromium powder (cermet/ 86WC-10Co-4Cr) predominantly applying the mostly preferred thermal spray technique; high velocity oxy fuel spray (HVOF). As SE wear depends upon distinct parameters; impact velocity/speed, slurry concentration, impact angle, and particle size, all the four parameters were examined employing L9 Taguchi technique for both, coated and uncoated/bare substrates. Among all the parameters, particle size was found to be least driving parameter. Coated samples exhibited 2 to 2.5 times better SE performance than the uncoated samples.

Keywords: Coating, SS304, corrosion resistant, wear.

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Transforming surface quality, exploring the potential of magnetorheological finishing

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ABSTRACT

Dimensionally precise and finely polished components are essential for optimal performance in current production systems. A high-quality surface treatment is necessary to improve the properties of engineering components. Surface finish is the final operation which is to be performed on the different engineering components. Surface finish influences various functional properties like power loss due to friction and wear resistance. However, the high-precision optics, lasers or X-ray surface finish plays a significant role in reflecting and/or reflecting white light. These applications require finishing up to the nano level. Modern manufacturing innovations have resulted in the development of sophisticated finishing methods. Because of the recent development and application of modern materials, finishing techniques for various engineering components are in great demand in contemporary industry. Traditional finishing procedures generate non-deterministic and difficult-to-control cutting forces. As a result, several micro/nano-finishing technologies have emerged. Magnetorheological finishing (MRF) is a sophisticated finishing technology that uses a variable magnetic field to regulate forces. Magnetorheological finishing technologies are capable of finishing a wide range of materials with intricate surfaces. MRF is used to polish a variety of ceramics, including glass, lenses, and jewels, as well as ferromagnetic and non-ferromagnetic materials. MRF procedures offer enormous promise and continued R&D in this area will pave the way for future innovation and ensure that MRF is widely adopted as the preferred finishing technique. This study presents a detailed review of Magnetorheological Finishing processes, their applications, obstacles encountered, and future prospects.

Keywords: Friction, wear, MRF, laser.

Effect of Microstructural Variation on Tribological Behavior of Ti-6Al-4V Alloy

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ABSTRACT

Titanium alloys are widely used in aerospace, power, chemical, food processing and biomedical industries due to their exceptional properties, such as good specific strength, excellent corrosion resistance, and biological inertness. These alloys have good biocompatibility and are also used in biomedical industries as total hip and knee implant replacements. Depending upon their chemical composition, these alloys are classified into five categories, i.e., alpha, near alpha, alpha plus beta, metastable beta, and beta alloys. Predominately, parts or components used in the industries, as mentioned earlier, are produced from alpha plus beta type titanium alloys. Ti-6Al-4V alloy is an alpha plus beta type titanium alloy, mainly used for this purpose and considered as a workhorse for the industries mentioned above. Ti-6Al-4V alloy is used as compressor disk and blade in aero-engine. Various microstructures, namely lamellar, bimodal, and equiaxed, can be obtained in this alloy as a result of different heat treatment procedures. The mechanical properties of Ti-6Al-4V alloy are mostly dependent on its different microstructural features. A fully lamellar microstructure of this alloy is reported to have high fatigue crack propagation resistance and fracture toughness, as well as it shows superior creep resistance. Equiaxed microstructure often has high ductility as well as fatigue strength and is generally preferred for superplastic deformation. The Bimodal microstructure can be considered to be a combination of both the lamellar and equiaxed microstructure. Hence, the bimodal microstructure combines the advantages of both the lamellar and equiaxed microstructure and exhibits optimum mechanical properties. A bimodal microstructure is reported to have advantages in terms of yield strength, tensile strength, ductility, and fatigue strength. Of late, therefore, the bimodal microstructure of Ti-6Al-4V alloy is generally exploited in making almost every industrial parts or components used for the intended purpose. Aero-engine components made up of Ti-6Al-4V alloy such as compressor disk and blades are continually exposed to solid particle erosion, i.e., flying off the aircraft, particularly in deserts where dust or sand storms impinge on the components themselves. Also, artificial bio-implants made up of Ti-6Al-4V alloy such as hip and knee joint replacements are always exposed to fatigue and sliding wear. From the literature review, it is observed that the structure–property correlationship of Ti-6Al-4V alloy for both solid particle erosion and dry sliding wear behavior is not established in detail. A research effort was attempted to study the effect of microstructural variation on tribological behavior of Ti-6Al-4V alloy. As the Ti-6Al-4V alloy is directly used as Bio-implants and Compressor blade, the structure-property correlation-ship study has a direct impact in Biomedical and aerospace industries.

Keywords: Aerospace, power, corrosion resistant, heat treatment.

Effect of cold rolling on the tribological behaviour of Inconel 718 superalloy

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ABSTRACT

Superalloys are the group of engineering alloys that are designed to operate at elevated temperatures, and they find application in various engineering sectors such as nuclear powerplants, steam turbines, aircrafts, etc. There are three important classes of superalloys i.e., iron-based, cobalt-based, and nickel-based superalloys. Among them nickel-based superalloys are used in both low and high temperature applications due to higher mechanical strength, good fatigue life, excellent wear and corrosion resistance. We aim to study the tribological behaviour of cold-rolled Inconel-718 alloy at room temperature and elevated temperature. Inconel-718 is a heat-treatable alloy and its strength is mainly contributed by the γ', γ'', and δ-phases present in it. Our study focuses on the systematic study of microstructural changes under different cold rolling conditions with isothermal aging and their effect on the wear behaviour of Inconel-718 at different normal loads. The cold-rolling with isothermal aging treatment was done to improve the mechanical strength of the materials through the combined effect of work-hardening and precipitation of γ', γ'', and δ-phases. Post tribological tests, characterization of wear tracks was done using 3D profilometry and scanning electron microscopy (SEM). The results indicate that the cold rolling results in higher wear resistance than the as-cast Inconel-718 alloy and the wear mechanism is greatly influenced by the load and the temperature.

Keywords: cold-rolling; isothermal aging; microstructure evolution; wear; Inconel-718

Nanotribology of molecular lubricants and 2D materials

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ABSTRACT

Friction and wear of engineering components result in enormous energy losses, reliability issues and environmental problems. Macroscopic contact involves interactions between micro- and nanoscale asperities owing to the surface roughness of the components. Observing and understanding the nanoscale mechanisms at play is inhibited by the hidden nature of the buried interface. Recent advances in novel experimental methods based on atomic force microscopy (AFM) are enabling such interactions to be studied with unprecedented resolution and insight. I'll discuss AFM based approach for investigating nanotribological properties of lubricants, additives and 2D materials. The interaction of lubricants and lubricant additives with material surfaces, including confinement induced structuring of lubricant molecules [1] as well as formation of protective tribochemical films [2] are key to the lubricant performance. The growth mechanisms of such tribochemical films are still poorly understood. Greater understanding of the formation of these films using AFM based approach can enable rational design of more environmentally friendly and energy-efficient engine oil formulations. I'll also discuss recent investigations of tribology of 2D materials where we demonstrate self-generation of lubricious graphene based tribochemical films on silica glass which reduces scratch induced surface damage [3]. In addition, our results reveal that super-lubricious and highly scratch-resistant glass surfaces can be realized using a few layer graphene films. Finally, in situ nanotribology of WS2 monolayer, which are excellent solid lubricants, will be discussed where role of defects, ageing and morphology of the monolayer as well as shear induced phase transitions play important role in determining its friction and wear behaviour [4, 5].

Keywords: Friction and wear, reliability, lubricant, tribofilm.

On the influence of electro-discharge-fabricated micro-channels and micro-pillars on the wettability and surface energy of Ti6Al4V

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ABSTRACT

The longevity and performance of artificial implants in total joint replacements (TJR) depend largely on surface roughness, surface chemistry, and surface texturing of the mating components. In the human body, the synovial fluid regulates the activity of the tribo-pair by lubricating the interface and promoting cell growth, attachment, and proliferation. To avoid premature failure in artificial implants, the interfacial fluids should be channelled in a way that it remains at the interface for prolonged durations. Ti6Al4V being the heavily exploited candidate for artificial implants, this work has fabricated micro-channels and micro-pillars on the surface of the said material through an electro-discharge route. The width of the profiles is varied to test/analyse the respective variation in wettability and surface energy through contact angle measurements. Three different fluids, viz. deionized water (DW), Hanke's solution (HKS), and bovine serum albumin (BSA) were tried on various textured surfaces to study their response. The low viscosity of DW causes it to be dominantly influenced by the geometry and dimensioning of the micro-textures. The comparatively low cohesion between the water molecules allows it to undergo rapid migration and demonstrate superior wettability for surfaces with micro-pillars (having low gap width). The surfaces show super-hydrophilicity for a gap width > 300 µm, irrespective of the type of patterning. For specialized fluids such as HKS and BSA, the electro-discharge texturing observably has a limited influence, as the cohesive force between the fluid molecules is significantly higher than the tendency for adhesion to the surrounding surfaces. Regardless, the surfaces engraved with unidirectional channels show better wettability than those with micro-pillars under similar conditions.

Keywords: Total joint replacement, Surface texturing, Micro-channel and pillars, Wettability, Surface energy.

Regression and machine learning model for the wear prediction in the bush bearing

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ABSTRACT

Bush bearings are widely used in the rotating machinery. The wear of the bearing leads to shoot up in vibration, noise and temperature level. The sensors are used to collect the data (current, noise, vibration and temperature). The data driven models are created and used for the predictive maintenance [1-3] In this paper, a regression model (RM) for the wear in the bush bearing is developed. The test rig is developed. The input parameters are load, speed, wear area, wear depth. The output parameters are current, noise, vibration and temperature. The data will be analyzed using ML algorithm and ML model will be developed to diagnose the wear in the bush bearing.

Keywords: Bearing, wear, vibration, noise, RM.

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Tribological aspect of grewia optiva reinforced TPU

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ABSTRACT

The desire to create a more sustainable environment, the use of natural/ cellulose fibers reinforced in composites (NFCs) is being considered for increasingly more applications. In this article grewia optiva fiber is analyzed in its different form while being reinforced into polyurethane. The purpose of this article is to familiarize the reader with the concerned matter by examining current knowledge of the abrasion and friction characteristics of composites as influenced by various operating conditions and the chemical processing of natural fibres. The tribological behavior of NFCs is influenced by the morphology of the natural fibers such as fiber length, diameter, orientation and surface roughness. Fibers with higher aspect ratios (length-to-diameter ratio) tend to provide better reinforcement and lower wear rates. The interaction between the cellulose fibers and the matrix material is crucial in determining the tribological properties of NFCs. The matrix provides a medium for load transfer and protects the fibers from external forces. Effective bonding between the fibers and matrix improves load transfer, reduces friction and minimizes wear. The worn surface morphology of all the developed samples has been examined using scanning electron microscope (SEM) to analyze the wear mechanism in different types of developed composites. Three different types of grewia optiva fibers (raw fiber, treated fiber and its developed woven mat) were incorporated into thermoplastic polyurethane (TPU) to develop structural composites by a hand lay-up technique.

Keywords: Natural/cellulose fibres, composite, friction, wear.

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Steel modification modes for improving the cast parts quality of the rolling stock couplers

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ABSTRACT

This article discusses the issues of improving the mechanical properties and improving the structure of steel grade 20GL intended for automatic couplers of freight cars by modifying the metal with a complex modifier PP-TM-14-FeVAlCa (Chemical powder wire for modification of liquid steel grade "PP-TM 14-FeVAlCa", chemical composition is V: 30-40%, Al: 10-15%, Ca: 15-20%, the rest is Fe) in a stopper ladle. For normal operation under such operating conditions, automatic coupler equipment of cars must have appropriate strength, increased energy intensity, the necessary absorbing capacity and the optimal shape of the power characteristic [1]. Cast parts of freight wagons operate under dynamic loads with a large number of impacts, which is the best way to evaluate the operational reliability of these parts. Moreover, according to the results of shock-fatigue tests simulating the same conditions as mentioned earlier. The proposed technology of the best composition of steel grade 20GL to ensure high mechanical characteristics by minimizing the amount of harmful impurities. As well as the development of proposals for improving the quality, mechanical properties and operational characteristics of steel by increasing the degree of its refining and modification with complex modifiers. The technology of the steel modification process in a steel-pouring ladle with a capacity of 6 tons made it possible to improve the mechanical properties, especially the value of impact strength.

Keywords: 20GL steel, modifier, oxygen, non-metallic inclusions, automatic coupler, mechanical properties, structure.

Systematic study of friction and high temperature life of grease with respect to additive influence

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ABSTRACT

Study of the friction and life of greases has significance to formulate new low-friction. This paper presents systematic study of the friction and high temperature life correlation of Lithium greases under the influence of additives. Studies were conducted on Lithium base grease as a reference. Conventional antiwear, friction modifier and solid additives based Lithium greases were evaluated. While determining Stribeck curve using a Tribocell accessory in a Rheometer, synergistic behavior was observed in a chosen set of these additives. Grease composition with this chosen set also resulted in highest high temperature life in corresponding ASTM D3527, ASTM D3336 tests and in FE 9 rig evaluation. Interesting results for friction coefficient were obtained in SRV study on these greases. SRV study confirmed the synergistic behavior was observed in a chosen set of these additives. The test results obtained were explained based on the mechanism of function of various additive combinations. The study has significance in devising a methodology to develop energy-efficient and long life greases.

Keywords: Lithium Grease, Friction, ASTMD3336, Rheometer, Antiwear

Computational fluid dynamic (CFD) model of worn hydrodynamic conical journal bearing

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ABSTRACT

Bearings are machine components designed to support and guide the rotation of other machine components. Fluid film bearings are used in many turbomachinery and high precision machine tools. In conical journal bearings, the inner surface tends to wear out due to frequent start-stop cycles and high loads. The CFD model is developed to simulate the wear of CJB in the ANSYS Fluent software package, which is used to calculate the hydrodynamic fluid film pressure under high-loaded conditions. The experimental investigation is carried out using a conical journal bearing test rig to determine the effect of wear having 25% radial clearance using VG 46 lubricant. The experimental results of the worn CJB show good agreement with the analytical data. The study investigates the effect of maximum pressure on finite worn conical fluid film bearings, considering the combined journal displacement ratio and whirl of the journal under various load conditions. The maximum pressure distribution plot follows a unique pattern as the load increases in simulation study as well as in experimental study.

Key words: Conical Journal Bearing (CJB), CFD, Wear, Hydrodynamic Pressure.

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Tribological behaviour and hydrogen embrittlement study of components used in hydrogen-powered engines and fuel cells

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ABSTRACT

The components working in hydrogen environments are at risk of failing due to the phenomenon of hydrogen embrittlement (HE). The materials were reported to experience loss in ductility, decreased fracture toughness, and degradation of fatigue life due to HE [1] which are undesirable for the service life of mechanical components. Advance high strength materials such as transformation-induced plasticity (TRIP) steel, martensitic steel, austenitic stainless steel, dual-phase (DP) steel, and others are widely used for their high strength, low weight, and for their ease of production. However, high-strength steels due to the high density of dislocations are susceptible to hydrogen embrittlement. The performance of this kind of material against a hydrogen environment needs to be evaluated. TRIP steel is known to have retained austenite which act as hydrogen traps [2] that can suppress the effect of HE. In this work, the performance of TRIP steel and high-strength martensitic steel in the presence of hydrogen environment is to be evaluated. The test specimens are charged with hydrogen in the presence of an electrolytic medium and subjected to a reciprocating sliding test. Carrier gas hot extraction technique was used to measure the amount of diffusible hydrogen permeated in the test sample. Further surface and subsurface characterization were performed to study the tribological and microstructural stability of the test specimen against the hydrogen environment. The outcome of the study will help to evaluate the behaviour of commonly used high-strength materials usage in automobile industries in presence of hydrogen environment.

Keywords: hydrogen embrittlement, ductility, toughness, fatigue life.

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Effect of sputter rate on the surface roughness and crystal structure of RF sputtered ZrN and ZrAlN coatings

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ABSTRACT

This research study aims to investigate the influence of deposition parameters, specifically the sputter rate, on the surface roughness and crystal structure of radio frequency (RF) sputtered ZrN and ZrAlN coatings. To achieve this, three different coatings were fabricated on D9 steel substrates using RF reactive gas sputtering. Zirconium and aluminium targets were used, along with an argon plasma and nitrogen as the reactive gas. The deposition rate of AlN was varied by adjusting the sputter rate of the Al target during coating deposition. The surface roughness of the coatings was evaluated using a 3D profilometer and surface probe microscopy (SPM). The crystal structure and chemical composition of the coatings were analysed through grazing incidence angle X-ray diffraction spectroscopy (GIXRD), Raman spectroscopy, and energy-dispersive X-ray spectroscopy (EDX). The variation in the deposition rate of Al resulted in different percentages of AlN, due to the higher incident energy of Al atoms promoting the formation of AlN within the coatings. Notably, the coating with intermediate AlN percentage exhibited minimum surface roughness. GIXRD analysis revealed that as the percentage of AlN increased in the crystal structure, the coatings displayed a more nanocrystalline or amorphous nature. The coating with a high AlN content also exhibited a significantly reduced crystallite size and a highly strained crystal structure. This can be attributed to the interruption of long-range ZrN-ZrAlN crystal growth during the deposition process. This study demonstrates the impact of deposition parameters on the surface properties and crystal structure of ZrN and ZrAlN coatings, showcasing the relationship between the deposition rate, surface roughness, and crystal growth during the fabrication process.

Keywords: surface roughness, SPM, GIXRD, ZrAlN, coatings

A study on performance assessment of water cooled thrust bearing pad in conjunction with nanoparticle doped lubricant film

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ABSTRACT

Thrust bearing finds application as a key element for heavy duty machines such as hydro-power plants (vertical shaft), submarines, steam engines, cement plant-ball mills (horizontal shaft) etc. Bearing temperature is a primary factor that affects the performance of hydrodynamic thrust bearings. Thermal deformation, misalignment, cavitation, reduction in minimum oil film thickness and subsequent drop in load carrying capacity, are some of the manifestations related to high bearing temperatures. The present study attempts to decrease the bearing temperature by utilizing novel hybrid (embedded cooling circuitry and nano particle doped lubricant) bearing set up. In this paper Naiver stokes and energy equations are solved numerically using the computational fluid dynamics simulations to compute the pressure, temperature and thermal deformation of water cooled thrust pad in conjunction with nano particle (TiO_2) doped lubricant film. The simulation results confirm (i) enhancement in pressure values e.g. maximum pressure increases from 5.6 MPa to 6.5MPa (ii) reduction of pad temperature values e.g. maximum pad temperature value reduces from 85℃ to 70℃ (iii) reduction of pad thermal deformation values e.g. maximum pad thermal deformation value reduces from 36.5µm to 14.56µm by equipping the conventional thrust pad with inbuilt cooling circuitry and nano particle doped lubricant. The results of present study establish the superior performance of novel hybrid bearing set up.

Keywords: Thrust bearing, Naiver stokes and energy equation, TiO_2.

Transient magnetic and temperature analysis of MR tribometer for three different tribological configurations

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ABSTRACT

Magnetorheological fluid (MR) is a type of smart fluid that shows the variable mechanical properties under the application of magnetic field. The magnetic particles present in the MR fluid makes a strong particle chain in the direction of applied magnetic field, the mechanical response of MR fluid depends on the stiffness, shear modulus, damping and tribological characteristics of this particle chain. In this paper, we have shown the transient magnetic field and temperature analysis of three different configurations (Pin on disc, ball on three plates and 4-ball tester) of MR tribometer under different load, speed and current conditions. Our main aim is to design a MR tribometer to generate high flux in the contact zone with minimum temperature rise. The magnetic field is varied by controlling current input to the electromagnetic coil. The temperature rise causes due to the electromagnetic heating of the coil and due to the friction between two solid parts under axial load. The temperature analysis is carried out for two different loading conditions for 30 minutes. From the Temperature analysis we found that the maximum rise in temperature in the contact zone is below the critical working temperature of MRF-132DG, and maximum magnetic flux up to 1T can be achieved with present design of MR tribometer.

Keywords: Magnetorheological fluid, tribological characteristics, stiffness, damping.

Piezo-viscous-polar lubrication of conical hybrid journal bearing with slip boundary conditions

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ABSTRACT

The present work examines the influence of velocity slip on the performance of piezoviscous-polar (PVP) fluid lubricated multirecessed conical hybrid journal bearing (MCHJB) system. In the realistic operating conditions, the journal/shaft of any rotary machineries operates at higher rotational speed and may have significantly higher relative speed corresponding non-rotating (stationary) bearing which causes velocity slip at solid-liquid boundary interface [1]. Subsequently, it affects the oil film pressure distribution and characteristics of MCHJB system. In the present analysis, four different cases of velocity slip are considered, i.e. (i) No slip at solid-liquid interface, (ii) slip at journal-lubricant interface, (iii) slip at bearing-lubricant interface and (iv) slip at journal-lubricant and bearing-lubricant interfaces. Besides that, the long chain additives molecules are mixed in the base oil to enhance their lubrication properties and thereby, improve the performance of bearing system. These additized lubricants exhibits pressure-viscosity dependency at higher pressures (or rotational speeds) and can modeled as piezoviscous-polar lubricant [2–4]. Therefore, to examine the synergistic effect of velocity slip boundary conditions and PVP lubrication, a novel form of Reynolds equation governing the flow of PVP lubricant in bearing clearance space is derived and solved using Galerkin's technique of FE analysis. The computed results reveals that the consideration of velocity slip boundary conditions significantly affects the bearing performance characteristics. Moreover, the use of PVP lubrication offers substantial improvement in the performance characteristics of MCHJB system.

Keywords: MCHJB, PVP, FEM, Galerkin's technique

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Lubrication behavior of chemically modified karanja oil blend and functionalized h-BN

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ABSTRACT

The current study employs karanja oil as a base stock for lubricants and chemically modified karanja oil as a blending agent, thereby improving the properties of the base stock. Fourier-transformed spectroscopy is used to confirm the formation of modified karanja oil. The chemically modified karanja oil has a higher viscosity than the base oil, which improves its load-carrying capacity at low speeds. Lubrication regimes are determined by running tests on a ball-on-three-plate geometry with variable speed and a constant 10 N load. The dynamic viscosity of the blends is investigated using a rotational viscometer at various temperatures. The frictional properties of the blends are investigated using a four-ball tribotester while varying the load, speed, temperature, and blend percentage. The results show that the blending factor has the greatest influence on the frictional properties of karanja oil, followed by speed and temperature. Notably, at lower speeds, the modified oil outperforms other blends. Furthermore, an equal proportion of modified and unmodified karanja oil is mixed and tested for lubrication performance on functionalized h-BN (hexagonal boron nitride). The tribological test on a four-ball tester shows that the karanja blend has better antiwear properties and greater stability than pristine h-BN.

Keywords: h-BN, Karanja oil, biolubricant

Development of emerging bio-lubricant of kusum oil using copper oxide nanoparticles

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ABSTRACT

Epoxidation improved the degrading properties of Kusum oil. Additionally, chemically modified Kusum oil was supplemented with copper oxide nanoparticles in specific ratios. Tribological testing was performed under different conditions with the physicochemical characteristics of the lubricants went through using a pin-on-disc tribometer. The addition of nanoparticles of copper oxide improves the viscosity index, viscosity, along with flash point. Rheological investigation revealed that all lubricants exhibited Newtonian behaviour characterized by a direct correlation between shear rate and shear stress. The modified Kusum oil's lubricity was increased by the inclusion of copper oxide nanoparticles but the resultant nanoparticle concentration was limited to 0.4%. In particular, additions at concentrations of 0.2% and 0.4% reduced the frictional coefficient along with raised the anti-wear characteristics. Additionally, electron microscope for scanning imaging demonstrated an improved the surface condition because nanoparticles were added at concentrations as high as 0.4%, highlighting their efficient lubricating function.

Keywords: Kusum oil, Epoxidation, Friction, Wear, Nanoparticles

Wear characteristics of nanoporous alumina coating for tribological applications

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ABSTRACT

Anodization is widely used in industries to improve the wear and corrosion resistance of aluminium surfaces. With a two-step anodization approach under controlled conditions, a nanoporous alumina (NPA) coating with uniformly distributed pores can be grown on aluminium. The presence of this oxide coating significantly improves the wear resistance of aluminium. Taking advantage of the high aspect ratio (pore depth to diameter ratio) of the nanopores, they can act as nano reservoirs capable of holding liquid lubricants. In this work, the pores are filled with organic liquid lubricants by changing the surface energy of the NPA coating to increase its affinity to organic molecules. The wear characteristics of the lubricant-impregnated NPA coating have been quantitatively studied by reciprocating wear tests using a ball-on-flat tribometer. The presence of lubricant in the coating showed an increase in the wear life of the coating compared to the non-lubricated NPA coating by many folds. The lubricant-impregnated nanoporous coating acts as a self-lubricated coating under reciprocating loads. Further, the wear life of the coating is found to be dependent on the geometry of the pores, which is a function of the anodizing parameters. By controlling the parameters like anodizing voltage, concentration of the electrolyte, duration of anodization, it is possible to grow the oxide coating of desired pore diameter, pore distance, and thickness. The effect of pore geometry on the wear characteristics of the coating can be exploited to grow coatings of desired wear life depending on the application of the coating.

Keywords: wear, corrosion, NPA, coating

Effect of microstructure on wear properties of spheroidal graphite (SG) cast iron

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ABSTRACT

Spheroidal Graphite (SG) Cast Iron is a material of choice in automobile industry owing to its unparallel favorable features like low cost, excellent castability and mechanical properties. In this study, three as-cast SG iron samples of grades SG420/12, SG550/6 and SG600/3 containing variable copper (Cu) and manganese (Mn) content were used. SG iron grades possess varying percentage of pearlite and ferrite phases depending on the Cu and Mn content present in the material. The idea was to study the effect of microstructure, particularly pearlite, ferrite and graphite on wear properties. The wear testing was carried out on universal tribometer by using ball on disc testing arrangement. It was observed that the microstructure of the materials plays an important role in wear rate of the material in addition to hardness and wear mechanism. The pearlite phase content of samples SG420/12, SG550/6 and SG600/3 increases as copper content increases from 420/12 to 600/3. The average coefficient of friction (COF) of SG550/6 was highest among the three samples while lowest average COF was observed in case of SG420/12. The specific wear rate decreased with increase in hardness and copper content in the material.

Keywords: Spheroidal Graphite, wear, COF.

An energetic approach to maintaining the natural property of cotton in conditions of external friction

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ABSTRACT

The theory proposed by Gibbs is used in the fundamental principles of the traditional energy approach regardless of the nature and laws of the external friction conditions. If the observed tribosystem is influenced only by the environment, then the structural-energetic flexibility produces minimal entropy under normal friction conditions and ensures the stability of the system. This article discusses the comprehensive development of the energy approach and the possibility of predicting and controlling the process through it, and discusses the newly obtained test-experimental results. The new practical and theoretical results that we offer in the qualitative evaluation of the energetic approach have a clear and simple solution without complex differential-integral equations. As a result, the main factors that have a strong influence are determined, and the necessary results are achieved with the use of a systematic approach, standard methods and tools.

Keywords: fiber, cotton, coefficient of friction, wear, surface roughness, material, real contact surface

Enhancing wear resistance of ZA-27 alloy through TiC reinforcement: A study on the effect of TiC content, load and speed

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ABSTRACT

This paper discusses the dry sliding wear behaviour of composites based on ZA-27 alloy reinforced with titanium-carbide (TiC) particles. The incorporation of TiC particles into the ZA-27 alloy aims to enhance its wear resistance and improve its performance in applications subjected to sliding contact. The composites are fabricated through an In-situ technique, ensuring a homogeneous dispersion of TiC particles within the ZA-27 alloy matrix. The primary objective of the work is to study the impact of three test factors, namely TiC percentage, load, and speed, on the wear rate of ZA-27 alloy and its two composites: ZA-27+5% TiC and ZA-27+10% TiC. Wear tests were conducted using a pin-on-disc tribometer underneath dry sliding conditions at various loads and speeds. Taguchi method was employed to study the influence of several factors on the behaviour of wear. The study concludes that the sliding speed has the highest significant effect on the wear rate, followed by contact load and TiC percentage. The research provides novel insights for the development of composites of ZA-27 alloy with the reinforcement of TiC particles to enhance their dry sliding wear resistance, which is a relatively unexplored area in the scientific literature. Furthermore, this analysis provides detailed analysis of the factors influencing wear behavior and guide material design and optimization strategies.

Keywords: ZA-27 alloy, Composites, Taguchi method, ANOVA, Pareto chart, and Wear resistance.

Effect of heat treatment on wear behaviour of Ti-6Al-4V alloy produced by laser-powder bed fusion technique

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ABSTRACT

Titanium and its alloys are widely used as implant materials due to their exceptional biocompatibility, light weight, good mechanical properties, and high corrosion resistance, but poor wear resistance. In this study, an attempt has been made to explore the wear resistance of Ti-6Al-4V samples fabricated by laser-powder bed fusion (L-PBF) technique by improving the surface properties and compared the results with that of conventional process. The examined samples were fabricated by the L-PBF process and then heat treatment of the as-built samples was done at 800°C for 1.5 h, following cooling in furnace. The effect of heat treatment on the wear behavior of L-PBF processed Ti-6Al-4V alloy was explored in dry conditions and with zirconia as a counter material to reveal the evolution of tribological properties. Wear tests were carried out on pin on disc machine under different loads and rotational speeds. Different wear mechanisms were identified for heat-treated and as-built samples. The uneven wear track width measurement showed irregular shapes, which are shown and discussed by scanning electron microscopy (SEM) images. Energy dispersive X-ray (EDX) of the surface layer showed the effect of heat treatment on the surface of the samples. The results showed that for different types of samples, the oxygen rich debris layer provided the protective layer after heat treatment. The combination of heat treatment and loads effects results in significant effect of heat treatment on the wear rate. Thus, L-PBF process combined with heat treatment can be utilized to fabricate wear resistant Ti-6Al-4V parts.

Keywords: corrosion, wear, EDX, SEM, heat treatment.

Green-lubrication in micro-nano topographies

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ABSTRACT

Micro-nano topographies can be formed on surfaces during machining operations. The lubricant wettability, flowability, and entrapment capacity of engineering surfaces can be affected by these surface topographies. Hence understanding the effect of lubricant behavior on micro-nano topographies helps to evaluate the performance of the lubricant used. This work has two sections, one on the influence of micro-nano-scale surface roughness frequencies, roughness parameters, and surface energy on lubricant performance, mixed wetting possibilities, and its transitions. Another part of the work explores the effectiveness of green lubricants over micro nano-topographies. Sessile drop experiments were conducted on hierarchical engineering surfaces having multiple micro-nao scale roughness frequencies. Results indicate that all roughness frequencies in a hierarchical rough surface contribute to the net roughness, although not necessarily to wettability transitions and hence lubrication effectiveness. In addition, Surface Energy could potentially affect this lubrication behavior. The study explores these concepts for evaluating lubricants, and the green lubricant used in the study has shown remarkable lubrication capabilities demonstrating its potential possibilities in multiple arenas related to Tribology and Machining.

Keywords: wettability, flowability, tribology, lubricant.

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A review on tribological behavior of high entropy ceramic coatings

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ABSTRACT

Surface coatings are widely used in several applications, including nuclear, marine, biomedical, and aerospace, due to their superior mechanical properties, thermal stability, biocompatibility, anticorrosion and tribological characteristics. Among the various coatings, high entropy ceramic (HECs) coatings gathered attention over the past few years, owing to the uniqueness of fabrication techniques and multifunctional properties compared to conventional materials. Ceramics with five or more primary cation elements in equal or nearly equal atomic percentages are known as high-entropy ceramics. High-entropy ceramic coatings (HECs) have more recently attracted interest in different industrial sectors due to their beneficial mechanical and tribological features at different temperatures and other conditions. Several researchers have studied the mechanical, oxidation, corrosion, and wear characteristics of high-entropy oxides, carbides, borides, and silicates using various coating and testing approaches. Using a variety of synthesis procedures, including magnetron sputtering, sintering, and thermal spray methods, an in-depth investigation of the tribological responses of high entropy ceramic coatings has been studied. However, there is a lack of study on the role of feedstock preparation routes and their morphology on the performance of High-entropy ceramic coatings. Hence, this study focuses on the powder morphology and microstructural features that link to the mechanical and tribological characteristics using various coating techniques. The comparison result shows that spark plasma sintering methods gives the direction toward the bulk production of high entropy ceramic coatings.

Keywords: High entropy ceramics, sintering, thermal spray methods, magnetron sputtering, tribological properties

Nano tribological behavior of spark plasma sintered Tic nano particle reinforced B-type Ti6Al4V alloys for biomedical application

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ABSTRACT

The present approach focuses to explore the effect of TiCp nano particulates reinforcements (0%, 0.5%, 1%, 1.5%, 2% and 2.5%) on the fretting wear and nano indentation behaviour of Ti6Al4V alloys based TMC's. Spark plasma sintering (SPS) process has been implemented with applied pressure of 80 MPa, to sintered the TMC's. X-ray diffraction (XRD) and FE-SEM equipped with Energy Dispersive X-ray Analysis (EDAX) were used to examine the newly prepared TMC's. Face centered CCD of RSM approach has been adopted to explore the fretting wear characteristics. The implementation of the approaches would results to identify the most significant and influencing process variables without the aid of numbers of physical experimental trials. The sintered Ti6Al4V/TiCp composites have varied TiCp nano-particle distributions in the metal matrix and were found to exhibit dense, pore-less microstructure. The resistance to fretting wear was improved significantly as the percentage of reinforcement increases upto 2%. The nano indentation behavior was also found to improved by 17% than that of monolithic Ti alloys. As new phases are developed, composite materials' properties are significantly altered.

Keywords: Spark plasma sintering (SPS), fretting wear, FESEM, XRD.

Vibration Fatigue Analysis of Structural Component: Experiment and Simulation Studies

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ABSTRACT

Structural components are engineered to withstand static loading conditions, but prolonged exposure to dynamic loading can lead to premature failure, well below their intended load-bearing capacity. Understanding the fatigue behaviour, especially in higher frequency ranges is crucial for such components. To ensure the safety and reliability of these mechanical systems, components are tested under a very high frequency which is called vibration fatigue analysis. Vibration fatigue analysis provides us with valuable insights into comprehending the natural frequency and other higher frequencies at which resonance occurs in a component. When the component reaches resonance, it can lead to a disastrous failure. Therefore, studying vibration fatigue, particularly to determine the natural frequency of the component, becomes highly crucial in preventing such catastrophic events. In this study, an attempt has been made to investigate the vibration fatigue characteristics of a structural component. To analyse the natural frequency of the structural component, frequency sweep ranging has been applied from 5 Hz to 500 Hz, using an electro-dynamic shaker. Real-time data acquisition has been carried out throughout the experiment using a set of accelerometers and strain gauges. These sensors continuously monitored the component's response throughout the experiment. During the frequency sweep, prominent peaks were observed in both the g-force measured by the accelerometers and the strain data obtained from the strain gauge sensors in the frequency range of 300-400 Hz. Stroboscopic visuals further corroborated these findings. Further, a 3D model of the structural component was created using a Coordinate Mapping Machine, and the coordinate data were imported into CATIA to develop a 3D CAD model as shown in Figure 1. Subsequently, a FEA model was developed in ANSYS as shown in Figure 2. This model was subjected to modal analysis using ANSYS. A good agreement between experiment and simulation was observed. The study was further extended to component with additional features created using machining. Furthermore, a static structural analysis was conducted in ANSYS software on the component to simulate its real-world behaviour under rotational loading conditions. Hence, a rotational velocity was imparted to the structural component. The central part of the structural component was then set to have a fixed support as the initial boundary conditions for the analysis. This means that the centre of the component was restricted from displacing in any direction, simulating the effect of being securely mounted or fixed in place. During the static structural analysis, the ANSYS software calculated and provided data on the stress and strain distribution within the component. Stress refers to the internal resistance of the material to deformation when subjected to external forces, while strain is the measure of deformation or elongation experienced by the material due to applied loads.

Keywords: Vibration; Fatigue; FEM Simulation

The frictional sliding behaviour of polymer with varying cross-linking density in contact with a conical indenter

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ABSTRACT

Study of adhesion properties of highly cross-linked polymer (HCP) network is necessary for its applications, as is understanding the mechanisms behind adhesion. The pull-off force and the energy of separation are calculated using the force-distance (F-d) curve and the energytime (Etot) curve, respectively. Out of all the available measuring methods, indentation is the one of the most suitable for method for studying mechanical properties of HCP network. It is observed that pull-off force and separation energy both increase with contact size until they begin to plateau at large contact sizes. Across all analysed contact sizes, this trend is observed. None of the continuum contact mechanics theories, such as the Maugis-Dugdale theory or the Johnson-Kendall-Roberts (JKR) theory, can account for this behaviour. The cohesive zone's area increases as the indenter is dragged out further, but the apparent contact radius remains constant until the energy release rate approaches the adhesion energy. In this work, we will present adhesion and frictional studies of HCP network with varying cross-linking density using molecular dynamics (MD) simulation approach. We have considered generic bead-spring (Kremer-Grest) approach to model the HCP network. Using an explicit conical indenter, adhesion and friction studies were performed. We find that crosslinking bond density has significant effect of adhesion and friction behaviour of HCP networks.

Keywords: highly cross-linked polymer (HCP) network, Maugis-Dugdale theory, Johnson-Kendall-Roberts (JKR) theory, molecular dynamics (MD)

Environment-dependent nanoscale wear behaviour of graphite: ambient vs underwater conditions

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ABSTRACT

Two-dimensional graphene material is an effective atomically-thin solid lubricant with extraordinary physical, mechanical and chemical properties; and the remarkable capability to reduce friction with a single atomic layer [1,2]. However, its lubricating property is influenced by the presence of surrounding medium where the interaction between the molecules and graphene layers may exhibit complex friction and wear behaviour [3]. For example, few layer graphene exhibits enhanced tribological performance in the presence of condensable vapours under humid environment, whereas it offers high friction with increased wear rates in vacuum or dry environment [4]. Research works carried out to investigate the wear behaviour of graphene at nanoscale level hitherto lack in delivering complete understanding of the wear in presence of water. Hence, the current research focuses to develop a fundamental understanding of liquid environment interaction with the sliding interface using an atomic force microscope (AFM). In the current work, the friction and wear characteristics of graphite were compared in the presence of two different environments: ambient and water at step edges and interior step-free regions, both at nano and sub-micron scales. The experimental evidences revealed that water rendered significantly poor wear resistance to graphene layers than ambient environment in both step edge and interior step-free regions. Altogether, this study discovers that the presence of water inflicts heavy damage to the graphite surface under loading.

Keywords: nanotribology, wear, highly ordered pyrolytic graphite (HOPG), graphene, atomic force microscopy

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Sliding wear and corrosion behaviour of Al-TiB2 functionally graded composite through centrifugal casting process

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ABSTRACT

The present study evaluates the wear and corrosion behaviour (in 3.5% NaCl solution) of Al-TiB2 Functionally-Graded Material (FGM) processed by the centrifugal casting method. The Al-TiB2 FGM composites were fabricated at 1000, 1100 and 1200 rpm in a graphite-coated mild steel mould. The wear and sliding friction behaviour against the rotating disk of EN 31 is studied with the help of the Tribometer. The wear test was conducted at 160 rpm rotational disc speed in dry condition under 50 N normal load for 10 minutes. The worn surface is characterized by scanning electron microscopy (SEM). The wear rate is calculated by the volume loss (mm3) per unit sliding distance of the sample measured before and after the test. Through microstructure, the correlation of wear rate and wear mechanism for Al-TiB2 particles inside the matrix comparison has been studied. The fabricated FGM composite proves its ability for use in automotive sliding applications and provides improved wear characterization at dry sliding conditions. The rotational speed of mould of centrifugal casting and its consecutive effect on corrosion resistance of composites is estimated with corrosion current density. Weight loss test is taken to understand the corrosion rate of Al-TiB2 FGM composites and corroded surfaces are studied by SEM images.

Keywords: Sliding wear; Corrosion; Centrifugal Casting; FGM; Al-TiB2

Numerical investigation on tribological behavior of structured surface in sliding bearing under lubrication

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ABSTRACT

Structured surfaces have been proven to be a remarkable method for enhancing the performance of sliding bearings in terms of friction reduction and load-carrying capacity. The performance of the structured surface is significantly influenced by characteristics such as shape, size, depth, area density, and pattern of arrangement which further vary according to the operating conditions. In this study, structured surfaces with deterministic shapes like square, circular, and triangular recesses have been evaluated for realistic operating conditions. The computational fluid dynamics model is developed to predict the performance of the parallel sliding bearing by solving the Navier-Stokes and continuity equation for incompressible flow. The model creditability is confirmed after conducting a detailed analysis and comparison with the literature. Subsequent optimization of structured surface characteristics aims to maximize the efficiency of parallel sliding bearings for a wide range of thrust loads and sliding velocities. The mechanism of the pressure build-up/micro hydrodynamic effect and prevention of lubrication rupture on the parallel sliding bearings is discussed. The results indicate that the percentage of sliding bearing area covered by a recess (partial or full structured surface) has a significant influence on the load-carrying capacity.

Keywords: Navier-Stokes, continuity equation, lubrication, friction.

A study on performance assessment of water cooled thrust bearing pad equipped with deep recess

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ABSTRACT

At high speeds minimization of operating temperature is the critical design objective in hydrodynamic thrust bearings as high temperatures are generated due to vigorous viscous shearing of oil film. Under such circumstances bearing parameters like thermal pad deformation and oil film thickness gain critical importance. The provision of leading edge groove serves as economical and efficient way to counter the high temperature generated during high speed applications. One of the recent approaches to reduce the bearing temperature is the use of pads with embedded cooling circuitries. Here heat is directly exchanged between pad and the cooling fluid flowing inside the cooling channel embedded on pad. In this study CFD (CFX) simulation code is used to numerically evaluate the effect of new hybrid bearing configuration (cooling circuitry and leading edge groove) on the performance parameters of thrust bearing. The effect of hybrid configuration used in this study has not been reported yet.

Keywords: Hydrodynamic, Thermal Pad Deformation, Oil Film Thickness, Computational Fluid Dynamics, Thrust Bearing

Femtosecond laser applications in tribology: A brief review

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ABSTRACT

Tribology, the science of friction, wear, and lubrication, plays a vital role in various industrial applications. As technology advances, researchers continuously seek innovative methods to understand and manipulate tribological processes. In recent years, femtosecond lasers have emerged as a promising tool for tribological applications due to their ability to create surface structures with sub-micrometer dimensions. These structures can significantly improve the tribological properties of materials, such as reducing friction, wear, and adhesion. Femtosecond lasers, which emit ultrashort pulses with durations in the femtosecond range (10-15 seconds), have opened new avenues in the realm of tribology due to their unique characteristics. The controlled and precise ablation capabilities of femtosecond lasers enable researchers to investigate surface engineering, microstructuring, and nano-modification processes on a variety of materials relevant to tribology, including metals, ceramics, and polymers. Additionally, femtosecond laser-induced surface texturing has shown remarkable potential in enhancing frictional properties and reducing wear on different surfaces. This paper aims to present a comprehensive review of the recent developments in femtosecond laser applications in the field of tribology. It begins with a brief overview of the advantages of femtosecond laser and provides comparative study with other laser sources, such as nanosecond and picosecond lasers. It then focusses on outlining the various applications of femtosecond lasers in tribology. In conclusion, femtosecond laser applications in tribology offer exciting possibilities for advancing our understanding of fundamental tribological processes and developing novel engineering solutions.

Keywords: Friction, wear, lubrication, laser.

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Estimation of coefficient of friction from extent of frictional noise in nonferrous alloy tribo-pair

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ABSTRACT

Herein, the contour interpolation technique was utilized to correlate frictional noise with the coefficient of friction during the sliding of Steel/Aluminum 4047 alloy and Steel/Alpha Brass alloy tribo-pairs. The effect of surface roughness and frequency on the frictional noise and its correlation with the coefficient of friction was also studied. The results indicate that the range of frictional noise obtained for different testing conditions was 79.56-94.35dB for Aluminum 4047 alloy and 75.91-90.51dB for alpha Brass alloy. Further, for different testing conditions, the friction coefficient range achieved was 0.159-0.22 for Aluminum 4047 alloy and 0.148-0.201 for alpha Brass alloy. The contour plots indicate that the coefficient of friction can be predicted as a range for varying frictional noise and sliding time.

Keywords: Coefficient of friction; Contour graphs; Frictional noise; Surface roughness; Regression; ANOVA; FESEM.

Enhancing the performance of concentrated tribo-contacts: Investigating the tribo-performance of nano grease lubricated textured concentrated contacts

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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, triboperformance 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 triboperformance 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.

Keywords: grease lubricated textured contacts, friction coefficient, nano particle blended oil/grease, boundary lubrication, electrical contact resistance

Bio-tribocorrosion studies on hierarchically architectured multi-scale surface features fabricated on Ti-alloy

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ABSTRACT

Increasing cases of implant failure caused by poor osseointegration and drug-resistant bacterial infection have imposed inexplicable challenges in healthcare and biomedical industry, thereby calling for effective surface engineering routes towards functionalizing the implant surfaces. Developing surface features at nano- and micro-/nano-scales have been proven to be effective in invoking osseointegration alongside preventing microbial growth through selective contact-killing mechanism. However, the tribo-corrosion behaviour of such surfaces fabricated on commercially used implantable biomaterials in a simulated body environment is not well understood and requires further development. In this study, a dual step surface processing route integrating laser micro-texturing and thermochemical treatment has been adopted to fabricate a hierarchical micro-/nano-structured morphology on Ti-6Al-4V ELI alloy. Preliminary investigations reveal a multi-layered porous and gradually densifying oxide layer with predominant TiO2-anatase phase constitution. Electrochemical studies in simulated body fluid reveal an improved passivation tendency on the nanostructured surface having an underlying micro-morphology, thereby imparting an enhanced corrosion resistance, as compared to only laser textured and only wet etched surface. The response of the surface under the synergistic action of bio-corrosion and wear is being undertaken, to reveal the surface degradation mechanisms under fretting tribo-corrosion environment. The bio-tribological performance of the surface-treated samples shall be crucial in determining their suitability for medical implant applications such as bone plates, stems and pins.

Keywords: Bio-tribocorrosion, fretting, hierarchical micro-/nano- structures

Tribology - for the machine condition monitoring - At site

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ABSTRACT

Plant machinery monitoring is critical both for the machine and plant reliability and sustainability. Tribology plays a critical and very important part in it - all the machines are lubricated for their sustainable run. Study reveals that machine faults are first detected through lube oil analysis even before they are detected through, acoustic emission and the most popular the vibrations monitoring and analysis, giving maximum pre-warning time. Main advantage with the vibration or the acoustic emission being they are monitored and analysed at site to enable the plant engineer to monitor the machines in real time for the timely planned corrective action. Importantly - in the complex machines eg gearboxes fault finding are much easier and simpler by using wear particle monitoring and analysis as compared to the Vibration analysis that involves significantly complex spectrum analysis to be carried out which requires very high skill and experience. As per renowned tribologist Dr Rabinowics of MIT, 70% of the machine failures are due to surface degradation all of which can be detected well at site and in time through oil analysis. Studies are available that monitoring and controlling water ingress in real time can extend the bearing life by at least four times. Lubrication analysis involves two main objectives - lubrication condition and the machine condition - both can be monitored by oil condition monitoring at site. Oil - like the blood in the human body, carries immense amount of information of the machine, its components and itself. And its monitoring and analysis is of prime importance AND doing this at site is of utmost importance from the pant engineers' perspective. Reliable and user-friendly easy to use instruments are available to monitor important critical parameters and the results correlating within an extremely good accuracy of the lab results. - At site- viz: Viscosity Water in Oil. AN BN. Insoluble. Particle Counting Ferrous debris monitoring and analysis Elemental analysis and soon FTIR oil analysis at site shall be available. Online sensors and now through IOT its even more convenient and advantageous for realtime machine monitoring

Keywords: Viscosity, lubrication, reliability, tribology.

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Impact of microstructure on erosion behaviour of 1.03 C alloy steel against alumina particles

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ABSTRACT

Solid particle erosion refers to the removal of material from the surface caused by the continuous impact of hard and angular particles with high impact velocity. Its severity has been seen in many engineering applications, including gaseous fluid valves, hydraulic systems, pipelines, aeronautical components, hydraulic pump impellers, and turbine blades. The current study focuses on the effect of microstructure on the erosion behaviour of 1.03 C alloy steel against alumina particles. Following casting, the as-cast material was heat treated to achieve pearlitic and bainitic transformations. The microstructure of the steel samples was examined using optical/scanning electron microscopy, and the phases were identified using XRD analysis. The steady state erosion rate of pearlitic/bainitic steel samples was determined by subjecting them to erosive wear at varied impact velocities ranging from 40 to 90 m/s and impact angles ranging from 15° to 90° using 50 µm sharp alumina particles as erodent. The erosion behaviour was correlated with the erosion power law model by E = kvn, and the velocity exponent (n) for bainitic microstructure was 3.18 and 2.34 for pearlitic microstructure, indicating that bainitic steel did not exhibit completely ductile or brittle erosion behaviour, but was in the transition zone. On the other hand, the pearlitic steel samples displayed ductile erosive behaviour due to their high toughness. Both microstructures showed similar erosion behaviour at low impact velocity (40 m/s), but at intermediate (60 m/s) and high (90 m/s) velocities, the pearlitic microstructure exhibited higher erosion resistance due to ductility than the bainitic phase. SEM analysis of the eroded surface revealed multiple erosion mechanisms, including ploughing and cutting, and alumina embedded and cracked at a high impact angle (90°). Cracks and pit development can be detected at 60° and 90° impact angles. A very small amount of microchipping was seen at a 60° angle. At a lower impact angle of 30°, micro ploughing, cutting, and lip development were observed.

Axisymmetric analysis of adhesive interaction between an elastic body and a rigid half-space using finite element method

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ABSTRACT

We have used the finite element method to analyse the adhesive contact interaction between an elastic object and rigid half-space. This approximates the adhesive interaction between an elastic asperity and a rigid surface. The adhesive force is incorporated as a body force derived from the Lennard-Jones potential. The general formulation is discussed first and then adapted for special case like symmetry handling. We present a convenient implementation of the axisymmetric formulation developed in this work, which provides significant computational benefits compared to a full three-dimensional formulation. The comparison of the results of our analyses with analytical solutions demonstrates the significance of axisymmetric formulations in terms of accuracy and computational speed. We have considered axisymmetric bodies of different sizes to study the influence of asperity sizes in adhesive interactions.

Keywords: Adhesion, van der Waals force, Finite element method, Body force formulation, axisymmetric formulation

"Vibration based condition monitoring of conical journal bearing using machine learning approach"

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ABSTRACT

This study provide an innovative machine learning, vibration-based condition monitoring method for conical journal bearings. Conical journal bearings are frequently employed in numerous rotating machines, and for effective industrial operations, their dependable performance is crucial. However, wear, alignment, and lubrication problems can cause serious failures and expensive maintenance due to downtime. A complete system that uses vibration data gathered from the bearing throughout its operating life to address these issues. Real-world operational data collected from diverse industrial setups is used in our experimental investigation to ensure the robustness and applicability of the suggested methodology. To find the best model for conical journal bearing condition monitoring, we compare the performance of Random Forest and Naïve Bayes machine learning algorithms. The outcomes show how the chosen model outperforms conventional approaches and enables early fault detection in terms of accuracy, precision, recall, and F1-score. This study offers an effective method for preserving the health of conical journal bearings, making a substantial contribution to the fields of predictive maintenance and condition monitoring. The suggested methodology can be easily incorporated into current maintenance procedures, minimizing maintenance expenses and downtime while ultimately increasing the overall productivity and dependability of rotating gear in industrial settings.

Keywords: Condition Monitoring, Machine Learning, Vibration Analysis

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Adhesion evaluation at the interface of the rough surfaces of the elastomer (PDMS)

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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, biochips, triboelectric nanogenerator, and electronic sensors. Adhesion at the interface of two materials can be controlled by various methods such as some chemical treatment on the surface of the materials, changing the mechanical property of materials and modifying the surface structure of the materials. To achieve structured PDMS surfaces, various techniques can be employed, such as micro-patterning or surface texturing. These methods create patterns or features on the PDMS surface, which can enhance the contact area and improve the adhesion at interface of the materials. The main idea of this study is to control adhesion at the interface by the modification of the surface topology of the elastomer. Adhesion was measured at the interface of two rough surfaces of the elastomer (PDMS). The rough surfaces of the elastomer (PDMS) produced against the sandpapers were termed the master samples. The varying roughness or texture on the master samples were developed by using sandpapers of various grit numbers. These master samples of elastomer (PDMS) were then used for sequential molding of elastomer to make the complementary (interfaces of same roughness) and non-complementary (interfaces of distinct roughness) surfaces. Adhesion measurements were performed using a wedge test at the interface of the complementary and non-complementary rough surfaces. The relation between adhesion and roughness of the elastomer (PDMS) will be presented and discussed.

Keywords: PDMS, surface texturing, roughness, adhesion.

Initiatives for circular economy in used oil at Indian oil

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ABSTRACT

Circular Economy in Used Oil In a rapidly changing world, the utmost concern today is pollution and scarcity of resources. One litre of used oil can contaminate one million litres of fresh water- a year's supply for 50 people, as it contains toxic substances such as benzene, lead, zinc, and cadmium, in addition to impurities such as dirt, metal parts and water. Used oil is a valuable resource as oil doesn't wear out, it just gets dirty. Global warming is the long-term heating of Earth's climate system due to human activities, primarily fossil fuel burning, which increases heattrapping greenhouse gas levels in Earth's atmosphere. The massive consumption of oil after extraction from the earth, processing, manufacturing, transportation, and disposal contributes substantially to release of greenhouse gases into the atmosphere thereby increasing pollution. To mitigate this concern, concept of Circular Economy in used oil has gained momentum in past two decades, wherein we not only use the rerefined oil, obtained from used oil for manufacture of lubricants, but also conserve the precious petroleum reserves for safer and healthier tomorrow. Moreover, recycling has potential to reduce the rate of global climate change by reducing the extraction and the amount of fossil fuels burnt in the manufacturing processes. This helps in lowering carbon footprints in the ecosystem. Re-refining of used lubricants could result in both environmental and economic benefits. Re-refining of used oil to manufacture base oil conserves more energy than reprocessing the used oil for use as fuel. The energy required to manufacture re-refined base oil from used oil is only one-third of the energy required to refine crude oil to produce virgin base oil. Therefore, re-refining is considered by many as a preferred option in terms of conserving resources as well as minimizing waste and reducing damage to the environment. In line with global trends, Niti Aayog has also initiated the drive to increase the usage of used oil in India and formed a committee on "Circular Economy in Used Oil Waste" headed by MOPMG to investigate various aspects with the primary objective to increase the consumption of used oil in India and the said committee submitted its report to MOPNG in August2021. Further, after multiple deliberations at various levels, MOEF & CC is in process to finalise EPR (Extended Producers Responsibility) legislation in used oil, expected to come in effect from 01.04.2024, in which Lube manufacturers and other stakeholders are being entrusted with responsibility to implement circular economy in lubricants.Recycling of used oils in India As per data available with CPCB, more than 400 authorized rerefiners(recyclers) are registered with CBCB/ SPCB, having a combined capacity of 1.5 MMTPA of re-refined oil. These re-refiners are distributed across 124 districts spread over 19 states. Thus, India has adequate rerefining capacity to process the used oils that are generated in the country. Used oil is mainly sourced from Auto OEM service stations & independent garages. Also, different industries, transport undertakings, mines, defence forces, power generating plants etc act as source of used oils through traders. Availability of quality RRBO (Re-Refined Base Oil) Availability of quality re-refined base oil is always a concern due to unstructured and non-standard used oil market in India. Most of the RRBO produced in India

conforms to Group I base oil category and is not suitable for most of the high-performance automobile applications such as engine and gear oils. In fact, the technology used for production of RRBO in India involves simple filtration, segregation of waste and vacuum distillation- which is just enough to produce Group I RRBO. Hydrogen is not used in the process at any stage, which is essential for production of high quality RRBO. In order to produce Group II RRBO, it is imperative to use hydrogen for hydrotreating and hydro-finishing during base oil production process to meet performance characteristics like high oxidation and thermal stability, improved fuel efficiency, low Noack volatility and low CCS. Further, modern day automotive formulations mandatorily require Group II/III base oils mainly to meet low emissions and high-performance requirements. Accordingly, all auto OEMs are based on Group II/III base oils only and hence for obtaining approval for formulations based on RRBO, it is mandatory for base oils to conform to Group II/III performance levels. During our discussions with OEMs like Maruti, Hyundai, Kia Motors, etc., they have categorically stated the requirement Group II/III base oils is mandatory as a pre-requisite for approval of formulations for their automotive applications. The basic hurdle today in India is non-availability of production facilities for these high-performance base oils (RRBO). Initiatives for circular economy and EPR at Indian Oil Indian Oil has launched four lubricants so far with 25% Re-refined base oils as follows-(i) HDMO 15W40 oil for commercial vehicles (ii) PCMO 5W30 oil for petrol vehicles (iii) MCO for four stroke bikes (iv) Tractor oil. These oils have been tested and found to lower generation of 10% CO_2 emissions in the eco system as the re-refining process requires lower energy for processing RRBO as compared with lubricants formulated with virgin base oils. Further, new products in hydraulic and gear oil categories are being planned for launch in the current year. Sales of more than 2500 KL was achieved for these grades in 2022-23. It is pertinent to note that the MCO launched with 25% RRBO has become one of the highest selling lubricants for two-wheeler category and is projected to cross sales volume of 5000 KL in 2023-24. Further, Indian Oil has also obtained approval for two grades based on RRBO from Tata Motors and three grades from M&M for plant fill. Sales of these grades is expected to start shortly once sale of RRBO is stabilised. With ongoing product development and marketing initiatives, IOCL is aiming to achieve objectives of Circular economy in used oil as per statutory requirements being drafted in the EPR for all stakeholders.

Keywords: Fossil fuel, lubricants, rerefined base oil, wear, engine oil.

Timely execution of recommendations of high wear particle concentration (WPC) reduces mechanical wear

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ABSTRACT

Adani Dahanu Thermal Power Station (ADTPS) is one of the best power generation plants in India. Plant has consciously adopted lube oil & grease monitoring program as one of the key Condition based maintenance management practices. Equipments are prioritized for close monitoring on the basis of criticality index to ensure high plant availability by ascertaining health of equipments. This paper uncovers the vital role of Routine Oil Condition Monitoring (OCM) in Industry 4.0 that identifies small problems within machinery components before they become catastrophic failures, which can acquire costly repairs & production to a halt. The paper discloses success story of execution of oil condition monitoring (OCM) program at ADTPS, wherein oil quality detoriation of critical auxiliaries Coal Mill Reducer Gearbox & Bulldozer Transmission Oil was detected during April 2023 and December 2022 respectively. Wear debris analysis report confirmed presence of high wear particle concentration (WPC) which helped in diagnosing exact root cause of abnormity well in advance enabling Maintenance Engineers to decide whether to replace or filter/centrifuge the oil avoiding downtime of the equipment. Timely execution of corrective action has prevented generation of secondary wear. This case study has clearly demonstrated that monitoring the level of wear particle concentration (WPC) is essential parameter for driving successful OCM program to pinpoint abnormality at early stage avoiding secondary damage to Main Reducer Gearbox of Coal Mill & Transmission system of Bulldozer. This has saved the plant from huge losses in terms of unplanned breakdown time and associated maintenance, manpower & spares costs. Other major benefits include prevention of downtime, avoidance of major gearbox repair or replacement costs and reliability of plant.

Key Words: Wear particle concentration. OCM, wear.

Biotribological studies of Structalit™/UHMWPE composites for hip joint application

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ABSTRACT

Ultra-high molecular weight polyethylene (UHMWPE) is a widely accepted liner material for hip joint replacement [1]. However, wear debris generated during articulation leads to adverse tissue reactions, resulting in osteolysis and implant failure [2]. Another primary concern of UHMWPE is its lower mechanical strength, necessitating a thicker cup coupled with a smaller head diameter. This geometrical constraint limits the range of motion of the joint. Therefore, both aspects of material design should be considered for new implant development. The current study is an effort to explore materials that can perform better than UHMWPE. In this work, Structalit/UHMWPE-based composites have been developed. Structalit is a biocompatible material (ISO 10993-5) with good mechanical strength. Its composites have shown excellent tribological performance under dry sliding conditions [3]. Therefore, this study is designed to extensively investigate its suitability for implant application. Biotribological experiments were conducted using an inhouse developed prosthetic biotribometer (IPR, Design registration-373354-001) under diluted bovine serum solution condition. The coefficient of friction and specific wear rate of S24 composite (Structalit with 24 wt% UHMWPE) against CoCrMo were 0.08 and 1.35×10-6 mm3/Nm, 27% and 53% lower than pure UHMWPE. The lower friction and specific wear rate of S24 were attributed to the higher bulk mechanical strength and lower interfacial shear strength. Abrasion, burnishing, and protuberances were important surface damage characteristics of UHMWPE, whereas Structalit/UHMWPE composites had few micro-cracks on their surface. The composite pin surface also demonstrated a heterogeneity-driven flow of lubricant, which could provide potential benefits during lubrication.

Keywords: wear, tribological behaviour, UHMWPE, composite

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Influence of ZrN/TiN ceramic composites nanofilms on structural and tribological behavior of β-type Ti6Al4V alloys

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ABSTRACT

This objective of the study was to investigate the mechanical and tribological properties of composite thin films of titanium nitride and zirconium nitride that were used to coat Ti-6Al-4V G5 alloys. The investigation's goal was to determine whether fretting wear behaviour might be used to pinpoint wear mechanisms. To do this, thin films were made utilising DC magnetron sputtering and a functional grading process. The coatings' iso-structural polycrystalline multilayer structure, which showed smaller grains, crystallites, and compressive stress, was discovered by analysis. It's interesting to note that as the number of bilayers increased, so did the films' hardness. A pin-on-disc test was performed for the tribological evaluation, and the resulting wear tracks were thoroughly analysed using Kelvin probe force microscopy (KPFM) and field-emission scanning electron microscopy/energy-dispersed spectroscopy (FE-SEM/EDS). The analysis of the mechanical characteristics showed that abrasive wear mechanisms accounted for the majority of wear mechanisms. Additionally, the use of KPFM made it possible to distinguish between adhesive and abrasive wear mechanisms. By measuring fluctuations in capacitance and surface potential, this separation was made possible, demonstrating that KPFM is a sensitive approach capable of identifying variations in the chemical composition of adhered materials. The results of this study also demonstrate the exciting potential of KPFM for investigating tribooxidation processes, offering priceless experimental data to further our comprehension of wear mechanisms at the nanoscale.

Keywords: Tribological properties, Ti-6Al-4V G5 alloy, fretting wear, KPFM.

Design and development of a multi-station prosthetic biotribometer as per ASTM F732 standard

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ABSTRACT

The life of implants is limited due to the wear of biomaterials. Biotribological experiments are generally conducted for 2-10 million cycles in bovine serum to simulate physiological environments. Therefore, wear data collection is a time-consuming and expensive process. In this sense, a material screening device should be multi-station, simple in design, and easy to operate. To capture the effect of different kinematics and physiological conditions of joints, it should be multi-functional, i.e., reciprocation, rotation, revolution, and any desired combination of these motions are necessary. Cross-shear motion and protein-containing liquids are critical factors affecting the wear life of implants [1,2]. Therefore, the designed device in this work includes both features. Three UHMWPE pins and three mirror-finished CoCrMo discs were selected as tribological pair. The tests were conducted in diluted bovine serum with a 20 mg/ml protein concentration. The nominal contact stress and sliding velocity were 2 MPa and 20.73 mm/s, respectively. The average specific wear rate of UHMWPE was obtained as 2.8×10-6 mm3/Nm, which is clinically relevant [3]. Abrasion, burnishing, and micron-sized scratches were found to be the dominant wear mechanism. Very few locations had protuberances which could be due to the early degradation of protein or the plastic deformation of UHMWPE. The meaningful specific wear rate data and surface damage mechanism produced with this device makes it very useful for biotribological applications.

Keywords: Biomaterials, wear, surface damage mechanisms, UHMWPE.

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Hydrodynamic analysis of herringbone grooved journal bearing for locomotive turbocharger rotor

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ABSTRACT

In this study, herringbone texture over the journal bearing surface has been proposed and optimized with an artificial intelligence technique to improve the static and dynamic coefficient of bearing under radial loading conditions. The non-linear Reynolds equation for herringbone grooved journal bearing (HGJB) has been formulated and solved numerically with the finite difference discretization method and SOR algorithm for pressure profile distribution, film thickness, load carrying capacity, and power loss. Further, the stiffness and damping coefficient of the bearing has been determined by using the perturbation method. The static and dynamic characteristics of HGJB are enhanced with the different texture parameters, such as helix angle, angular groove width, number of grooves, groove depth, eccentricity ratio, and speed. An artificial neural network (ANN) is used to train the distinctive datasets obtained from the numerical analysis, and its performance is assessed by computing the root mean square error (RMSE) and regression coefficient (R2). From this training, an R2 value close to 1 designates the better performance of the model and accurate prediction of result with a lower percentage error. Following ANN analysis, an ANFIS surface plot is produced to identify the optimum value of the bearing parameters for which it has a maximum load-carrying capacity, stiffness, and damping coefficient. The outcome of this paper highlights the importance of numerical methodology, parametric analysis, and the applicability of artificial intelligence networks for the design of herringbone grooved journal bearing.

Keywords: HGJB, ANN, RMSE, wear.

Tribochemical investigation of wear tested samples of lube blends containing various additives using XPS for performance evaluation

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ABSTRACT

Surface analysis is extremely important to study tribochemical reactions occurring on frictional surfaces. Many surface analysis techniques are used for the characterization of boundary lubrication films. Among them, ESCA is a versatile surface analytical tool having high sensitivity & high resolution and is being used for Surface spectroscopy, Imaging and Depth profile studies. XPS characterization of tribo-chemical reaction film formed under friction test condition with different additives such as anti-wear (AW), extreme pressure (EP) and dispersant (DP), carried out at IOC R&D Centre, has been discussed w.r.t performance of the lubricants. Base oil blends containing MoDTC and ZDDP as AW / EP additive showed better performance compared to "Cl" and "P" based additives due to the formation of metal sulphides with iron on the sliding surfaces. Additive-Additive interaction by the addition of ZDDP along with MoDTC and MoDTP showed synergistic effect in the case of ZDDP with MoDTC which can be attributed to enhanced decomposition of MoDTC in presence of ZDDP as indicated by XPS. However, MoDTP as such possesses better AW properties than MoDTC due to its high reactivity with metal surface. The presence of metal sulphides under sub-surface layers was confirmed by depth profile analysis. In the case of lube blends containing nano PTFE as AW/EP additive, presence of dispersant like PIBSI reduces agglomeration of nanoparticles but competes with PTFE for tribofilm formation as indicated by XPS analysis.

Keywords: Lubricant, MoDTC, MoDTP, ZDDP, PTFE, XPS

Prediction of dynamic coefficients of foil journal bearings for high-speed rotor of turbopumps using artificial intelligence techniques

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ABSTRACT

Cryogenic engine of space launch vehicle uses turbopumps for higher thrust and longer burn duration. These turbopumps are considered as most critical components in a cryogenic engine. The rotor of the cryogenic engine subjected high radial load nearly 2000 N and this load is supported by angular contact ball bearings. These ball bearings are subjected to extreme adverse temperature and unbalance load, which leads to small life. Further, the working capacity of ball bearings is limited to the DN index of the rotor. Foil bearings has been proved to have long life and high-speed capability, with exceptional reliability, over a wide range of temperatures and various process fluids. However, high radial stiffness and damping is often a challenge in the development of foil bearings. Current research target to predict the load carrying capacity, radial stiffness and damping of bump type foil bearing which can be used in a test case LH2 turbopumps rotor with a 62.8 mm diameter and rotating at 38,000 rpm. A numerical model is developed using Reynold's equation, structural equations and perturbation methodology to predict load carrying capacity and dynamic coefficients. The load carrying capacity was found to be close to the radial load developed in a 30 kg rotor with G2.5 balancing grade. The results also reveal that the stiffness increases with the bearing number and decreases with increased bearing compliance whereas the damping shows an opposite nature. Further, the stiffness coefficients tend to increase and the damping coefficients tend to decrease corresponding to increase in speed. Further, the output data from the numerical model is given as input to the Artificial Neural Network (ANN) and a target space is generated for predicting the new dynamic coefficients. The ANN model is developed using five input foil bearings parameters based on Sobol® sensitivity analysis. For prediction of dynamic coefficient, the decision surfaces are obtained from the ANFIS network gives insight into the range of parametric data for maximization and minimization of direct and cross-coupled stiffness and damping.

Keywords: Cryogenic engine, ANN, ANFIS network, foil bearing.

Microstructural characterization and tribological properties on green pellets of wave transparent Si3N4 – SiO2 ceramics

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ABSTRACT

The superb quality of the ceramics includes good chemical stability, good creep and fatigue resistance, high hardness, good thermal resistance and low density [1]. Therefore ceramics are used in applications like aerospace, space, rocket nozzles, bearings, biomedical cutting tools, bullet-proof vests, and microwaves for the communication system [2]. Until now, no research has been found on the tribology of green pellets of ceramics. So in this work, the green ceramics Si3N4 + SiO2 compact produced by compression moulding at a pressure of 65 bar and temperature of 250 °C with Si3N4 (99.99% pure, APS< 10 µm) and SiO2 (99.9% pure, APS: 250 nm) powders with stoichiometric ratio. In compression moulding, the strength of the green pellets enhanced the binder's binding ability. Ball (Si3N4 ball of diameter 6.35 mm, 24000 HV10) [3] on disk tribo test will perform on a polished surface of green pellets. Before the tribo test, the phase analysis performed by XRD (Malvern Panalytical, U.K.), The morphology of the surface of green ceramics compacts, analyzed by FESEM (JEOL, JSM7900F, JAPAN) and surface roughness of polished surface (PS) analyzed by optical microscope (Olympus, DSX500, JAPAN). The tribological properties friction, wear, oxide formation will be analyze by using a ball on disc trobometer. The worn morphology will analyze by FESEM and EDS.

Keywords: Green pellets, ceramics, roughness, wear.

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Effectiveness of UHMWPE as additives in commercial lithium soap greases (with & without tackifier additive)

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ABSTRACT

Ultra-high-molecular-weight polyethylene (UHMWPE), a thermoplastic polymer is well known for offering very low friction and high wear resistance in adhesive, abrasive, reciprocating, fretting wear modes and wear resistance in erosive wear mode. Its particles are used as fillers in polymer composites to improve the triboperformance of a composite significantly. A lot is reported on the exploration of particles of various solid lubricants such as PTFE (Polytetrafluoroethylene), MoS2 (Molybdenum disulfide), graphite, etc. as additives such as EP (Extreme pressure), AF (Anti-friction) and AW (Anti-wear) in greases. Innovations in technology are demanding a search for more and more efficient and environment-friendly additives at lower costs. Keeping this in view, it was decided to explore the potential of particles of UHMWPE as EP, AW, and AF additives in grease since this has not yet been reported in the literature. UHMWPE particles are comparatively cheaper, chemically inert, environment-friendly, easily available, and have a very high shelf life. This paper describes the process for the development of Lithium- based grease using poly alpha olefin (PAO) oil as a base-stock and micro-sized UHMWPE particles as a filler in various amounts 0, 0.5, 1, 1.5, 2 %. Developed greases were evaluated for physical (drop point and penetration test) and tribological performance such as a four-ball EP tester to measure the weld load (EP property) and a four-ball wear tester to measure AF and AW properties. Though there was no significant improvement in a drop point, the consistency decreased gradually with an increase in the percentage dosage of particles. The tribo-results showed improvement in load-carrying capability almost by 50 % at 1% dosage, which proved to be optimum. The inclusion of particles proved beneficial for AW and AF performance also although, the % benefits were less when compared to EP benefits. The SEM was used to understand the reasons behind an improvement in performance.

Keywords: Solid lubricants, Anti-Friction, Anti-wear, Extreme Pressure, Drop point, Wear scar diameter, Weld load

Investigations on surface properties and surface morphology in dissimilar joining of Mg-WE43 and Al-7075 alloy

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ABSTRACT

The materials engineers are developing hybrid materials/joints that posses multitude of properties, one such hybrid structure is Mg-Al joints. Moreover, the growing demand of weight reduction in transport sector has further enticed the need of Mg-Al dissimilar joints. The joining of such hybrid structures by fusion welding often results in uneven weld surfaces with high desnity of intermetallic compounds (IMCs). The uneven weld bead and IMCs are detrimental to weld properties. The present study employed solid state welding to address the aforementioned problems. In this study Mg-WE43 and Al-7075 alloys were welded by Friction stir welding (FSW) process. Microstructural properties of the welded surfaces were evaluated using Optical microscopy (OM), scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS). Surface properties (wear, micro hardness and corrosion) were analysed using wear tester, micro-hardness tester and potentiodynamic polarisation tests. The findings also showed a decline in the IMCs content. These results provide a different method for improving the surface properties and strength of Mg/Al dissimilar joints. Furthermore, the study correlates the effect of process parameters such as temperature variation through different media (Air and Demineralised water), tool rotational speed and tool traverse speed on surface properties and morphology.

Keywords: Mg-Al joints, intermetallic compounds, EDS, FSW.

Parameter Optimization of the Gear Lubrication of Open Girth Gears

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ABSTRACT

The use of Open Gear Lubricants (OGL) in various industries, ranging from bituminous products to oil-based greases, plays a crucial role in ensuring efficient machinery operation. However, conducting field trials to evaluate lubricant performance under actual operating conditions can be impractical or costly. Therefore, the development of suitable laboratory tribological evaluation methodologies becomes essential. Literature on laboratory tests for comparing test conditions with actual operating conditions in coal-fired power plants describe quantification of wear as a key parameter for lubricant performance evaluation. This paper examines the existing research on laboratory test methods and performance parameters for open gear lubricants, presents a test method aiming to simulate real-world operating conditions in a controlled laboratory environment and optimize the lubricating parameters in the field condition. The important operating conditions to be simulated in the laboratory test methods are outlined, including load, temperature, gear dimensions, sliding speed, spraying pattern, and test duration. The modification of the FZG rig to accommodate the spray lubrication system is proposed to evaluate lubricating and wear protection properties of OGL. The spray lubrication system, include the components such as a spray nozzle, pump system, solenoid valve, and compressor. The cyclic timers attached with the solenoid air valve and OGL flow line motor control the OGL lubricant spray interval time. Wear loss measurement, thermal imaging technique and 3 phase energy meter readings, are employed to quantify the effectiveness of the OGL lubricant in reducing wear, controlling temperature distribution on gears and energy consumption in the gear system. This study presents insights into the performance of the OGL lubricant, contributing to the optimization of gear functionality and longevity. Optimum nozzle-gear contact surface distance is required for proper distribution of lubricant over gear contact surface which is crucial for optimal performance. A lab-scale test setup also helps to determine the spray interval to simulate starvation, which is dependent on the lubricant's performance. This study summarizes lubrication parameters to be optimized in open gear lubrication and enhancing gear functionality and durability by systematically varying these parameters and analyzing their effects.

Keywords: Open Gear Lubricants, FZG, Spray Lubrication

Utilizing physics-informed neural networks for the assessment of two-lobe hydrodynamic journal bearings

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ABSTRACT

This work introduces an innovative approach for the analysis of two-lobe hydrodynamic journal bearings, leveraging the power of physics-informed neural networks (PINNs). This methodology utilizes PINNs to solve the complex Reynolds equation, shedding light on the intricate performance characteristics of these bearings, particularly in the context of cavitation phenomena. This strategy incorporates adaptive techniques and employs vertical load balancing, ensuring that this model efficiently captures the nuances of the bearing's behavior. Moreover, the input parameters of the PINNs to include crucial performance metrics, such as journal eccentricity, to further refine the analysis. This research work includes in a comprehensive case study involving a two-lobe journal bearing, where we compare the results of our method with those obtained through traditional finite element methods. Through this comparative analysis, we demonstrate the remarkable effectiveness of our proposed approach in providing invaluable insights into the intricate lubrication characteristics of two-lobe hydrodynamic journal bearings. This work not only advances our understanding of complex lubrication dynamics in journal bearings but also underscores the potential of PINNs in addressing real-world engineering challenges, offering a promising avenue for more efficient and insightful bearing design and analysis techniques.

Keyword: Lubrication Analysis, Neural Network, Deep learning Reynolds Equation

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[1] Authors, Year, Title of the referenced material, Name of the Journal or Book, Vol. (Issue) page numbers, book publisher's name, city etc.

Open Induction Cast Pb-Sn-Cu Alloy as Superior Wear-Resistant Hard Coating Material

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ABSTRACT

This study focuses on the development of a low-friction ternary alloy based on lead, copper (Cu), and tin (Sn), intended for coating applications. The alloyfabricated via open induction casting method, resulting in a distinctive two-phase microstructure. Notably, the alloy exhibited an exceptionally low hardness value of 15 HV.In subsequent pin-on-disc tribometer studies, the alloy's performance was remarkable, particularly at a temperature of 80°C. At this temperature, the alloy demonstrated a reduced Coefficient of Friction (CoF) and a decreased wear rate compared to other temperatures. Noteworthy is the fact that the wear rate of this alloy was significantly lower than observed in other soft-metal-based alloys.These findings underscore the alloy's effectiveness in reducing friction, positioning it as a promising candidate for durable and efficient coatings across various industries.

Keywords: Coefficient of Friction, hardness, wear.

Impact of various parameters on the tribological performance of nano lubricants considering oxide nanoparticles in conventional, semi-synthetic, and fully synthetic lube oils

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ABSTRACT

In the realm of lubrication, nanoparticles exert a notably positive influence on enhancing tribological performance, particularly certain oxide nanoparticles exhibit exceptional capabilities as friction and wear mitigators. However, a substantial research gap exists concerning the efficacy of oxide nanoparticles across various lubricant categories. Therefore, this study meticulously elucidates the effective integration of oxide nanoparticles in diverse lubricant categories. Employing HRTEM, XRD, and FTIR, we characterize shape, size, and crystallinity. A Taguchi L18 orthogonal array is employed for experimental planning, with performance characteristics of nano lubricants measured using four-ball testers. The experimental findings reveal a hierarchy of parameters governing the minimization of the coefficient of friction (COF), which are as follows: nanoparticle type, nanoparticle composition, load, speed, and lubricant, in that order. Similarly, the parameters controlling the reduction of wear scar diameter (WSD) are ranked as follows: load, nanoparticle composition, nanoparticle type, speed, and lubricant (base oil). Furthermore, an analysis of variance (ANOVA) is conducted to assess the contributions of these factors to COF and WSD. Regarding COF, 43.37% of the variance is attributed to nanoparticle type, 26.78% to nanoparticle composition, 14.49% to load, 11.8% to speed, and 2.36% to lubricant (base oil). In the case of WSD, the factor contributions are 47.67% for load, 22.4% for nanoparticle composition, 14.03% for nanoparticle type, 7.26% for lubricant (base oil), and 7.01% for speed.

Keywords: Lubrication, COF, WSD, FTIR, HRTEM.

Wear performance of HVOF Al_2O_3-based coatings - An experimental investigation

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ABSTRACT

Tribological and erosive wear is a damaging process that deteriorates the surfaces of engineering components. It poses significant challenges in various applications, including gas turbines, heat exchangers, pumps, wind turbine blades, and piping systems. To address this issue, implementing surface modification techniques is crucial to enhance component durability and extend their lifespan in erosive environments. By modifying surface properties such as hardness, toughness, and resistance to particle impacts, overall component performance and reliability can be improved. In this Work, the HVOF surface modification technique is employed due to its exceptional characteristics, including high coating density, bond strength, and cohesion strength. This Work focuses on the utilization of rare Earth oxide, lanthanum oxide (La_2O_3) as a reinforcing material in Al_2O_3 coatings with varying weight percentages (1.4%, 1.6%, and 1.8%). Tribological testing was performed at different loads and erosion testing was conducted at different angles (30°, 45°, 60°, and 90°) under dry conditions. The type of failure observed during the testing provided insights into the coating's brittleness or ductility. Ductile coatings exhibited maximum erosion rates at around 30°, while brittle ceramics demonstrated peak erosion rates at a 90° angle. The findings revealed that the incorporation of La_2O_3 up to 1.6% significantly improved the erosion resistance of the Al_2O_3-based coatings. This enhancement is attributed to the formation of new phases that hinder the formation of coarse grains, resulting in a finer grain structure. Thorough SEM and XRD analyses were performed to gain a comprehensive understanding of the obtained results. Understanding and addressing both tribological and erosion wear is vital in the development of effective wear mitigation strategies for a wide range of applications. The results revealed that lanthanum oxide (La_2O_3) coating helps to improve the erosion wear performance of the coating and shall help in various application such as Automotive, Aerospace and Defense, Marine, Oil and Gas Industry etc.

Keywords*:* Erosion, HVOF, Coating, Al_2O_3, La_2O_3.

Investigations on the multilayered hard ceramic coating over the cast iron substrate

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ABSTRACT

In this article, multilayer coating the hard ceramics of Al_2O_3 and TiO_2 was deposited over the cast iron substrate using HVOF thermal spray coating method. The mechanical, morphological, tribological and electrochemical behaviors of the coated samples was investigated. The morphological study of the coating specimen showed the mechanism of deposition and presence of the coating materials up to the desired thickness over the surface. The microhardness of the coated sample increased considerably compared to the substrate material. The residual stresses induced in the material during coating were measured and found compressive in nature. The coated specimen was investigated on the high temperature rotary tribometer and the tribological behavior was compared with the substrate material. The results showed the decrement in the specific wear rate by ≈ 57% as compared to substrate. The SEM investigations of the wear track reveals that the wear mechanism was having the predominance of smearing and abrasion. The electro-chemical behavior of the coating was studied using liner polarization test under acidic environment, the coating showed remarkable inertness to corrosive environment.

Keywords: Multilayer coating; HVOF thermal Spray; Tribology; Corrosion test.

Enhancement of tribological properties of lube base oil by nanostructured 2H-MoS_2 grown on silica nanoparticles

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ABSTRACT

Friction and wear-induced energy and material losses are prevalent occurrences in engineering systems. The utilization of effective lubrication systems for interacting surfaces minimizes the friction and wear, thereby prolonging the operational lifespan of engineering components. Among the 2D nanostructured materials, MoS_2 has been recognized as an excellent lubricous material because of its remarkable mechanical attributes, lamellar structure driven by van der Waals interactions, high thermal stability, minimal shear resistance, and a large surface area. Nonetheless, the poor dispersibility of 2D layered nanomaterials has posed a significant obstacle to their effective utilization for liquid lubricants. The present work demonstrates single-step hydrothermal approach to grow nanostructured MoS_2 on the surface of thoroughly dispersed silica nanoparticles in the reaction media to afford the MoS_2 coated silica (MoS_2@SiO_2). The crystalline and structural features of MoS_2@SiO_2 are examined by XRD, Raman, and FESEM analyses. The MoS_2@SiO_2 dispersed in SN-150 lube base oil is used for steel tribopair to explore the enhancement of tribological properties. A minute dose of MoS_2@SiO_2 (0.1 $mg.mL^{-1}$) in SN-150 lube base oil reduced wear scar diameter and friction of steel tribopair by 12% and 34%, respectively. The spectroscopic and microscopic results based on FESEM, EDS, and Raman measurements will be discussed during the presentation to emphasize the detailed lubrication mechanism, accentuate the pivotal role of MoS_2@SiO_2 in augmenting tribological properties

Keywords: Friction, wear, FESEM, EDS, Raman spectroscopy, nanomaterial.