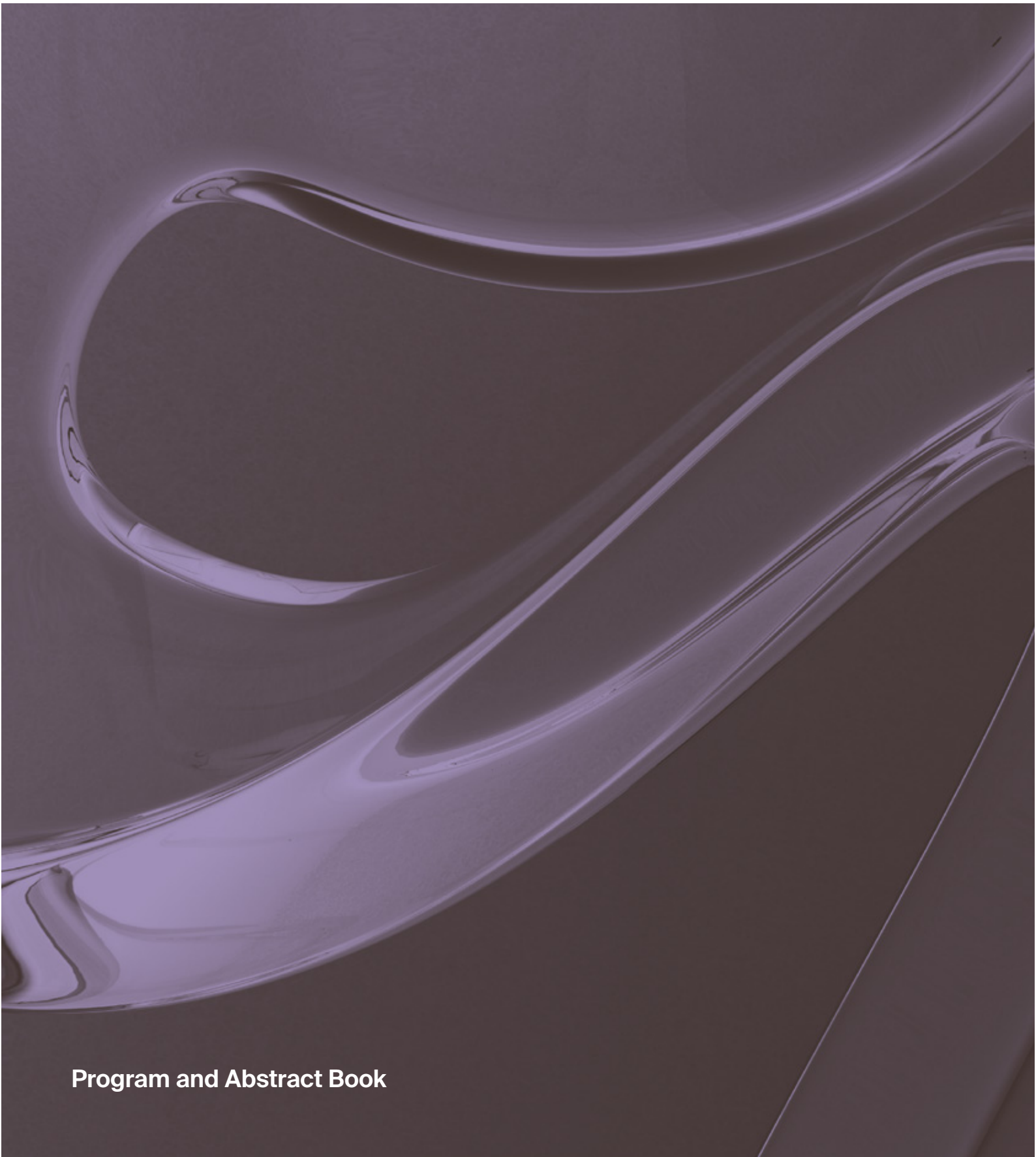
IOCLTC
2026

Conference

The 1st International Online Conference on Lubricants and Tribological Contacts

16–17 November 2026, online



Program and Abstract Book

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16–17 November 2026 | Online

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Welcome from the Chair

Dear Colleagues,

We are delighted to invite you to the upcoming conference, **the 1st International Online Conference on Lubricants and Tribological Contacts (IOCLTC 2026)**. This online conference is organised by the MDPI open access journal *Lubricants* (ISSN 2075-4442, Impact Factor 3.6) and will be held on **16–17 November 2026**.

This first conference will cover a significant part of the very broad scope and themes of the journal, which is rather unique in the field of tribology and associated disciplines. The program is structured around the following **key sessions**:

S1. Lubricants
S2. Lubricated Contacts
S3. Mechanics of Contacts
S4. Friction, Wear, Corrosion and Fatigue
S5. Emerging Trends in Tribology

Engage directly with cutting-edge research, exchange insights with global academic and industry leaders, and build valuable connections. We ensure inclusive participation by offering free online registration, eliminating geographical and financial barriers to knowledge and networking. All submitted abstracts undergo review by our esteemed scientific committee, guaranteeing a conference program of exceptional quality and relevance.

We are deeply indebted to *Lubricants*, the cornerstone journal enabling this inaugural conference. As a major forum since 2013, *Lubricants* has promoted scientific progress through high-impact publications, fair and rigorous review processes, and strong community engagement, including impactful Travel Grants and conference sponsorships. The journal now extends its proactive commitment directly through establishing this conference series. This event mirrors *Lubricants*' broad scope and thematic priorities, further solidifying its pivotal role in advancing tribology research globally.

We, therefore, invite you to participate and contribute your research findings to an event which is sure to be successful and ground-breaking.

Kind regards,



Prof. Dr. Homer Rahnejat
Conference Chair
School of Engineering and Computing, University of Lancashire, Preston, UK



lubricants
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Lubricants (ISSN 2075-4442) publishes regular research papers, reviews, letters and communications covering all aspects of tribology, including the study and application of the principles of friction, lubrication and wear. Our aim is to encourage scientists to publish experimental, theoretical and computational results that provide new insight and understanding into the scientific and technical basis for lubrication and related phenomenon. There is no restriction on the maximum length of the papers. The full experimental details must be provided so that the results can be reproduced. There are, in addition, three unique features of this Journal: Manuscripts regarding research proposals and research ideas are welcome; Electronic files and software regarding the full details of the calculation and experimental procedure, if unable to be published in a normal way, can be deposited as supplementary material; Manuscripts concerning summaries and surveys on research cooperation and projects (that are founded by national governments) to give information for a broad field of users.

Journal Webpage: https://www.mdpi.com/journal/lubricants

Session Chairs



Prof. Dr. Adolfo Senatore
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Prof. Enrico Ciulli
Department of Civil and Industrial Engineering, University of Pisa, Pisa, Italy



Prof. Dr. Giuseppe Carbone
Department of Mechanics, Mathematics and Management, Polytechnic University of Bari, Bari, Italy;
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Prof. Dr. Henara Lillian Costa
School of Engineering, Universidade Federal do Rio Grande, Rio Grande, Brazil



Dr. Patricia Johns-Rahnejat
School of Engineering and Computing, University of Lancashire, Preston, UK



Dr. Ramin Rahmani
Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, UK



Prof. Dr. Robert Ian Taylor
School of Engineering and Computing, University of Lancashire, Preston, UK



Dr. Sashi Balakrishnan
Castrol, Reading, UK



Prof. Dr. Yong Sun
Jihua Laboratory, Foshan, China

Keynote Speakers



Prof. Dr. Seong H. Kim

Department of Chemical Engineering and Materials Research Institute, Pennsylvania State University, University Park, State College, PA, USA



Prof. Dr. Zhongmin Jin

School of Mechanical Engineering, Southwest Jiaotong University, Chengdu, China

Invited Speakers



Prof. Dr. Andreas Almqvist

Division of Machine Elements, Luleå University of Technology, Luleå, Sweden



Prof. Dr. Antoine Chateauminois

Soft Matter Science and Engineering Laboratory (SIMM), ESPCI Paris, PSL University, Paris, France; Centre National de la Recherche Scientifique (CNRS), Paris, France



Prof. Dr. Boris Zhmud

Tribonex AB, Uppsala, Sweden



Prof. Dr. Ian Sherrington

School of Engineering and Computing, University of Lancashire, Preston, UK



Dr. Janet Wong

The Tribology Group, Department of Mechanical Engineering, Imperial College London, UK



Dr. Jun Qu

Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA



Prof. Dr. Marco Paggi

IMT School for Advanced Studies Lucca, Lucca, Italy



Prof. Dr. Martin H. Müser

Department of Materials Science and Engineering, Universität des Saarlandes, Saarbrücken, Germany



Dr. Thomas Lohner

Gear Research Center (FZG), Technical University of Munich, Garching near Munich, Germany



Dr. Tianyi Han

State Key Laboratory of Tribology in Advanced Equipment, Tsinghua University, Beijing, China

Program Overview

	16 November 2026	17 November 2026
Morning	**Session 4.** Friction, Wear, Corrosion and Fatigue	**Session 1.** Lubricants **Session 2.** Lubricated Contacts
Afternoon	**Session 4.** Friction, Wear, Corrosion and Fatigue **Session 3.** Mechanics of Contacts	**Session 5.** Emerging Trends in Tribology

IOCLTC 2026 Program

16 November 2026 (Monday)	

Session 4. Friction, Wear, Corrosion and Fatigue

Time: 09:00 (CET, Basel) | 03:00 (EST, New York) | 16:00 (CST, Beijing)

Time in CET	Speaker	Title
9:00-9:10	**Prof. Dr. Homer Rahnejat** Conference Chair	Opening Speech from the Conference Chair
9:10-9:20	**Prof. Dr. Adolfo Senatore** **Prof. Dr. Yong Sun** Session Chairs	Welcome from the Session Chairs
9:20-9:40	**Prof. Dr. Ian Sherrington** Invited Speaker	Practical Approaches to Mixed Friction Modelling
9:40-9:55	**Marco De Stefano** Selected Speaker	Tribocorrosion investigation on biomaterials for total hip replacements
9:55-10:10	**Svetlana Boshnakova** Selected Speaker	Tribocorrosion Behavior of Various Coatings on Duplex Stainless Steel
10:10-10:25	**Tianhao Xie** Selected Speaker	Understanding the Formation Mechanisms of Leaf Layers on the Rail Surface using a High-Pressure Torsion Test
10:25-10:40	**Roger Lewis** Selected Speaker	Wheel/Rail Interface Friction Assessment: High Pressure Torsion Testing; Creep Force Modelling and Field Validation
10:40-10:55	**Xiaoming Shen** Selected Speaker	Influence of Additively Manufactured Polymer Counterbody Geometry and Material on Measurement Variability in Three-Body Ball-on-Disk Wear Testing
10:55-11:10	**Jürgen Frieß** Selected Speaker	Advanced Measuring Equipment for Studying the Lubrication State in Tribocontacts
11:10-11:25	**Mohammed Salem Al-Shan** Selected Speaker	Effect of Contact Load on the Oil lubrication Behavior of Thermally Oxidized Ti-6Al-4V Sliding against Alumina.
11:25-11:40	**Yizhao Liu** Selected Speaker	Effect of treatment time on the oil lubrication behavior of thermally oxidized CP-Ti sliding against AISI 52100 Steel
11:40-11:55	**Luis Vicente Wilches Peña** Selected Speaker	Grinding-Induced Microstructural Variations in Pearlitic Rail Steels under Tribological Conditions

Session 4. Friction, Wear, Corrosion and Fatigue
Session 3. Mechanics of Contacts

Time: 14:00 (CET, Basel) | 08:00 (EST, New York) | 21:00 (CST, Beijing)

Time in CET	Speaker	Title
14:00-14:20	**Dr. Jun Qu** Invited Speaker	Does combination of a lubricant anti-wear additive and a hard coating double the surface protection?
14:20-14:35	**Jorge Alarcon** Selected Speaker	Comprehensive Failure Analysis and Remaining Useful Life Prediction of Main Wind Turbine Bearings: A Multi-Parametric Approach
14:35-14:50	**Arash Kariminejad** Selected Speaker	Effect of Loading-System Inertial Mass on Friction and Wear of TiAlN-Coated Steel under Unidirectional Sliding
14:50-15:00	**Prof. Dr. Giuseppe Carbone** **Dr. Patricia Johns-Rahnejat** Session Chairs	Welcome from the Session Chairs
15:00-15:20	**Prof. Dr. Antoine Chateauminois** Invited Speaker	Friction of thin hydrogel films: Disentangling the contributions of poroelastic flow and interface molecular interactions
15:20-15:40	**Prof. Dr. Marco Paggi** Invited Speaker	High-Fidelity Contact Mechanics: AFM-Informed Simulations and Contact-Induced Fracture

15:40-16:00	**Prof. Dr. Martin H. Müser** Invited Speaker	Contrasting ice and rock tribology
16:00-16:15	**Aleligne Yohannes Shiferaw** Selected Speaker	A Load-Controlled Indentation Framework for Characterizing Soft Viscoelastic Materials in Biomechanics
16:15-16:30	**Camilla Caldari** Selected Speaker	Investigation of spherical contact with different degrees of geometric conformity for elastic and elasto-plastic materials.
16:30-16:45	**Pavel Makarov** Selected Speaker	A Phenomenological Friction Model Capturing Plastic Saturation of Rough Surface Contacts
16:45-17:00	**Ashfaqul Hoque Khadem** Selected Speaker	Particle-Size-Dependent Nanomechanical Behavior of Fe3O4-Reinforced Electrospun PVDF Nanofibers

17 November 2026 (Tuesday)

Session 1. Lubricants
Session 2. Lubricated Contacts

Time: 09:00 (CET, Basel) | 03:00 (EST, New York) | 16:00 (CST, Beijing)

Time in CET	Speaker	Title
9:00-9:10	**Prof. Dr. Robert Ian Taylor** **Dr. Sashi Balakrishnan** Session Chairs	**Welcome from the Session Chairs**
9:10-9:30	**Prof. Dr. Boris Zhmud** Invited Speaker	Fuel economy engine oils and engine tribology
9:30-9:50	**Dr. Janet Wong** Invited Speaker	Effect of Electric Field on Behaviour of Lubricants
9:50-10:05	**Jaime Nácher Mestre** Selected Speaker	Development and Characterization of Sustainable Plant-Based Lubricants for Minimum Quantity Lubrication (MQL) Applications
10:05-10:20	**Ali Aourdou** Selected Speaker	Tribochemical stabilization of high-viscosity natural esters by a deep eutectic solvent on AISI 316L stainless steel under starved and flooded sliding conditions.
10:20-10:30	**Prof. Enrico Ciulli** **Dr. Ramin Rahmani** Session Chairs	Welcome from the Session Chairs
10:30-10:50	**Prof. Dr. Andreas Almqvist** Invited Speaker	Influence of Wall Slip on Load Support, Friction and Cavitation in Rough Lubricated Contacts
10:50-11:10	**Dr. Thomas Lohner** Invited Speaker	Aqueous Lubrication of Gears: Friction, Film Thickness, and Power Loss
11:10-11:25	**Jiahe Poy** Selected Speaker	Physics-Informed Data Assimilation of Experimental Measurements for Hydrodynamic Journal-Bearing Pressure Prediction
11:25-11:40	**Piyush Jain** Selected Speaker	Prediction of Friction Coefficient in Elastohydrodynamic Lubricated Contacts through a Multi-Source, Few-Shot Transfer Learning Artificial Neural Network Approach
11:40-11:55	**Yang Zhao** Selected Speaker	Generative deep learning for hydrodynamic lubrication prediction by a deconvolutional neural network

Session 5. Emerging Trends in Tribology

Time: 14:00 (CET, Basel) | 08:00 (EST, New York) | 21:00 (CST, Beijing)

Time in CET	Speaker	Title
14:00-14:10	**Prof. Dr. Henara Lillian Costa** Session Chair	**Welcome from the Session Chair**
14:10-14:40	**Prof. Dr. Zhongmin Jin** Keynote Speaker	Bio-tribology and Tribo-biology

14:40-15:10	**Prof. Dr. Seong H. Kim** Keynote Speaker	Triboelectrochemistry — Electrical Properties of Tribofilms formed at Electrified Interfaces
15:10-15:30	**Dr. Tianyi Han** Invited Speaker	Ion Adsorption and Hydration Superlubricity
15:30-15:45	**Yi Tao** Selected Speaker	Emergent Temperature Dependence of Friction from Quantum Many-Body Theory
15:45-16:00	**Fabio Tatzgern** Selected Speaker	Advancements in ultrasonic methods for in-situ lubricant monitoring.
16:00-16:15	**Luciana Nasca** Selected Speaker	Mechanistic Origins of Wet Adhesion in Mushroom-Shaped Microstructures: A Theoretical Study Interfacial Dynamics
16:15-16:30	**María García-Pérez** Selected Speaker	Towards Electrically Assisted Lubrication Through Surface Engineering
16:30-16:45	**Samuel D. Fernández-Silva** Selected Speaker	Smart biolubricants derived from waste cooking oils: electrorheological and tribological response of cellulose nanofibril dispersions
16:45-17:00	**Silvia Logozzo** Selected Speaker	New trends in wear assessment of biomechanical components: challenges and achievements
17:00-17:10	**Prof. Dr. Homer Rahnejat** Conference Chair	**Closing Speech from the Conference Chair**

Poster List

Submission ID	Author	Title
Sciforum-176308	**Marco Negrete Rios**	Effect of hydrodynamic drag and Reynolds number on friction performance for canola oil-based biolubricants
Sciforum-177552	**SANDEEP SONI**	Performance Evaluation of Elliptical Journal Bearing Using ANN with Micropolar Lubricants
Sciforum-184948	**Ibrahim Habibov**	Rapid Assessment of the Wear Limit of Grinding Balls Used in the Mining Industry
Sciforum-199920	**amine beloufa**	Numerical Analysis of Hydrodynamic Journal Bearings for Turbine Pump Applications
Sciforum-202379	**Helal Uddin**	Systematic Numerical Investigation of Lubricated Bearing Rolling-Sliding Contacts: Effects of Load, Speed, and Lubrication Parameters on Friction, Wear, Temperature, and Reliability.
Sciforum-205693	**Arisbel Cerpa Naranjo**	INFLUENCE OF A COMMERCIAL CERAMIC ADDITIVE ON THE RHEOLOGICAL BEHAVIOR AND STRUCTURAL CHARACTERIZATION OF 0W30 AND 10W60 LUBRICATING OILS
Sciforum-205905	**Huu-Dien Nguyen**	Finite Element Analysis of a Slider–Crank Mechanism Using ANSYS Workbench
Sciforum-206541	**Clarisse Kate Alagar**	Optimization and Performance Evaluation of a Bio-Based Lubricating Grease from Virgin Coconut Oil, Beeswax (Apis cerana), and Alumina Nanoparticles (Al_2O_3) Using a D-Optimal Mixture Design.
Sciforum-206542	**Roger Lewis**	Tailoring the Properties of Laser Sintered Composites for Tribological Applications
Sciforum-207578	**Saba Abdul Shakoor**	A First-Principles Study of Layered Materials for Low Friction Coating
Sciforum-206986	**Huu-Dien Nguyen**	Finite Element Simulation of Contact Mechanics and Tribological Behavior in Gas-Filled Shock Absorbers for Light Delta Aircraft
Sciforum-207243	**Gabriela Macías**	Development of Waste-Derived Carbon Functional Fluids for thermal management and tribological performance in electrified mobility
Sciforum-207276	**Nafiseh Forghani**	Optimization of Two-Photon Polymerization for Fabrication of High-Density Micropatterned Contact Interfaces
Sciforum-207301	**Artem Borisov**	Thermal and tribodecomposition mass spectra of polymer-polymer friction pairs.
Sciforum-207636	**Milica Vlahović**	Image-Based Predictive Modeling of Cavitation Wear Evolution for Service-Life Estimation
Sciforum-207420	**Huu-Dien Nguyen**	Finite Element Analysis of Stress Intensity Factor in Functionally Graded Material Compact Tension Specimen Using ANSYS
Sciforum-207443	**Abdellah Azmani**	Hybrid Spectral Graph Attention Learning for Intelligent Rolling-Bearing Fault Diagnosis Using Vibration Signals
Sciforum-207457	**Marek Szewczyk**	The influence of sheet surface modification on tribological properties in the sheet strip drawing test
Sciforum-207514	**Mian Ahmad**	Friction torque reduction due to laser surface texturing in Cam tappet contact - A Mathematical modeling approach
Sciforum-207575	**Hafiz Syed Hasan**	Development and Validation of an Electrical Monitoring Technique for Electrified Lubricated Contacts
Sciforum-207599	**María Hernández-Sierra**	Rheological Characterization of Automotive Hydraulic Fluids and Biodegradable Oil
Sciforum-207624	**Mengyuan Li**	Feasibility of using Non-Destructive Techniques for Measuring Tooth Degradation

Sciforum-207637	**Arisbel Cerpa-Naranjo**	Rheological Evaluation and Life Cycle Assessment (LCA) of Lubricating Nanofluids Formulated with Multi-Walled Carbon Nanotubes
Sciforum-210584	**Mikheev Roman**	Friction of composites based on antifriction Babbitt reinforced with TiNi particles
Sciforum-210634	**Bruce Fabijonas**	Fluid Film Bearings in Low Speed Applications: Thrust Bearings in Rotary Air Preheaters
Sciforum-212584	**Yusuf Kepir**	Tribological Behavior of Micronized Carbon Fiber-Reinforced PP/PA6 Composites under Dry Sliding Conditions
Sciforum-212650	**Yusuf Kepir**	Tribological Behavior of Micronized Glass Fiber-Reinforced PP/PA6 Composites

Session 1. Lubricants

Sciforum-176308: Effect of hydrodynamic drag and Reynolds number on friction performance for canola oil-based biolubricants

Marco Ulises Negrete Rios [1], Sandra Rojas Osorio [1], María T. Hernández-Sierra [2], Arnoldo Maeda Sánchez [3], Karla J. Moreno [3, 4,*]

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Biolubricants based on vegetable oil have gained much attention because they address lubrication issues by incorporating various additives, including inorganic and natural compounds, thereby extending their use across a wide range of applications [1,2]. This study assesses the impact of the hydrodynamic regime and the drag force on the friction performance of canola oil containing eugenol and curcumin as antioxidant additives. For that purpose, rheological assessments were previously conducted to determine the Reynolds number (Re) and the hydrodynamic drag force. Friction tests were conducted in sliding contact with a constant normal load of 0.5 N.

The measured friction force (Ff) was 0.050 N for the base oil, 0.040 N for CaO/Eugenol, and 0.045 N for CaO/Curcumin, corresponding to friction reductions of 20% and 10%, respectively, compared to the unmodified oil. The Re range obtained was 4.45 to 4.92, indicating that the biolubricants operate in a laminar flow regime. The estimated drag force remained on the order of 10^{-4} N, representing approximately 0.8% to 1.0% of the total friction force. Although the hydrodynamic contribution is less than the contact friction component, the results demonstrate that the lubricant's physicochemical modifications alter flow conditions and modulate the overall tribological response. Reducing frictional force directly reduces energy loss during sliding contact, indicating a potential boost in energy efficiency when these formulations are used in mechanical systems operating under similar conditions.

From a sustainability standpoint, using vegetable oil-based lubricants with naturally derived additives that improve tribological efficiency shows promise for reducing energy losses and lowering dependence on conventional mineral-based lubricants. Overall, the results suggest that balancing rheological properties and hydrodynamic behavior can help develop high-performance, environmentally friendly bio-based lubricants.

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Sciforum-184948: Rapid Assessment of the Wear Limit of Grinding Balls Used in the Mining Industry

Sevinc Abasova [1,*], Ibrahim Habibov [1] and Famil Gamidov [2]

[1] Azerbaijan State Oil and Industry University
[2] Head of Production of Azerbaijan International Mining Company

Abstract. The mining industry of the Republic of Azerbaijan is one of the leading sectors of the non-oil economy. Currently, the extraction of non-ferrous metals is carried out by two companies: Azerbaijan International Mining Company (AIMC) and AzerGold. The first company is a joint venture between Azerbaijan and the British company Anglo Asian Mining, while in the second company the production share fully belongs to the Republic.

During the grinding of ores, it is often necessary to determine the residual life of grinding balls. During operation, their mass decreases due to wear, which significantly affects grinding quality and requires additional loading of the mill drum. In this regard, the aim of this study is to establish the relationship between the resource indicator, the physical and mechanical properties of materials, and the operating parameters of the mill, enabling rapid assessment and response to product quality.

As a result of numerous experimental studies and using the MILLTRAJ simulation program, a mathematical relationship was established between the critical wear value, ore hardness, drum rotation speed, impact toughness, and mill loading degree.

During operation, one of the key conditions is to ensure Y ≤ Ykr, where Y and Ykr represent the current and critical wear values of grinding balls, respectively. The value is determined as Ykr = ..., where the diameters of the steel balls after and before use are considered. Ykr is the critical wear limit. The allowable wear limit for SAG mills is taken as Y = 50%.

Based on experimental studies (Y=f(T), Y=f(H), Y=f(V)) and the MILLTRAJ simulation program, a mathematical model was obtained that establishes an empirical relationship between steel ball wear and process parameters:

$Y = k \cdot (H+4)V0.2\ T2 = (0.012 \cdot H + 0.048)V0.2\ T2$



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Sciforum-205693: Influence Of A Commercial Ceramic Additive On The Rheological Behavior And Structural Characterization Of 0W30 And 10W60 Lubricating Oils

Arisbel Cerpa Naranjo [1,*], Jaime Ruíz Rodríguez [1], Javier Pérez Piñeiro [2], María Fuencisla Guilsanz Muñoz [2], María Isabel Lado Touriño [1] and Norma López Pérez [1]

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This study evaluates the influence of a commercial ceramic additive on the rheological behavior and chemical structure of two multigrade lubricating oils: 0W30 and 10W60. The research focuses on analyzing flow and viscosity curves under varying temperatures and additive concentrations. Furthermore, a comprehensive chemical and structural characterization of the formulation—both in its pure and modified states—was conducted via Fourier Transform Infrared Spectroscopy (FT-IR).

For the experimental phase, formulations were prepared with additive volumetric concentrations of 3% and 6% v/v. The mixtures were homogenized using magnetic stirring for one hour and subsequently sonicated for fifteen minutes to optimize particle dispersion within the oil matrix. Rheological characterization was performed using a rotational rheometer with a cone-plate geometry, spanning a temperature range from 20 °C to 160 °C at 20 °C intervals. The analysis assesses the impact of temperature, additive dosage, and base oil type on flow resistance, while determining whether the suspensions maintain a Newtonian profile or exhibit deviations due to the dispersed solid phase.

The experimental results demonstrate that both oils, in their pure and additived states, retain a strictly Newtonian behavior. Temperature and additive concentration proved to be the governing parameters of the system's rheology: the ceramic compound successfully increases the kinematic viscosity in both lubricants, whereas rising temperatures induce the expected viscosity decrease. In conclusion, these findings provide a valuable comparative assessment of both multigrade formulations, validating the effect of the ceramic additive on their thermal stability and viscous performance.



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Sciforum-206541: Optimization and Performance Evaluation of a Bio-Based Lubricating Grease from Virgin Coconut Oil, Beeswax (Apis cerana), and Alumina Nanoparticles (Al_2O_3) Using a D-Optimal Mixture Design.

Clarisse Kate Lanceta Alagar *, Precious Arlene Villaroza Melendrez *, Marita Natividad De Lumen, Rhea Batac, Joel Rivadeneira and Ralph Kristoffer Gallegos *

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A bio-based lubricating grease was formulated from virgin coconut oil (VCO) as the base oil, Apis cerana beeswax as the thickener, and alumina (Al_2O_3) nanoparticles as the additive, with component proportions constrained to 0–5 wt% Al_2O_3, 20–30 wt% beeswax, and 70–80 wt% VCO. Twelve formulations were generated through a D-Optimal Mixture Design in Design-Expert® and characterized for dropping point and apparent viscosity. All formulations produced stable, semi-solid greases with no observed phase separation, with dropping points ranging from 55°C to 59°C and apparent viscosities ranging from 0.0538 Pa·s to 3.4986 Pa·s. Statistical modeling showed that beeswax and VCO significantly affected dropping point, while Al_2O_3 exerted its influence on apparent viscosity primarily through binary and ternary interactions with the other components. Numerical optimization using the desirability function identified 0.00 wt% Al_2O_3, 30.00 wt% beeswax, and 70.00 wt% VCO as the optimal formulation, yielding a predicted dropping point of 58.357°C and apparent viscosity of 0.204 Pa·s, with an overall desirability of 0.839. This formulation was re-prepared and subjected to a Rotating Disk Electrode (RDE) Fine Wear Test under actual gear contact conditions, where iron emerged as the dominant wear metal at 179.7 ppm, consistent with the steel composition of the test gears, while secondary wear metals remained at comparatively low concentrations. These results indicate that a fully bio-based grease composed of VCO and beeswax alone, without nanoparticle reinforcement, can achieve a statistically optimized balance of thermal stability and rheological performance while exhibiting preliminary evidence of adequate wear protection under real contact conditions.



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Sciforum-207599: Rheological Characterization of Automotive Hydraulic Fluids and Biodegradable Oil

Marlen León-Serrano [1], Omar Said Mendoza-Martínez [1], José Ángel Colin-Robles [1], Karla Judith Moreno [2] and María Teresa Hernández-Sierra [1,*]

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Automotive fluids are fundamental to the safe and efficient operation of vehicles, as they transmit energy, provide lubrication, protect against corrosion, and ensure the stability of critical systems. Among them, brake fluid plays a vital role by transmitting hydraulic pressure within the braking system, guaranteeing safety and immediate response. Similarly, power steering fluid enhances vehicle maneuverability by reducing friction and wear in pumps and valves. The physicochemical and rheological characterization of these fluids is essential for evaluating their performance and exploring environmentally friendly alternatives. The primary objective of this work is to analyze the physicochemical and rheological behavior of conventional automotive hydraulic fluids and an unmodified canola oil baseline. Rather than proposing an immediate replacement, the study aims to quantify differences in viscoelastic response and thermal sensitivity to identify future modifications. The experimental focus is a detailed rheological comparison of representative commercial products (DOT 3 brake fluid and an STP power-steering fluid) against the canola sample. To achieve this, the fluids were characterized through FTIR spectroscopy, density measurements, viscosity index determination, and comprehensive rheological testing. The rheological characterization was conducted in a Discovery HR-3 Hybrid Rheometer using three complementary approaches: thermo-rheological evaluation, steady-state flow tests, and oscillatory tests, providing a robust framework for comparing conventional automotive fluids with sustainable alternatives. The results reflect the functional requirements of each system: stability and safety in the brakes; protection against cold and hydraulic performance in the steering. Commercial fluids meet the operational requirements and identify the modifications needed to move toward viable plant-based formulations.

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Sciforum-207609: Development and Characterization of Sustainable Plant-Based Lubricants for Minimum Quantity Lubrication (MQL) Applications

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Introduction

Minimum Quantity Lubrication (MQL) has become one of the most promising sustainable lubrication strategies for machining, significantly reducing lubricant consumption while maintaining process performance. Although plant-based lubricants offer important environmental advantages over mineral oils, formulating them to achieve the physicochemical and tribological properties required for effective MQL operation remains challenging. This work presents a starting point for the formulation and characterization of plant-based lubricants intended for machining applications.

Methods

Five plant-based lubricant formulations were prepared and experimentally characterized. Lubricants were spiked with sustainable and endless additives from the land (green sources) and sea & ocean (blue sources). Their performance was compared with that of commercial MQL lubricants through viscosity measurements, friction coefficient evaluation under different tribological conditions, contact angle measurements on carbide substrates to assess wettability, and energy dissipation analysis during tribological testing. Based on the experimental results, environmentally friendly and non-toxic additives were incorporated to improve the lubricant properties and achieve the target performance values.

Results

The characterization identified the influence of the proposed additives on lubricant behavior. The best-performing formulations achieved physicochemical and tribological properties close to those of commercial products: a viscosity of approximately 45 cSt, an energy dissipation of about 300 J during tribological tests, and a contact angle of approximately 11° on carbide tools. These results demonstrate that renewable plant-based lubricants can be tailored to satisfy the key requirements for MQL applications while reducing their environmental impact and risk exposure.

Conclusions

The proposed methodology establishes an initial framework for the development of plant-based lubricants with properties comparable to those of commercial MQL fluids. The best formulations constitute a promising starting point for environmentally friendly and non-toxic machining applications. Future work will focus on validating their performance under practical turning, milling, and drilling conditions by evaluating tool wear, cutting forces, surface finish, and lubricant consumption.

Author contributions: Conceptualization, Jaime Nácher Mestre, Rosa Mondragón and José Vicente Abellán-Nebot; Methodology, Alejandro Ruiz-Pastor, Jaime Nácher Mestre, Rosa Mondragón, David Leal Cano, Kudama A. Habib and José Vicente Abellán-Nebot; Validation, Rosa Mondragón; Formal analysis, Alejandro Ruiz-Pastor, Jaime Nácher Mestre, Rosa Mondragón, David Leal Cano, Kudama A. Habib and José Vicente Abellán-Nebot; Investigation, Alejandro Ruiz-Pastor, Jaime Nácher Mestre, Rosa Mondragón, David Leal Cano, Kudama A. Habib and José

Vicente Abellán-Nebot; Resources, Jaime Nácher Mestre, Rosa Mondragón, Kudama A. Habib and José Vicente Abellán-Nebot; Data curation, Alejandro Ruiz-Pastor, Rosa Mondragón, David Leal Cano and José Vicente Abellán-Nebot; Writing - original draft, Alejandro Ruiz-Pastor, Jaime Nácher Mestre, Rosa Mondragón, David Leal Cano, Kudama A. Habib and José Vicente Abellán-Nebot; Writing - review and editing, Alejandro Ruiz-Pastor, Jaime Nácher Mestre and Rosa Mondragón; Supervision, Rosa Mondragón, Kudama A. Habib and José Vicente Abellán-Nebot;



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Sciforum-207637: Rheological Evaluation and Life Cycle Assessment (LCA) of Lubricating Nanofluids Formulated with Multi-Walled Carbon Nanotubes

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The addition of nanomaterials to lubricants represents a promising strategy for optimizing their performance under demanding operating conditions. This study evaluates the rheological behaviour and environmental impact of nanofluids based on 5W-30 and 20W-50 engine oils containing multi-walled carbon nanotubes (MWCNTs), aimed at determining their technical and environmental feasibility for industrial applications. The raw materials and dispersions were characterized by Transmission Electron Microscopy (TEM), Scanning Electron Miscroscopy (SEM) and Fourier-Transform Infrared Spectroscopy (FTIR). Rheological behaviour was analyzed using a Rheotest 6000 rheometer at different MWCNT concentrations (0.25 wt%, 0.50 wt%, and 0.75 wt%) across a thermal range of 20 °C to 160 °C. Additionally, a Life Cycle Assessment (LCA) was performed with a SimaPro software via the IPCC and ReCiPe methods. Rheological results revealed that the incorporation of MWCNTs alters the oil behaviour from Newtonian to pseudoplastic. Regarding environmental analysis, the IPCC method showed a slightly higher carbon footprint for the 20W-50 oil () compared to the 5W-30 oil (), demonstrating that the oil mass generates a significantly greater impact than the nanoparticles. Furthermore, the ReCiPe evaluation identified higher impacts on human health from global warming as well as human toxicity (carcinogenic and non-carcinogenic), confirming trends consistent with the 20-year IPCC model and ratifying the dominance of the base fluid in the overall environmental footprint. In conclusion, the developed nanofluids exhibit favorable rheological responses for advanced lubrication, featuring an environmental impact profile primarily governed by the selection of the base oil.

Author contributions: Conceptualization, Arisbel Cerpa-Naranjo; Methodology, Arisbel Cerpa-Naranjo; Writing - original draft, Arisbel Cerpa-Naranjo; Writing - review and editing, Arisbel Cerpa-Naranjo; Supervision, Arisbel Cerpa-Naranjo; Project administration, Arisbel Cerpa-Naranjo; Funding acquisition, Arisbel Cerpa-Naranjo;



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Sciforum-207663: Analytical Method for Damage Reliability Assessment of Steel

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A36 steel also known as S235JR in Europe or ASTM A36 in the United States is a very common material in steel structures. It is widely used because it is strong, durable, and easy to weld. But one of the major challenges when working with it is monitoring the progression of fatigue damage.

In this study, we sought to estimate the service life of A36 steel. To do so, we conducted fatigue tests on notched specimens, followed by static tensile tests to observe how the residual ultimate stress decreased. This allowed us to track the progression of damage using Erisman's law and to analyze the Wöhler curve (S-N curve). The experimental results helped us determine the constants associated with this curve. Next, based on this curve, we evaluated the damage using a model based on the damaged stress model.

Next, we'll conduct a reliability study. We'll use the stress-strain method. The idea is to analyze the degradation of the ultimate residual stress as a function of the life fraction. This will allow us to determine that fraction and compare it to the results we already have.

Finally, we compared the critical life fractions obtained using the two laws to identify the one that enables effective predictive maintenance.



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Sciforum-210690: Tribochemical stabilization of high-viscosity natural esters by a deep eutectic solvent on AISI 316L stainless steel under starved and flooded sliding conditions.

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The tribological performance of natural esters in boundary-lubricated contacts is often limited by elevated viscosity, which impedes debris evacuation and promotes third-body abrasive wear under oil-starved conditions. This work evaluates a biodegradable deep eutectic solvent (DES) of menthol and decanoic acid as a tribochemical additive (0.1 wt.%) in PAO 4, sunflower oil, and castor oil. Wrought AISI 316L stainless steel was tested on a ball-on-disc tribometer under starved (100 µL) and fully flooded (60 mL) unidirectional sliding conditions (8 N, 0.05 m/s).

Under starved conditions, neat castor oil produced a friction coefficient of 0.172 and a 937 µm wear track width, showing debris retention. Adding 0.1 wt.% DES reduced friction to 0.126, wear track width to 621 µm, and the specific wear rate by approximately 70% (from 21.57 × 10^{-5} to 6.50 × 10^{-5} mm^3 N^{-1} m^{-1}). EDX analysis of the DES-treated track indicated a uniform surface film formed via reaction between the decanoic acid and the 316L passive layer.

Under fully flooded conditions, the DES-castor oil formulation maintained stable boundary lubrication (µ = 0.090) with no progressive surface degradation. However, DES incorporation into non-polar PAO 4 yielded poor performance across both regimes due to limited miscibility. Results demonstrate that base oil polarity governs the tribochemical efficacy of this DES on AISI 316L, and chemical film formation successfully offsets the debris-entrapment limitations of high-viscosity natural esters.

Author contributions: Conceptualization, Ali Aourdou; Methodology, Ali Aourdou and José Manuel Liñeira Del Río; Validation, Maria Jose Tobar Vidal; Formal analysis, Ali Aourdou; Investigation, Ali Aourdou; Writing - original draft, Ali Aourdou; Writing - review and editing, José Manuel Liñeira Del Río; Visualization, José Manuel Liñeira Del Río, José Manuel Amado Paz and Maria Jose Tobar Vidal; Supervision, José Manuel Amado Paz and Maria Jose Tobar Vidal;



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Session 2. Lubricated Contacts

Sciforum-199920: Numerical Analysis of Hydrodynamic Journal Bearings for Turbine Pump Applications

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Performance testing of turbomachinery components is a critical stage in the development and validation of gas turbine engines. Experimental investigations are required to determine the aerodynamic, mechanical, and dynamic characteristics under both design and off-design operating conditions. In addition to evaluating aerodynamic efficiency and performance, these tests are essential for verifying the structural integrity and reliability of rotating components subjected to high velocity and severe loading conditions. To achieve these objectives, a test section was designed, developed, and integrated into an existing high-speed test rig. The test section consisted of the turbine stage under investigation, a journal-bearing, the surrounding casing, and an appropriate support structure. The turbine drive shaft was supported by a pair of hydrodynamic journal bearings specifically selected to withstand high-speed operating conditions.

The primary objective of the present work was to redesign the journal-bearing system in order to improve the overall dynamic behavior and operational reliability. A second objective was to develop a bearing configuration whose preload characteristics remain relatively insensitive to variations in operating conditions such as velocity, temperature, and applied loads. Although extensive research has been conducted on the rotor dynamics of high-speed rotating machinery, including turbopumps, machine tool spindles, and gas turbine engines. Very limited information is available regarding practical design solutions for troubleshooting and stabilizing rotating systems that exhibit severe operational instabilities.

This work presents a comprehensive experimental and numerical investigation of the journal-bearing system used in a high-speed turbine test bench. Dynamic response measurements, vibration analyses, and numerical simulations were performed to identify the sources of instability and evaluate alternative bearing designs. The proposed solutions successfully improved the stability and operability of the rotating system, providing valuable guidelines for the design and optimization of high-speed turbomachinery test facilities.



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Sciforum-202379: Systematic Numerical Investigation of Lubricated Bearing Rolling-Sliding Contacts: Effects of Load, Speed, and Lubrication Parameters on Friction, Wear, Temperature, and Reliability

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This study presents a systematic numerical investigation of bearing contact mechanics and evaluates tribological performance and reliability under different operating conditions. The study emphasizes the computational methodology used to quantify rolling-sliding contact, rather than the general benefits of lubrication and systematically includes the effects of the operating parameters. Initial model parameters (material properties, geometry, lubricant viscosity) were taken from published engineering data and literature. A numerical contact analysis was then carried out to explore the effects of the applied load, the rotational speed and the lubricating-film parameters under the theoretical relationships. The principal performance indicators were the calculated coefficient of friction (α), wear rate (β), contact temperature rise (γ), reliability index (δ), and service-life factor (λ). Under the optimized simulated conditions, the calculated coefficient of friction (α) decreased from 0.15 to 0.05, corresponding to a 66.7% reduction. The calculated wear rate (β) decreased from 1.80×10^{-3} mm^3/Nm to 0.52×10^{-3} mm^3/Nm, corresponding to a 71.1% reduction. The contact temperature rise (γ) decreased from 78°C to 48°C, while the reliability index (δ) increased from 0.82 to 0.96. Furthermore, the optimized lubrication parameters produced up to a 2.8-fold improvement in the computed service life factor (λ). From these results, the influence of systematic variation of the operating and lubrication parameters on the behaviors of the rolling-sliding contact was demonstrated. The study also illustrates that limits of operation and reliability related performance indicators for the application of bearing can be quantified by predictive numerical modeling.



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Sciforum-205571: Effect of Surface Texturing and Magneto-Rheological Lubricants on the Characteristics of Circular and Three-Lobe Journal Bearings

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Multi-lobe journal bearings are highly effective in improving the static and dynamic characteristics required in scenarios characterized by high loads and fluctuating speeds. The present study investigates the combined effects of surface texturing and the adaptive control offered by magneto-rheological (MR) lubricants, specifically comparing the performance of circular and three-lobe journal bearing configurations. The Finite Element Method is used to solve the modified Reynolds equation to obtain the hydrodynamic pressure distribution, with discrete textures applied as cylindrical caps on the bearing pad. The non-Newtonian behavior of the MR lubricant is modeled using the continuous Bingham fluid model. To effectively capture the cavitation phenomenon across these distinct bearing profiles, mass-conserving JFO boundary conditions are employed using switch functions. Parametric optimization indicates optimal non-dimensional values for dimple radius and dimple depth. Furthermore, applying textures to the first half of the bearing pad significantly expanded the hydrodynamic pressure region. The results demonstrate that combining cylindrical cap textures with a three-lobe configuration and MR fluid yields a higher minimum film thickness and improved direct stiffness coefficients compared to the circular baseline. Although this configuration results in marginal power losses due to increased viscous damping from the texturing and MR effect, this trade-off provides a viable solution for utilizing the adaptive behavior of these lubricants to suppress vibrations in high-speed machinery



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Sciforum-207461: Generative deep learning for hydrodynamic lubrication prediction by a deconvolutional neural network

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Conventional prediction of the lubricated contact is conducted by solving governing equations, e.g., Reynolds equation. Here, inspired by modern generative deep learning method, we propose to predict the lubrication scenario by deep neural networks.

In specific, we design and train a deep deconvolutional neural network to achieve immediate lubrication pressure and film thickness prediction by the trained deconvolutional neuraln nework with high predicting precision. Compared to classical methods that takes a few seconds for lubrication simulation, our data-driven method is able to ouput the lubrication scenartion within 0.1 s on an ordinary personal computer. In addition, to look into how the neural network generates the desired lubrication pressure and film thickness distributions, we extract the latent high-level features the neural network constructs from the input working conditions, which show a checkerboard-like behaviour at the output of each layer. Then, integrating all these checkboard-like patterns for the processing of the neural network's activation function transforms the latent features into the desired presssure distributions in hydrodynamic lubrication. We also show that the selection of non-linear activation function, e.g., sigmoid, helps to complete the non-linear transformation from the last layers' multiple oututs to the final lubrication distribution. Moreover, a slight finetune of the trained neural netowrk could easily expand the neural network's applicability range into cavitated lubrication contact and other scenarios, which endorse the versatility of our data-driven method for lubrication prediction.

In conclusion, we levarage modern generative deep learning models to achieve immediate and accurate hydrodynamic lubrication pressure and film thickness distribution prediction.

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Sciforum-207466: Numerical analysis of Nano-Lubricant Effects on the Performance of a Hydrostatic Rotary Table Using ANSYS Fluent

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Hydrostatic rotary tables are important part in precision machining systems due to their high load-carrying capacity, good stiffness and provide accurate positioning. The current study focused on numerical analysis of an aluminium oxide (Al_2O_3) water nanofluid as working fluid used in a capillary-compensated hydrostatic rotary table with a double rectangular recess design. The use of an Al_2O_3-Water nanofluid is investigated not only to increase viscosity, but to adjust the hydraulic properties of a water-based lubricant. While oil-based lubricants offer appropriate viscosity and load supporting characteristics, the present study focused on water-based lubrication applications only. A three-dimensional computational fluid dynamics (CFD) model was created and analysed using ANSYS Fluent under steady-state laminar flow conditions. The effective properties of the nanofluid were determined by using the mixture model for density and the Krieger-Dougherty model for effective dynamic viscosity. Nanoparticle volume fractions changing from 1% to 10% were considered to obtain their effect on pressure distribution, lubricant flow rate, load-carrying capacity and static stiffness. The results show that increasing the nanoparticle volume fraction increase the effective viscosity and hydraulic resistance of the capillary compensated system, which causes modifying the pressure-flow balance and pressure distribution under the given operating conditions. The obtained pressure distribution affects the load-carrying ability and static stiffness of the bearing. Thus, any observed variations in load-carrying capacity and stiffness are associated with the modified pressure distribution rather than with the viscosity as direct source of load capacity. The double rectangular recess geometry also influences the pressure distribution as well as the static performance of hydrostatic rotary table. These results provide understanding about the relationships between nanofluid characteristics, capillary effects and pressure distribution which provide a foundation for assessing the static performance of Al_2O_3-Water nanofluids in precision hydrostatic rotary tables.



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Sciforum-207575: Development and Validation of an Electrical Monitoring Technique for Electrified Lubricated Contacts

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Electrical currents passing through lubricated rolling contacts are an increasing reliability concern in electrified powertrains, where shaft voltages and high-frequency currents can cause lubricant-film breakdown and electrically induced surface damage. Reliable electrical monitoring is therefore essential for distinguishing separated and conductive contact states and identifying transient dielectric breakdown events.

This study presents the development and validation of an electrical excitation and monitoring technique for subsequent integration with a friction and wear testing machine. The technique was initially evaluated using a static steel ball–ball configuration under separated and direct metallic-contact conditions. A 12.5 kHz square-wave signal with a nominal amplitude of 20 V peak-to-peak was applied through a capacitively coupled, current-limiting circuit, while the applied and contact-side voltage signals were monitored simultaneously.

Distinct electrical responses were observed for the two contact conditions. Direct metallic contact produced a clear change in the contact-side voltage due to the formation of a conductive path, whereas the separated condition exhibited a weaker response influenced by electrical noise and parasitic coupling. Introducing lubricant under static direct-contact conditions did not establish a confirmed electrically insulating film, and no dielectric breakdown or electrical discharge was detected under the tested conditions.

The results validate the capability of the developed technique to distinguish electrical responses associated with separated and conductive contact states. Future work will integrate the technique with the friction and wear testing machine under lubricated dynamic rolling conditions, with improved voltage and current monitoring to investigate lubricant film dielectric breakdown, transient electrical discharge behavior, and associated surface damage.



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Sciforum-210034: Thermoelectromechanical Modelling of Space-Charge Transport and Electric Field Distribution in EHL Contacts

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Electrification of machine elements — from EV drivetrains to bearings and gears near power electronics — exposes elastohydrodynamic lubricated (EHL) contacts to stray voltages, risking electrical discharge machining (EDM)-like surface damage and lubricant degradation. Predicting this response requires resolving electric field, space-charge transport, and Joule heating within a film whose thickness, pressure, and temperature are set by the underlying thermal-EHL (T-EHL) solution.

This work presents a one-way coupled thermoelectromechanical model. A deterministic T-EHL solver computes pressure, film thickness, and temperature fields via a transient Reynolds equation coupled to a quasi-static energy equation. These fields feed a three-dimensional electrical discharge module solving the Poisson equation and a single-species charge continuity equation (drift, diffusion, Ohmic conduction) on a film-conforming mesh, with permittivity from the Clausius–Mossotti relation and Arrhenius-based conductivity calibrated for polyalphaolefin (PAO) base oils.

Boundary conditions prove critical: naive zero-flux treatment causes unbounded charge buildup, while absorbing electrode and local inflow-outflow conditions yield a bounded, timestep-independent steady state, verified against the parallel-plate field estimate, boundary current balance, and net-charge tracking. Under 5–10 V DC bias, the model predicts outlet-localized charge separation atop a dominant leakage current of tens of picoamperes — a testable experimental target — laying groundwork for a two-way coupled breakdown model

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Sciforum-210634: Fluid Film Bearings in Low Speed Applications: Thrust Bearings in Rotary Air Preheaters

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A common criticism of using tilting-pad fluid-film bearings in low rotating speed applications is that an adequate pressure field cannot be created. However, fluid-film bearing manufacturers have a history of successful operation in these environments when properly designed and paired with an appropriate lubricant. This talk reviews one such application--thrust bearings in rotary air preheaters.

Rotary air preheaters are devices installed typically in power plants which reuse the heat of the exhaust gasses to heat the incoming fresh air, thus improving the plants' efficiency. The bearings used in these devices range from 580 mm to 2.2 m in diameter and are subjected to continuous loads in excess of 4 MPa at incredibly slow speeds, less than 0.1 m/s at mean diameter. Calculated minimum film thicknesses using a high-viscosity oil (215 mm^2/s at operating temperature) are on the order of 6 μm or smaller. The standard assumption is that such operating conditions place the application in the mixed-lubrication region on a Stribeck curve. However, a careful review of the bearing performance demonstrates that these bearings operate in the fully hydrodynamic regime on the Stribeck curve.

This talk will briefly review rotary air preheaters and then Stribeck curves as functions of the traditional Hersey number and lambda values. We will review rudementary film-thickness calculations and show how these bearings sit in the fully hydrodynamic region of the Stribeck curve. Time permitting, we will address using the results of modern high-fidelity FEM codes to calculate minimum film thickness and how the Stribeck curve changes. Finally, a will end with a reassurance that tilt-pad fluid-film bearings perform well in low-speed applications.

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Sciforum-210660: Physics-Informed Data Assimilation of Experimental Measurements for Hydrodynamic Journal-Bearing Pressure Prediction

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Accurate prediction of hydrodynamic pressure distribution is essential for journal-bearing performance analysis. Although conventional two-dimensional Reynolds-equation-based models generally provide reasonable predictions, agreement with experimental measurements varies with bearing geometry and operating conditions. Good agreement is observed for shorter bearings, while discrepancies increase at larger bearing length-to-diameter (L/D) ratios and lower Ocvirk numbers. Experimental characterisation of the complete pressure field is also limited by the number of circumferential sensor locations. This study investigates a physics-informed neural network (PINN) framework for assimilating sparse experimental pressure measurements into Reynolds-equation-based pressure prediction. The Reynolds equation and associated boundary conditions are imposed as physical constraints, while seven circumferential pressure measurements are incorporated to refine the pressure field and infer bearing-state parameters. Of 27 operating cases, 22 are used for training and experimental data assimilation, while five complete cases are withheld for validation. The results show that the benefit of assimilation depends on the initial theory–experiment discrepancy. For L/D=0.25, where conventional predictions agree well with measurements over the investigated Ocvirk-number range of 0.217–1.46, assimilation produces only minor changes. In contrast, at L/D=0.5, where discrepancies become more pronounced towards the lower end of the investigated Ocvirk-number range, assimilation substantially improves agreement. For a data-trained low-Ocvirk-number condition, the experimental pressure residual (based on mean square error) decreases from 1.537 to 0.180, an approximately 88% reduction, while the PDE residual decreases from 0.0302 to 0.0250. For the unseen validation cases with substantial experiment-theory deviation, the experimental pressure residual decreases from 0.0903 to 0.0621, corresponding to an approximately 31% reduction, demonstrating improved agreement with experimental measurements at an operating condition not included during training. These results demonstrate that physics-informed data assimilation can preserve Reynolds-equation behaviour, where the conventional formulation is adequate, while improving pressure prediction where its simplifying assumptions become increasingly limiting.

Author contributions: Conceptualization, Jo-Han Ng and William Woei Fong Chong; Methodology, Jiahe Poy; Software, Jo-Han Ng; Validation, Jiahe Poy; Formal analysis, William Woei Fong Chong; Investigation, Jiahe Poy; Resources, William Woei Fong Chong; Writing - review and editing, Jo-Han Ng; Visualization, William Woei Fong Chong; Supervision, William Woei Fong Chong;



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Sciforum-214344: Prediction of Friction Coefficient in Elastohydrodynamic Lubricated Contacts through a Multi-Source, Few-Shot Transfer Learning Artificial Neural Network Approach

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This study examines the potential for use of experimentally measured traction coefficient under elastohydrodynamic lubrication (EHL) conditions under different conditions for training an artificial neural network that could potentially be used as a generic initial assessment tool. In this study a physics-informed Artificial Neural Network is trained on 4,519 experimentally EHL friction measurements from ten different sources with a few-shot-ridge regression adapter calibrated on approximately 30 points per target dataset. Three input representations are compared: a full dimensional set (8 parameters), a dimensionless set based on Hamrock and Dowson's groups and a two parameter reduced set comprising the modified Hersey number and slide-to-roll ratio. The network incorporates a custom Dual Stribeck Activation output layer that enforces the physical shape of the Stribeck curve with non-negative friction and a well-defined EHL plateau throughout training instead of a post-hoc constraint. Against three independent holdout targets, the adapted model reaches R^2 = 0.984 based on the data from Zapletal 2018 with RMSE = 9.0% of mean CoF and R^2 = 0.934 based on the data provided in Lu, et al 2006 from those 30 measurements alone. Out-of-distribution diagnostics potentially can isolate the physical root cause of each base-model failure, and SHAP attribution shows the network recovers physically correct feature weightings including piezo-viscosity dominance for Lu, et al 2006, and load dominance for Simpson et al, 2024 without any mechanistic encoding of these dependencies.

Author contributions: Conceptualization, Piyush Jain; Methodology, Piyush Jain; Validation, Piyush Jain; Formal analysis, Ramin Rahmani; Data curation, Piyush Jain; Writing - original draft, Piyush Jain; Writing - review and editing, Ramin Rahmani; Supervision, Ramin Rahmani;



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Session 3. Mechanics of Contacts

Sciforum-203547: A Phenomenological Friction Model Capturing Plastic Saturation of Rough Surface Contacts

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Introduction

Classical friction laws, including the Amontons–Coulomb model and power-law approximations such as Kragelsky's, exhibit fundamental limitations at extreme normal pressures. These models predict unphysical vanishing or even negative friction coefficients when extrapolated beyond their validity range, failing to capture the saturation of the real contact area that occurs as surface asperities fully flatten under high loads.

Methods

We propose a novel phenomenological friction model derived from the exponential distribution of asperity heights combined with the two-component adhesion–deformation theory of friction. The model takes the form $\mu(p) = b_1 + (b_0 - b_1) \exp(-b_0 p/s)$, where b_0 and b_1 are the friction coefficients at zero and infinite pressure, respectively, and s is the effective plasticity limit of the contact layer. Building on this formulation, we construct a pressure-dependent generalization of the Stribeck effect, in which the difference between static and kinetic friction is modulated by the proximity to plastic saturation.

Results

The proposed model yields physically correct limiting behavior: $\mu \to b_0$ at low pressures and $\mu \to b_1 > 0$ at extreme pressures, thereby avoiding the artifacts of classical power laws. Analysis reveals that increasing normal pressure progressively suppresses the static–kinetic friction gap, with the Stribeck effect vanishing entirely in the plastic saturation regime. Three distinct contact regimes are identified — elastic, transitional, and fully plastic saturation — each characterized by qualitatively different energy dissipation behavior.

Conclusions

The model provides a robust, analytically tractable framework for contact mechanics under extreme pressures. It is directly applicable to the design of high-load tribological systems such as sliding bearings, seals, and braking interfaces, as well as to micro-scale contacts in MEMS/NEMS devices.



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Sciforum-206986: Finite Element Simulation of Contact Mechanics and Tribological Behavior in Gas-Filled Shock Absorbers for Light Delta Aircraft

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Shock absorbers in aircraft landing systems undergo severe dynamic loading and repeated sliding contacts, making tribological performance a critical factor for reliability and service life. This study employs the Finite Element Method (FEM) in ANSYS to investigate the contact mechanics and stress distribution of a gas-filled shock absorber used in light delta aircraft under various landing overload conditions (2×, 4×, and 8× gravitational loads).A detailed three-dimensional model was developed, incorporating realistic geometry of the cylinder, piston, piston rod, and gas chamber. Special attention was given to contact interactions between the piston and cylinder wall, rod and end cap, and sealing interfaces. Frictional contact formulation was applied to simulate sliding motion under impact loading. Material properties, nonlinear contact behavior, and boundary conditions were carefully defined to replicate actual operating conditions.Simulation results reveal von Mises stress distribution and contact pressure patterns in critical tribological zones. At 2× overload, stresses remain within safe limits with moderate contact pressure. As overload increases to 4× and especially 8×, significant stress concentrations appear at sliding interfaces, indicating potential risks of wear, surface fatigue, and material degradation. The analysis highlights how contact mechanics and friction influence the overall structural response and energy dissipation performance of the shock absorber.The findings provide valuable insights for optimizing material selection, surface treatments, and lubricant choices to enhance tribological performance, reduce wear, and improve durability under repeated landing impacts. This research demonstrates the effectiveness of advanced FEM simulation in evaluating tribological contacts within high-performance mechanical components, contributing to the development of more reliable and longer-lasting shock absorption systems in aerospace applications.



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Sciforum-207276: Optimization of Two-Photon Polymerization for Fabrication of High-Density Micropatterned Contact Interfaces

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Two-photon polymerization (2PP) enables the fabrication of polymeric microstructures with complex three-dimensional geometries and sub-micrometer resolution, providing new opportunities for engineering microscale contact interfaces. In such interfaces, the geometry, spacing, and mechanical properties of surface microstructures can strongly influence their deformation and mechanical response under contact loading. Therefore, reliable control of the fabricated microstructure is essential for developing functional and reproducible contact interfaces.

In this work, a systematic optimization of 2PP was performed to fabricate large-area, high-density micropatterned surfaces with controlled geometrical and mechanical characteristics. Using a Nanoscribe Photonic Professional GT2 system and IP-Visio photoresist, four fabrication strategies combining different CAD geometries and laser writing approaches, namely solid and contour trajectories, were investigated. The influence of key printing parameters, including writing speed, hatching distance, slicing distance, and hatching strategy, was evaluated through morphological characterization and scanning electron microscopy.

The optimized fabrication conditions enabled the production of approximately 4 × 4 mm^2 surfaces containing nearly 48,000 hexagonal micropillars arranged in a dense periodic lattice, with improved dimensional accuracy and uniform inter-pillar spacing. The resulting micropatterned structures were validated as biomimetic scaffolds for culture of human ARPE-19 retinal pigment epithelium cells. The analysis demonstrated that micropatterned interfaces have superior performance with respect to flat controls (not micropatterned) in terms of cell adhesion, proliferation and differentiation with possible applications in the treatment of retinal detachment.

Further studies have been conducted to assess the influence of fabrication parameter on mechanical response of micrometric pillars, obtained by 2PP comparing the behavior of three different resins. Microcompression tests revealed that tiny details in design and fabrication strongly alter the contact stiffness in indentation tests supporting the importance of controlling microstructure geometry and fabrication parameters for obtaining reproducible mechanical responses of microscale contacts.



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Sciforum-207420: Finite Element Analysis of Stress Intensity Factor in Functionally Graded Material Compact Tension Specimen Using ANSYS

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This study presents a detailed numerical investigation of the Mode I Stress Intensity Factor (SIF) in a Compact Tension (CT) specimen fabricated from functionally graded material (FGM) using the Finite Element Method (FEM) in ANSYS software. In FGMs, material properties vary continuously in space, providing superior mechanical performance compared to conventional homogeneous materials. In this research, the elastic modulus varies exponentially along the x-direction according to the function $E(x) = E_0 e^{\lambda x}$, while Poisson's ratio is kept constant at $\nu = 0.3$. A two-dimensional plane strain model was developed in ANSYS Workbench. Quadratic quadrilateral elements (PLANE183) with highly refined mesh near the crack tip were employed to accurately capture the stress singularity. The crack was simulated using the Fracture module, and the Interaction Integral method was utilized to compute the Stress Intensity Factor (K_I). Appropriate boundary conditions were applied, including tensile loading (P) at the pin holes. A mesh convergence study was performed to ensure the independence of numerical results from element size.The numerical results obtained from ANSYS were compared with the available analytical solution derived from the theoretical formula reported in the literature. The comparison demonstrates excellent agreement, with a relative error of only 2.32% (FEM: 5.812 MPa$\sqrt{cm}$ versus analytical: 5.9503 MPa$\sqrt{cm}$). This study confirms the reliability and effectiveness of ANSYS software for fracture mechanics analysis of heterogeneous materials with continuously varying properties. The findings provide valuable insights for the design and safety assessment of advanced FGM structures in aerospace, nuclear, and biomedical applications.



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Sciforum-207476: A Load-Controlled Indentation Framework for Characterizing Soft Viscoelastic Materials in Biomechanics

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This work develops a load-control indentation method for creep and relaxation testing of soft viscoelastic materials, with direct application to biological tissues. The material is modeled using a modified power-law (MPL) viscoelastic law, which captures the broad-band relaxation behavior observed in tissues and gels, unlike the standard linear solid (SLS) model. The classical Greenwood–Ting auxiliary-time construction, originally derived for SLS materials, is extended to the MPL case to handle decreasing contact radius during unloading under arbitrary load histories. Spherical indentation under a step, triangular ramp, and half-sine load histories are analyzed within the Hertz framework. During intervals where the contact radius increases, the Lee–Radok correspondence principle with the MPL creep function is used. During intervals where the contact radius decreases, a generalized Greenwood–Ting auxiliary-time construction, extended from SLS to MPL materials, is applied. The model predicts the full-time evolution of contact radius, indentation depth, and load–indentation hysteresis. Analytical results are validated against axisymmetric finite-element simulations. The effects of loading rate, relaxation ratio, and power-law exponent are examined to show how the broad-band relaxation spectrum controls hysteresis and energy dissipation. The approach provides a practical and robust basis for load-controlled creep and relaxation indentation tests on soft biological materials where SLS-based models are insufficient.

Author contributions: Conceptualization, Antonio Papangelo; Methodology, Aleligne Yohannes Shiferaw, Michele Tricarico and Antonio Papangelo; Validation, Luciano Afferrante; Investigation, Aleligne Yohannes Shiferaw, Michele Tricarico and Antonio Papangelo; Resources, Antonio Papangelo; Data curation, Aleligne Yohannes Shiferaw and Michele Tricarico; Writing - original draft, Aleligne Yohannes Shiferaw and Antonio Papangelo; Writing - review and editing, Michele Tricarico, Luciano Afferrante and Antonio Papangelo; Supervision, Luciano Afferrante and Antonio Papangelo; Funding acquisition, Antonio Papangelo;



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Sciforum-207566: Microvibration-Enhanced Adhesion in Soft Contacts:

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High-frequency, micrometrical vibrations can dramatically enhance the adhesive performance of soft interfaces, providing a simple and rapid strategy to achieve reversible and tunable adhesion, a phenomenon referred to as vibroadhesion. Despite increasing interest in vibroadhesion, a comprehensive understanding of the mechanisms governing this phenomenon and their quantitative description has remained elusive. Here, we combine systematic experiments and theoretical modeling to investigate the adhesive behavior of vibrating viscoelastic PDMS–glass contacts during unloading. Adhesion tests were performed using borosilicate glass spherical indenters of different radii on PDMS substrates subjected to high-frequency vibrations, while varying substrate thickness, elastic modulus, thermodynamic work of adhesion, unloading rate, and preload. In all cases, vibration activation induced an abrupt expansion of the contact area, followed during unloading by an evolution closely resembling the classical JKR solution, but with a substantially increased effective work of adhesion. The pull-off force increased with vibration amplitude until reaching a saturation level, consistently associated with the onset of interfacial instabilities (wrinkling). Although the absolute pull-off force strongly depended on geometry and material properties, the maximum adhesion enhancement relative to static conditions remained remarkably constant at approximately 13-fold. Unloading rate exhibited only a weak influence on adhesion enhancement, whereas preload was found to be nearly irrelevant. A lumped mechanical model incorporating independently measured rate-dependent interfacial adhesion accurately reproduced the experimental observations without adjustable parameters, providing both qualitative and quantitative agreement. These findings establish a unified framework for understanding vibroadhesion and offer practical design guidelines for vibration-modulated adhesive interfaces with rapidly switchable and controllable adhesion.

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Author contributions: Conceptualization, Michele Tricarico and Antonio Papangelo; Methodology, Michele Tricarico, Aleligne Yohannes Shiferaw and Antonio Papangelo; Software, Aleligne Yohannes Shiferaw and Antonio Papangelo; Validation, Michele Tricarico; Formal analysis, Michele Tricarico; Investigation, Michele Tricarico, Aleligne Yohannes Shiferaw and Antonio Papangelo; Resources, Antonio Papangelo; Data curation, Michele Tricarico and Aleligne Yohannes Shiferaw; Writing - original draft, Michele Tricarico; Writing - review and editing, Michele Tricarico and Antonio Papangelo; Visualization, Michele Tricarico; Supervision, Antonio Papangelo; Project administration, Antonio Papangelo; Funding acquisition, Antonio Papangelo;



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Sciforum-207569: Investigation of spherical contact with different degrees of geometric conformity for elastic and elasto-plastic materials.

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This work presents a parametric numerical procedure for the analysis of contact between a sphere and a spherical-cavity seat over different degrees of geometric conformity. The model is developed in ANSYS Mechanical APDL with MATLAB support and is based on an axisymmetric formulation, allowing the automatic generation of geometry, mesh, contact conditions and post-processing routines from a limited set of input parameters: the radii of the bodies, the imposed indentation depth, the macro dimensions of the involved bodies and the material properties.

The procedure provides a flexible and repeatable framework for studying contact configurations that range from non-conformal to highly conformal cases. The numerical model is first assessed against Hertz theory in the non-conformal elastic regime, where pressure distribution, contact radius and force-indentation response can be compared with closed-form solutions. Conformal configurations are then examined through comparison with the Winkler-based formulation. In this case, the validation focuses on the normal relative displacement field, the pressure field obtained through the local proportionality between pressure and displacement, and the resulting global force response obtained by integration over the contact region. This allows the verification of both the local contact behaviour and the overall stiffness predicted by the numerical model. The onset of plasticity is also evaluated through Hertzian estimates of initial yielding, which are used as an analytical reference for interpreting the numerical results. The analysis considers the main quantities characterizing the contact problem, including pressure profiles, force-indentation curves, Von Mises equivalent stress and equivalent plastic strain.

Attention is given to the consistency of the automated workflow and to the influence of the adopted discretization on local and global contact quantities. The procedure provides a structured numerical tool for investigating both conformal and non-conformal spherical contacts under elastic and elasto-plastic material behaviour in a repeatable manner.



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Sciforum-207616: Design, Fabrication, and Finite Element Drop-Impact Evaluation of a 3D-Printed Soft Robotic End-Effector for Strawberry Harvesting

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Harvesting strawberries is labor-intensive and expensive, as the fruit must be gripped, detached and carried without bruising or mechanical damage. The fruit's size, ripeness, orientation, and position, along with the fruit stem's orientation and position, further complicate the development of reliable robotic harvesting systems. In this paper, a 3D-printed soft robotic end-effector for robotic strawberry harvesting is designed and fabricated, capable of coordinated cutting, collection, and impact reduction. The end-effector, designed in SolidWorks, consisted of a strawberry holder, a sliding tray, a structural plate, a support column, sliders and a cutting mechanism. The rigid parts were produced from polylactic acid (PLA), and the compliant part was made from thermoplastic polyurethane (TPU) for cushioning during fruit handling. A prototype was produced via fused deposition modeling, and the mechanical configuration's feasibility was investigated. The dynamics of strawberries interacting with the compliant tray during controlled drop events were studied using finite element analysis in ANSYS Mechanical. Three major variables were drop height, strawberry size, and fruit density, and 15 simulations were created to evaluate these three. The models tested were small, medium and large strawberries; densities from 917.4 to 1147.7 kg/m^3; and dropping heights from 20 to 100 mm. The tray was secured on four sides, and strawberries were dropped from a known height under gravity. These are the main response parameters: equivalent stress, total deformation and internal energy. This approach is used to assess soft-robotic harvesting components before physical testing and system-level integration.



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Sciforum-207619: Particle-Size-Dependent Nanomechanical Behavior of Fe_3O_4-Reinforced Electrospun PVDF Nanofibers

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Poly(vinylidene fluoride) (PVDF) is a semi-crystalline polymer with tunable mechanical, piezoelectric, and chemical resistance properties. PVDF nanofibers have found tremendous applications in sensing, energy storage, and bio-scaffold applications. Yet, the nanoparticle-induced nanomechanical attributes of such nanofibers remain underexplored. Here, we fabricate PVDF and PVDF-Fe_3O_4 nanofibers leveraging electrospinning and investigate the nanoscale mechanics using atomic force microscopy (AFM). To elucidate the mechanical response, we reinforce PVDF with 20 and 50 nm sizes of Fe_3O_4 nanoparticles. Our results indicate that reducing particle size alters the fiber morphology, surface roughness, distribution of crystalline-amorphous regions, and local modulus of the nanofiber composites. Additionally, we observe load-dependent modulus behavior, in which increasing the load reduces the local modulus across all samples. Among the nanofibers, the 20 nm system showed the highest modulus (2.78 MPa) at 500 nN compared to the neat PVDF or in 50 nm systems. To explain such behavior, we leverage some micromechanical models (Voigt, Reuss, Halpin-Tsai, Mori-Tanaka, Guth-Gold) to theoretically calculate the composite modulus, but they fail to replicate the experimental results. To explain the particle-size-induced mechanics, we develop a theoretical model that accounts for AFM contact mechanics and nanoparticle size inclusions. Our proposed model produced mean absolute percentage errors of 9.29% and 15.26% for the 20 nm and 50 nm systems, respectively. While other micromechanical models fail, our model provides a logical solution to the nanoparticle-induced modulus response in PVDF nanofiber systems.

Author contributions: Conceptualization, Ashfaqul Hoque Khadem and Lihua Lou; Methodology, Ashfaqul Hoque Khadem; Formal analysis, Ashfaqul Hoque Khadem; Investigation, Ashfaqul Hoque Khadem; Supervision, Lihua Lou; Project administration, Lihua Lou; Funding acquisition, Lihua Lou;



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Session 4. Friction, Wear, Corrosion and Fatigue

Sciforum-177560: Tribological development for the gate valves hermetic elements

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Gate valves are essential components in industrial fluid control systems, but the hermetic sealing elements of these valves face severe tribological challenges. Continuous friction and wear at the gate–seat interface can degrade sealing performance, increase actuation force requirements, and eventually cause leakage or failure, especially under high-pressure or corrosive conditions. This paper addresses the need for improved tribological performance of gate valve hermetic elements by exploring advancements in materials, surface engineering, and design optimization. The article presents a combined approach employing both experimental tribological testing and computational analysis to evaluate friction and wear behavior of various sealing material pairs, coatings, and surface treatments under simulated valve operating conditions. Key parameters such as friction coefficient, wear rate, and microstructural integrity were measured across different lubrication regimes and operational environments. The results demonstrate that incorporating advanced wear-resistant coatings (hardfacing or ceramic-based coatings) and optimized sealing surface geometry significantly reduce frictional losses and mitigate wear at the gate–seat interface. Enhanced material combinations, including high-hardness alloys and self-lubricating composites, showed up to notable improvements in wear resistance and maintained reliable sealing under extreme pressures and corrosive media. These tribology-driven developments contribute to extended valve service life and more stable leak-tight performance. The findings offer practical guidelines for designers and engineers to improve gate valve reliability, reduce maintenance needs, and ensure safer operation in demanding industrial applications.



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Sciforum-178484: Grinding-Induced Microstructural Variations in Pearlitic Rail Steels under Tribological Conditions

María Cristina Bedoya Bedoya [1], Luis Vicente Wilches Peña [1,*], Johnnatan Rodriguez Fernandez [1], José William Restrepo Montoya [1], Jaime Jaramillo Carvalho [2], Juan Camilo Sanchez [2], Fabio Alexander Suarez Bustamante [3] and Alejandro Toro Betancur [4]

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Rail grinding is widely used as a preventive maintenance technique in railway systems to remove surface defects and restore rail geometry; however, the tribological interaction between the grinding wheel and rail steel can generate significant subsurface microstructural transformations. In this study, an experimental methodology was developed to investigate the relationship between grinding parameters and microstructural evolution in pearlitic rail steels under controlled laboratory conditions. A dedicated experimental setup was designed to reproduce representative grinding conditions while allowing the systematic variation of cutting speed and depth of cut. Rail steel coupons (R260 grade) were subjected to controlled grinding tests, after which specimens were extracted from the contact region and prepared using standard metallographic procedures. Microstructural characterization was conducted using Optical Microscopy (OM) and Scanning Electron Microscopy (SEM), complemented by microhardness measurements to evaluate mechanical changes within the modified layers. The results revealed pronounced subsurface microstructural modifications, including severe plastic deformation of the pearlitic structure and the formation of White Etching Layers (WELs) with variable morphology and thickness. The region immediately beneath the WEL interface exhibited heavily distorted lamellar pearlite, while hardness profiles showed a marked increase near the surface compared with the bulk material, indicating localized strain hardening. The observations suggest that the formation of these transformed layers is strongly associated with intense plastic deformation generated by tribological loading during grinding. Nevertheless, the potential contribution of frictional flash temperatures cannot be excluded, suggesting that WEL formation may result from a coupled thermo-mechanical mechanism. These findings highlight the importance of understanding the interaction between grinding parameters, tribological stresses, and thermal effects to optimize rail maintenance strategies and mitigate undesirable microstructural degradation.



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Sciforum-195213: Does combination of a lubricant anti-wear additive and a hard coating double the surface protection?

Jun Qu

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For a contact interface under boundary lubrication, wear protection relies on both the lubricant physicochemical characteristics and the surface mechanical properties. Anti-wear additives—traditionally zinc dialkyldithiophosphate (ZDDP) and tricresyl phosphate (TCP) and, more recently, oil-soluble ionic liquids—are important components of many lubricants. They are designed to protect the contact surface via forming a tribofilm *in situ* via thermomechanically triggered chemical reactions. Concurrently, various hard coatings have been developed with promise for reducing friction and wear. Common ceramic coatings include titanium nitrides (TiN, TiAlN, CrN, etc.), carbides (WC-Co, VC, Cr_3C_2, etc.), and borides (TiB_2, $AlMgB_{14}$, etc.). Diamond-like-carbon (DLC) coatings are among the most successful carbon-based thin films. While both lubricant anti-wear additives and hard coatings are being used in many industrial applications, a fundamental question remains: would using them together provide double surface protection? The short answer is: not necessarily and sometimes an incompatible additive-coating pair could even accelerate the wear loss. This talk uses a few case studies, synergistic or antagonistic, to reveal the mechanisms behind the compatibilities between the lubricant chemistry and coating composition. Tribochemical reactions at the contact interface could be either beneficial to form a self-healing tribofilm or detrimental leading to excessive tribocorrosion. Results provide critical insights for future lubricant and coating development and implementation.



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Sciforum-205905: Finite Element Analysis of a Slider–Crank Mechanism Using ANSYS Workbench

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The slider–crank mechanism is one of the most widely used mechanical transmission systems in engines, compressors, and industrial machinery. Accurate prediction of its structural response under loading conditions is essential for improving reliability and extending service life. This study presents a finite element analysis of a three-dimensional slider–crank assembly using ANSYS Workbench. The geometric model was developed in CAD software and imported into the finite element environment through the STEP format. Appropriate material properties, contact definitions, boundary conditions, and external loading were assigned to simulate the operating condition of the mechanism. The computational procedure consisted of geometry preparation, mesh generation, static structural analysis, and post-processing of numerical results. The structural performance was evaluated through total deformation, equivalent (von Mises) stress, equivalent elastic strain, and displacement distribution. The numerical results demonstrate that the highest stress is concentrated around the pin connection regions where the load transfer occurs, whereas the maximum deformation appears near the free moving components of the mechanism. The obtained stress and deformation patterns are consistent with the expected mechanical behavior of slider–crank systems. The study confirms that ANSYS Workbench provides an efficient numerical tool for evaluating structural integrity and identifying critical locations before prototype manufacturing. The proposed simulation methodology can be applied in the design optimization and reliability assessment of mechanical transmission mechanisms.



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Sciforum-206337: Computational Modeling of Fatigue Crack Path Evolution in Ti-6Al-4V under Cyclic Loading

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This study presents a detailed numerical investigation of fatigue crack propagation in linear elastic materials subjected to mixed-mode (Mode I + Mode II) loading, with particular emphasis on the role of geometric discontinuities in Modified Compact Tension Specimens (MCTS). Finite Element (FE) analysis using ANSYS is employed to simulate mixed-mode fatigue crack growth in four Ti-6Al-4V specimen configurations (MCTS01–04), each characterized by different hole locations and spacing. Within the framework of Linear Elastic Fracture Mechanics (LEFM), Paris' law is adopted to quantify fatigue crack growth behavior and establish crack length–cycle relationships for the considered configurations.

The computational methodology integrates incremental crack growth under cyclic loading, fatigue life prediction based on crack propagation rates, and precise evaluation of mixed-mode Stress Intensity Factors (SIFs). Crack path trajectories are determined using energy release rate criteria in conjunction with local stress field analysis. Simulations are performed under constant amplitude loading conditions to accurately predict crack propagation paths and corresponding fatigue life.

A systematic parametric study is conducted to assess the influence of hole placement and spacing on stress concentration, crack deflection, and crack growth rates. The results reveal significant sensitivity of crack trajectories and fatigue life to geometric variations. These findings provide critical insights for the design and optimization of damage-tolerant structures, demonstrating the effectiveness of advanced fracture mechanics-based numerical modeling in predicting fatigue behavior.



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Sciforum-206542: Tailoring the Properties of Laser Sintered Composites for Tribological Applications

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Laser Sintering enables the manufacturing of complex or bespoke, functional polymer components, yet controlling their tribological properties for subsequent applications still presents a challenge. This study explores the use of waste materials in low weight percent additions as functional additives into a nylon 12 Laser Sintered polymer. Here, the tribological performance of the nylon 12 composites is investigated under dry sliding conditions against a steel counterface, across two differing loads and two contact configurations, in accordance with ASTM G99.

Post sliding testing covered wear analysis and X-Ray Photoelectron Spectroscopy to identify wear rates and debris composition. The results demonstrate that contact condition exerts the greatest influence on tribological performance, probing fundamentally different friction and wear mechanisms. In the polymer disc configuration, unstable friction behaviour was observed, displaying repeated cycles of transfer film formation and disruption under the periodic contact. The polymer pin configuration prompted a more stable transfer film to form through continuous contact and improved debris retention on the counterface. Increasing the applied normal load reduced friction on the polymer disc but produced an opposite trend for the composite pins. This indicates that filler materials alter the load sensitivity of the tribological interface opposed to simply modifying the COF.

While surface roughness influenced the running-in behaviour, its effect diminished quickly after the first 50-70m of sliding. Under steady-state conditions, the tribological performance was governed predominantly by the transfer film evolution and third-body interactions. The composite containing waste carbon fibres exhibited the lowest COF and one of the lowest specific wear rates; while composites containing glass bead and calcium carbonate demonstrated significant reductions in friction despite negligible changes in surface morphology. These findings suggest that filler materials in low concentrations influence the tribological interface through modification of transfer film stability, providing insight into optimisation of Laser Sintered polymer components.

Author contributions: Conceptualization, Roger Lewis, Candice Majewski and Finlay Wilby; Methodology, Roger Lewis, Candice Majewski and Finlay Wilby; Validation, Roger Lewis, Candice Majewski and Finlay Wilby; Formal analysis, Roger Lewis, Candice Majewski and Finlay Wilby; Investigation, Roger Lewis and Finlay Wilby; Resources, Finlay Wilby; Data curation, Roger Lewis; Writing - original draft, Roger Lewis, Candice Majewski and Finlay Wilby; Supervision, Roger Lewis and Candice Majewski;



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Sciforum-206660: Tribocorrosion investigation on biomaterials for total hip replacements

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Introduction

The combined action of mechanical wear and corrosion, known as tribocorrosion, is a degradation mechanism occurring in biological environments. A clear example is the total hip replacements where the chemical aggressivity of synovial fluid, coupled with the coupling between liner and cup or head affects the long-term survival of the medical devices. At the moment hard coatings are commonly adopted for improving the tribological properties. This study aimed thus to compare the tribocorrosion performance of TiNbN-coated AISI 316L stainless steel, uncoated AISI 316L stainless steel, and CoCrMo alloy under testing conditions representative of the range of motion and applied loads occurring in total hip replacements.

Methods

Dry and lubricated tribological tests were carried out by a linear reciprocating tribometer and a potentiostat supplied with an electrochemical cell. The counterpart was Titanium Grade V whereas the solution was composed of sodium chloride (0.9% NaCl per 500 ml of distilled water, pH 5.8). For the corrosive part, open-circuit potential, galvanic, potentiodynamic and potentiostatic tests were conducted. Finally, surface analysis was achieved via optical confocal/interferometric profilometry and scanning electron microscopy.

Results

TiNbN-coated stainless steel showed the least favorable corrosion response when tested under purely electrochemical conditions, while maintaining good performance during combined tribocorrosion testing. CoCrMo exhibited the best overall behavior under tribocorrosion conditions. However, this alloy was associated with the greatest wear of the titanium counterbody and the highest friction-related response under dry sliding conditions. These findings indicate that the ranking of the materials varied according to whether corrosion, wear, or their synergistic interaction was the dominant mechanism.

Conclusions

The results demonstrate that corrosion resistance alone is not sufficient to predict the performance of metallic biomaterials under tribocorrosion conditions. The response of the complete tribosystem, including the wear of the counterbody, must be considered when selecting materials and coatings for biomedical applications.



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Sciforum-206859: Sliding friction tests on photochemically cured acrylate coatings with bio-based versus fossil-based monomers

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Bio-based UV-curable acrylate coatings are emerging as sustainable alternatives to conventional petrochemical systems, but their tribological performance remains scarcely studied. This study investigates the sliding friction behaviour of photochemically cured acrylate coatings with alternative bio-based and fossil-based monomers. Friction measurements were performed using a high-precision Basalt N2 tribometer under reciprocating sliding against an elastomeric O-ring simulating a rubber contact against wood coatings. Testing was conducted at room temperature under controlled normal loads, sliding speeds, and multiple measurement locations to account for coating heterogeneity. The coefficient of friction was evaluated as a function of coating monomer composition and crosslinking functionality. Results revealed substantial local variation in friction across the coated surfaces, highlighting the importance of spatially resolved tribological characterization. Therefore, an appropriate tribological testing protocol was developed to account for statistical variation of friction over different locations. Despite this variability, clear differences between coating formulations were observed. In particular, a 20 to 30% higher coefficient of friction was experienced on coatings with bio-based monomers as compared to the fossil-based analogues, while the coefficients of friction gradually decreased for a higher functionality of the acrylate monomer. These findings agree with compositional analysis that demonstrated the presence of a residual oligomer fraction at the surface of bio-based coatings. Moreover, their glass transition temperature is a few degrees lower than that of fossil-based coating analogues. Therefore, the latter phase likely acts as a mobile viscoelastic phase that causes reduced mechanical hardness and greater deformation under load in parallel with enhanced energy dissipation. The observed frictional response is consistent with previously reported improvements in ductility and reductions in abrasive wear for bio-based formulations.



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Sciforum-207301: Thermal and tribodecomposition mass spectra of polymer-polymer friction pairs.

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The goal of the presentation is to quantitatively describe the information obtained by thermal and tribodecomposition experiments in the vacuum chamber of mass-spectrometer (~10^{-6} Torr) and atmosphere conditions based on synchronous registration of mass-spectra of volatile molecular products of polymer decomposition, friction force, thermopair measurements of triboinduced heating and calculated flux of the energy generated by friction forces. The physical principles of mass-spectrometric detection of the quantity and the rate of desorption of the molecular decomposition products of macromolecules are preliminary considered based on the dependencies of the registered flux of the decomposition molecular products in vacuum of mass-spectrometer on thermopair measured temperature for the polymer layers of submicron thickness. The examples include the friction between depolymerizing polymers: polymethylmethacrylate, polyoxymethylene, polytetrafluoroethylene and other polymers, e.g. polyamide, as well as friction of the polymers against steel. The polymers used in the study are characterized additionally by differential scanning calorimetry. The experimental correlations between the composition and kinetics of formation of the molecular products, friction force transitions, the character of the triboinduced surface roughness changes and triboinduced vibration energy flux registered with piezoelectric transducer are discussed. Temperature measurements for the experimentally registered friction force kinetic dependencies are compared to finite elements calculations of the thermal problem in the friction geometries used (cylinder-on-flat, ball-on flat, etc.) both in technical approximation of uniform stress distribution as well as in realistic case of non-uniform distributions of friction stress over contact area. The data are compared to the measurements of wear of the polymers expressed as the ratio of the macroscopic loss of mass of the polymer as a result of friction or the mass of the molecules desorbed to the work of friction forces at different levels of energy flux generated by friction forces.



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Sciforum-207457: The influence of sheet surface modification on tribological properties in the sheet strip drawing test

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The tribological properties of sheet metal surfaces play a significant role in plastic forming processes, influencing the material's deformation, the value of technological forces, and the quality of the resulting products. One of the most important parameters describing the contact conditions between the tool and the material is the coefficient of friction, whose value depends, among other things, on surface topography, unit pressure, and lubrication conditions. Modifying the surface layer can change the nature of contact between mating surfaces, influencing the intensity of friction phenomena. The aim of the study was to determine the effect of selected sheet metal surface modification methods on the coefficient of friction determined in a strip drawing test.

The study was conducted using a tribotester with controlled pressure values. The sample surfaces were prepared in three variants: as-delivered, after sanding, and after sandblasting. Tribological tests were performed under dry friction conditions and with lubrication using S100 Plus oil for pressures of 3, 6, and 9 MPa.

Analysis of the results showed that for the as-received surface and after sanding, the friction coefficient increases with increasing pressure during dry friction, with the lowest values obtained for the as-received sheet metal. Under lubrication conditions, both sanding and sandblasting led to a lower friction coefficient compared to the unmodified surface. The obtained results confirm that appropriate shaping of the surface topography can positively influence friction conditions in sheet metal forming processes, especially in the presence of a lubricant.

Author contributions: Conceptualization, Marek Szewczyk; Methodology, Marek Szewczyk; Validation, Marek Szewczyk; Formal analysis, Marek Szewczyk; Investigation, Marek Szewczyk; Resources, Marek Szewczyk; Data curation, Marek Szewczyk; Writing - original draft, Marek Szewczyk; Visualization, Marek Szewczyk;



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Sciforum-207499: Advanced Measuring Equipment for Studying the Lubrication State in Tribocontacts

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A tribocontact, i.e. the contact between two bodies in relative motion, is difficult to access with most sensors. In such contacts, lubrication is essential to ensure smooth running behaviour and long service life. It is often not possible to investigate tribocontacts in machinery without modifying the machine itself. In this work, the lubrication state was intentionally varied in a laboratory test rig, and the effect of lubrication loss on running behaviour was investigated.

The study was conducted using a pin-on-disc tribometer. To provide a defined lubrication condition, a pump was used to supply lubricant continuously; towards the end of the test, the pump was switched off in order to study lubrication loss. Using an ultrasonic sensor, the Triboacoustic Pin, the film thickness in the contact was measured during the test run, providing detailed information on the amount of lubricant present in the contact. A high-speed thermal camera was used to measure the temperature of the disc after it had passed through the contact. A high-speed camera was used to study the contact dynamics, in particular loss of contact under unfavourable vibration conditions. A 3D laser Doppler vibrometer was used to scan the dynamics of the test rig at several rotational speeds, enabling contactless operational vibration analysis of the test rig.

It was found that all the sensors used can provide information on the lubrication state in the contact without influencing the contact situation, as they are either contactless sensors or sensors that can be applied to existing machine components. The individual sensors can provide detailed information, for example on film thickness, temperature distribution or loss of contact. This knowledge can be used, for example, to optimise the type of lubricant or the amount of lubrication for machinery.

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Author contributions: Conceptualization, Markus Varga; Methodology, Jürgen Frieß and FabioFabio Tatzgern; Validation, Jürgen Frieß, FabioFabio Tatzgern and Florian Widder; Investigation, Jürgen Frieß, FabioFabio Tatzgern and Florian Widder; Resources, Markus Varga; Data curation, Jürgen Frieß, FabioFabio Tatzgern and Florian Widder; Writing - original draft, Jürgen Frieß; Writing - review and editing, Jürgen Frieß and Markus Varga; Visualization, FabioFabio Tatzgern and Florian Widder; Supervision, Jürgen Frieß; Project administration, Markus Varga; Funding acquisition, Markus Varga;



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Sciforum-207512: Effect of Contact Load on the Oil lubrication Behavior of Thermally Oxidized Ti-6Al-4V Sliding against Alumina

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Ti-6Al-4V is widely used in engineering, aerospace, and automotive applications due to its excellent mechanical properties, but its low surface hardness and poor tribological performance limit its use in sliding contacts. Ti-6Al-4V specimens were thermally oxidized (TO) at 625 °C for 0.5 h, and their tribological performance under oil-lubricated sliding was investigated across a wide range of contact load. Characterization by XRD, SEM, and EDX confirmed the development of an oxide layer (OL) and an oxygen diffusion zone (ODZ) on the surface of the alloy after the TO treatment. Tribological tests were conducted using a ball-on-disk configuration at different loads of 5, 10, 20, 40, 60 and 100 N against an Al2O3 counterbody in 10W-40 oil-lubricated environments. The results show that the engine oil failed to lubricate the untreated Ti-6Al-4V, leading to unstable high friction from the sliding contact. TO treatment at 625 °C for a short time of 0.5 h was very effective in enhancing the oil lubrication behavior of the contact pair, resulting in much increased wear resistance of Ti-6Al-4V compared with the untreated alloy. Under oil-lubricated conditions, the TO treated surfaces maintained a low and stable COF of 0.12 and a low wear rate in the order of 10-6 mm3m-1N-1 over the investigated load range. Increasing the applied load from 40 to 100 N caused plastic deformation of the oxide layer without severe material removal or catastrophic failure. Despite localized damage, the oxide layer maintained low friction and effective wear resistance. These findings demonstrate that short-duration thermal oxidation (TO) enhances the tribological performance of Ti-6Al-4V under lubricated sliding conditions and reveals the effect of contact load on oxide layer deformation and durability.

Author contributions: Conceptualization, MOHAMMED SALEM AL-SHAN and Richard Bailey; Methodology, MOHAMMED SALEM AL-SHAN and Richard Bailey; Software, MOHAMMED SALEM AL-SHAN and Richard Bailey; Validation, MOHAMMED SALEM AL-SHAN and Richard Bailey; Formal analysis, MOHAMMED SALEM AL-SHAN and Richard Bailey; Investigation, MOHAMMED SALEM AL-SHAN and Richard Bailey; Resources, Richard Bailey and Yong Sun; Data curation, MOHAMMED SALEM AL-SHAN; Writing - original draft, MOHAMMED SALEM AL-SHAN; Writing - review and editing, MOHAMMED SALEM AL-SHAN, Richard Bailey and Yong Sun; Visualization, MOHAMMED SALEM AL-SHAN, Richard Bailey and Yong Sun; Supervision, Richard Bailey and Yong Sun; Project administration, Richard Bailey;



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Sciforum-207514: Friction torque reduction due to laser surface texturing in Cam tappet contact – A Mathematical modeling approach

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Higher efficiency and lower emissions of modern IC engines are still a challenge for all components of the valve train. One of the most critical tribological interfaces, the cam–tappet operates under severe mixed lubrication under high contact stress and sliding velocities. Surface texturing techniques have been developed based on the laser method and are considered to be a promising micro-tribological modification to obtain lubrication behavior improvement and energy saving. The frictional torque characteristics of a flat-faced tappet with laser made micro-texture patterns on its surface in a cam mechanism. One-dimensional mathematical modelling and integration of the 3D transverse leakage compensation are developed, which include the hydrodynamic, asperity and thermal/shear-thinning effects and trace the contact behavior across the cam cycle. Asperity interactions, flow factors, viscosity response, temperature dependent material properties are included in the modelling approach. The influence of the modification of the micro-texture geometry and its distribution on the film thickness, pressure distribution and lubricant rheology is demonstrated, affecting the frictional torque. The results show that a suitably designed laser texture can indeed greatly reduce the friction under certain operating conditions. This research offers insights of relevance for advanced surface engineering in automotive valve trains and can be used to further advance mechanical efficiency in internal combustion engines.



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Sciforum-207561: Influence of Additively Manufactured Polymer Counterbody Geometry and Material on Measurement Variability in Three-Body Ball-on-Disk Wear Testing

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Three-body abrasive wear is one of the most common wear mechanisms in industrial applications. The ASTM G75 Miller test is widely used for evaluating abrasive wear resistance under slurry conditions. However, the standard method requires long testing times, offers limited flexibility in test configuration, and often exhibits considerable variability in the measured wear results. These limitations restrict its suitability for rapid material screening and systematic parameter investigations.

In this work, a flexible tribological test method was developed as an alternative to the conventional Miller test. The key element of the concept is an additively manufactured polymer counterbody (pin), enabling rapid modification of both geometry and material while maintaining a constant nominal contact pressure. The modular approach allows systematic investigation of the influence of counterbody design on the tribological response.

Experimental results demonstrate that both the counterbody geometry and polymer material significantly influence the wear behavior, affecting both material removal and test reproducibility. Optimized test configurations achieved higher material removal together with lower coefficients of variation, indicating improved repeatability.

The developed test method provides a flexible and reproducible approach for investigating three-body abrasive wear while substantially reducing experimental effort compared with the conventional Miller test. The concept offers considerable potential for accelerated material screening and systematic studies of wear mechanisms under slurry conditions.

Author contributions: Conceptualization, Xiaoming Shen, Thomas Lindner, Lukas Tegelkamp and Thomas Lampke; Methodology, Xiaoming Shen, Thomas Lindner and Lukas Tegelkamp; Validation, Xiaoming Shen; Formal analysis, Xiaoming Shen; Investigation, Xiaoming Shen; Writing - original draft, Xiaoming Shen; Writing - review and editing, Thomas Lindner and Lukas Tegelkamp; Visualization, Xiaoming Shen; Supervision, Thomas Lindner, Lukas Tegelkamp and Thomas Lampke; Project administration, Thomas Lindner and Thomas Lampke; Funding acquisition, Thomas Lampke;



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Sciforum-207570: Effect of treatment time on the oil lubrication behavior of thermally oxidized CP-Ti sliding against AISI 52100 Steel

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Outstanding corrosion resistance and low density are advantages of commercially pure titanium (CP-Ti). But poor wear resistance becomes the limitation of its use in different fields. Oil lubrication is one of the direct methods employed to reduce friction and wear and to improve material performance. However, titanium is a metal that is difficult to be lubricated by conventional oil lubricants. Simple surface treatments such as thermal oxidation (TO), normally requires a long period of time for oxygen diffusion. To promote sustainability by reducing energy consumption, short time surface treatments are more preferable. The aim of this research work is to discover the effectiveness of short time TO treatments in improving the oil lubrication behavior of CP-Ti under a high contact load. CP-Ti samples were TO treated at 625 ℃, times ranging from 0.5 h to 24 h. Friction tests were carried out under oil lubricated conditions, under 60N. The counterbody material was AISI 52100 steel ball. The results demonstrate that under such boundary lubrication conditions, all the TO treated samples can be effectively lubricated with low coefficient of friction (COF) below 0.09 and low wear rates in the order of $10^{-5}mm^3m^{-1}N^{-1}$. This work discovered that very short time treatment (0.5 h) is sufficient to change the surface characteristics of CP-Ti, effective oil lubrication can be achieved. This is attributed to the thin rutile oxide (TiO_2) layer on the surface and the oxygen diffusion zone at the subsurface. EDS and Raman spectroscopy analysis revealed the existence of zinc, phosphorus and sulfur compounds on the steel counterface, indicating the formation of a tribofilm on the counterface. The formation of such a tribofilm can provide excellent wear protection under high loads. The short TO treatment time indicates less energy consumption in manufacturing and thus is more preferable in practical applications.



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Sciforum-207577: Wheel/Rail Interface Friction Assessment: High Pressure Torsion Testing; Creep Force Modelling and Field Validation

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The wheel/rail interface has to be carefully managed to achieve friction levels needed for efficient and safe train operation. Sometimes friction needs to be at an intermediate level to reduce energy consumption and wear; at other times, if there are leaf layers present, friction needs to be increased and at the rail gauge corner in curves it might need reducing to very low levels, to deal with wear and crack formation.

Different types of products can be applied to the wheel/rail interface using wayside applicators, or from onboard trains to achieve the varying friction levels required. These are usually tested in small scale laboratory tests to evaluate their performance. One of the challenges then is scaling from the friction level recorded in these to the full-scale operation contacts.

This work was aimed at assessing product performance using a High Pressure Torsion (HPT) method. The outputs were then used to parameterise the Extended Creep Force (ECF) model to enable full-scale predictions to be made that could be compared with field measurements of wheel/rail interface friction.

The work presented is based on case studies of top-of-rail friction modifiers designed to give intermediate friction and sand used to increase friction from low levels.

Author contributions: Conceptualization, Roger Lewis, Martin Evans and Alexander Meierhofer; Methodology, Roger Lewis, Will Skipper, Martin Evans, Klaus Six and Alexander Meierhofer; Validation, Roger Lewis, Will Skipper, Martin Evans, Klaus Six and Alexander Meierhofer; Formal analysis, Roger Lewis, Will Skipper and Martin Evans; Investigation, Will Skipper and Martin Evans; Resources, Will Skipper; Data curation, Roger Lewis, Will Skipper and Martin Evans; Writing - original draft, Roger Lewis, Will Skipper, Martin Evans and Klaus Six; Supervision, Roger Lewis; Project administration, Roger Lewis; Funding acquisition, Roger Lewis;



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Sciforum-207578: A First-Principles Study of Layered Materials for Low Friction Coating

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Abstract Content

The development of environmentally sustainable, PFAS-free low-friction coatings is essential for improving the durability and tribological performance of engineering components. Polytetrafluoroethylene (PTFE), although widely used for its low coefficient of friction, suffers from environmental concerns, limited wear resistance, and performance variations across different contact surfaces. In this work, we combine first-principles calculations with experimental validation to investigate alternative coating materials for durable, non-fluorinated tribological applications.

Density functional theory (DFT) calculations are employed to examine heterostructures comprising a SiO_2 substrate, an Al_2O_3 interfacial layer, and two-dimensional materials including MoS_2, graphene, and hexagonal boron nitride (h-BN). The structural stability of the heterostructures is evaluated through binding energy calculations, while sliding energy barriers are used to predict frictional behaviour. The effect of interfacial oxygen on adhesion and sliding is also investigated to assess its influence on coating performance and durability.

Guided by the computational results, thin-film coatings are fabricated using atomic layer deposition (ALD) and evaluated experimentally through tribological testing to determine their coefficient of friction, wear behaviour, and durability. This integrated computational–experimental approach provides valuable insights into the design of next-generation PFAS-free low-friction coatings and establishes a framework for developing robust, environmentally friendly tribological materials for advanced engineering applications.



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Sciforum-207586: Assessing Recycled Titanium as a New Option for Lightweight Railway Wheel Materials

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Increasing life of railway wheels reduces carbon footprint associated with their production and lost revenue from wheel regrinding to return them to profile. It is reported that a reduction in wheel damage can be achieved by reducing dynamic forces acting on the wheel/rail interface. This can be achieved by using a material that is lower in density than steel, which is the conventional material used for railway wheels, to reduce their weight. Titanium is approximately 40% lower in density than steel and the potential use of which is thought to be beneficial for this application because the feedstock can be harnessed from titanium waste from aerospace component machining. This titanium waste can be cleaned, graded and then consolidated using field assisted sintering technology (FAST). The use of titanium alloys as railway wheels has previously been explored in small-scale tests, however the approach used was not representative of real-world wheel service conditions. The aim of this work is assessing the use of titanium as a railway wheel material through understanding its tribological performance in rolling/sliding tests under representative wheel service conditions.

To assess the tribological performance of titanium alloy wheel in representative wheel/rail interface conditions, a series of small-scale twin-disc tests were conducted for titanium alloys wheels and compared to a conventional steel wheel. During the experiments the following data was assessed; mass losses, friction data, surface and subsurface evolution and wear debris. Rather than ratchetting the titanium wheel material twinned to harden and wore by adhesion or abrasion (see Figure 1). The wheel disc wear rose over steel, however, the rail wear rate dropped compared to that with a steel wheel. The findings demonstrate that titanium could be a promising alternative railway wheel material for reducing rail wear and subsequent travel disruptions for grinding interventions.

Author contributions: Conceptualization, Forbes Gusha, Roger Lewis and Kate Tomlinson; Methodology, Forbes Gusha, Roger Lewis, Kate Tomlinson, Martin Jackson and Sam Lister; Validation, Forbes Gusha, Roger Lewis, Martin Jackson and Sam Lister; Formal analysis, Forbes Gusha and Sam Lister; Investigation, Forbes Gusha; Resources, Forbes Gusha, Roger Lewis and Martin Jackson; Data curation, Forbes Gusha and Roger Lewis; Writing - original draft, Forbes Gusha, Roger Lewis, Kate Tomlinson, Martin Jackson and Sam Lister; Supervision, Roger Lewis, Kate Tomlinson and Martin Jackson; Project administration, Roger Lewis;



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Sciforum-207617: Understanding the Formation Mechanisms of Leaf Layers on the Rail Surface using a High-Pressure Torsion Test

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For decades, rail systems with the ability to carry large numbers of passengers over long distances have been the most carbon-efficient form of public transport and they have become an essential part of our daily mobility. In the UK, however, many passengers express dissatisfaction with rail delays. These are often caused by factors such as congestion, signalling problems and low friction resulting from leaf layers. The formation mechanism of the leaf layer is still largely not understood..

This study used an HPT test machine to simulate the actual wheel-rail contact interface to study how leaf layers are formed on the rails and depleted by cycles aimed to simulate a wheel passage over the layer. This experiment can help us better understand and study the basic mechanisms of leaf layer formation and lay the foundation for studies on how to remove the black layer more efficiently in the future.

The tests used different ratios of leaves to water, but the final results seemed similar. After the 4th cycle, a black layer formed, and the coefficient of friction (CoF) maintained a stable value from the 5th to the 8th cycle. After the 8th cycle, the value of CoF increased. At the same time, the thickness of the leaf layer on the wheel and rail specimens continued to decrease, which also indicated that the leaf layer was wearing away and eventually metal-to-metal contact occurred.

Such results are consistent with the results of experiments carried out on track, which also proves that this is a relatively reliable experiment. It provides a viable test platform for assessing low friction mitigation products.

Author contributions: Conceptualization, Tianhao Xie and Roger Lewis; Methodology, Tianhao Xie and Roger Lewis; Validation, Tianhao Xie and Roger Lewis; Formal analysis, Tianhao Xie; Investigation, Tianhao Xie; Resources, Roger Lewis; Data curation, Tianhao Xie; Writing - original draft, Tianhao Xie and Roger Lewis; Supervision, Roger Lewis;



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Sciforum-207623: Field Wear Assessment of a Rail Head Repaired with Laser Cladding

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The fundamental issues of wear and rolling contact fatigue failures have not yet been solved and they remain drivers of maintenance cost and safety management in rail systems worldwide. Effective maintenance is essential to prevent failure progression, typically involving rail grinding and rail weld repairs, however welding introduces extended heat-affected zones (HAZ), that are prone to cracking. Laser Cladding enables precise repair of damaged rail with significantly lower heat input, reducing HAZ-related risks. Building on small-scale laboratory studies, the first results are reported here for a novel laser clad repair method validating its performance in full scale laboratory and field trials.

Short lengths of R260 grade rail and HP335 rail were repaired with R260 laser clad material. The process involved machining out material following welding standards for rail repair, pre-heating the rail and applying laser cladding in layers until the section returned to just above profile, followed by a final machining stage to restore the original profile. This was carried out in a workshop to ensure repair quality, whilst using techniques that could be translated to in-situ application in later project phases. Repairs were completed at depths of 3 and 9 mm. R260 grade rail steel powder was used to repair both rails to minimise waste.

A field trial on a 9mm R260 rail repair section was performed to validate laboratory full-scale laboratory results under operational conditions. Preliminary findings suggest that laser clad repairs using like-on-like materials provides good surface integrity and bonding to the substrate as well as compatible strain/deformation behaviour reducing the risk of the issues seen with weld repairs such as lack of fusion and differential surface wear. This research demonstrates the potential of laser cladding as a high-precision alternative to conventional rail repair methods under service conditions.

Author contributions: Conceptualization, Mustafa Faisal, Kate Tomlinson and Roger Lewis; Methodology, Mustafa Faisal, Kate Tomlinson, David Fletcher, Ruby Thomas Kempka and Roger Lewis; Validation, Mustafa Faisal, David Fletcher and Ruby Thomas Kempka; Formal analysis, Mustafa Faisal and Ruby Thomas Kempka; Investigation, Mustafa Faisal; Resources, Mustafa Faisal; Data curation, Mustafa Faisal and Ruby Thomas Kempka; Writing - original draft, Mustafa Faisal, Kate Tomlinson, David Fletcher, Ruby Thomas Kempka and Roger Lewis; Supervision, Kate Tomlinson and Roger Lewis; Project administration, Kate Tomlinson and Roger Lewis;



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Sciforum-207624: Feasibility of using Non-Destructive Techniques for Measuring Tooth Degradation

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Dental degradation is a chronic degenerative disease and cannot be avoided. This study aims to verify the possibility of using non-destructive and radiation-free techniques to detect and measure the changes to teeth geometry from wear. Ultimately a technique is required that can be used in the mouth by dentists to measure/detect relatively small amounts of wear.

Optical coherence tomography (OCT), ultrasound and focus-variation microscopy (Alicona) were used to measure the wear loss of samples in this research. A Universal Mechanical Tester (UMT) was used to create wear scars on the samples by two types of wear modes with variable test cycles. The first involved an impact and then a uni-directional slide to mimic a chewing action. The second just involved reciprocating sliding to mimic bruxism

Wear tests were carried out using a zirconia ball impacting/sliding against flat specimens made from an artificial tooth restorative material (Vita Enamic and Fibrafill® CUBE) that were used to mimic a tooth. Artificial saliva was added to improve the oral simualtion.

Depth measurements from OCT showed particular promie when compared to the Alcona measurements. In order to analyse actual tooth material and more realistic surface geometries, bovine and then extracted human teeth will be analysed in the future.

Author contributions: Conceptualization, Mengyuan Li; Methodology, Mengyuan Li and Roger Lewis; Validation, Mengyuan Li and Roger Lewis; Formal analysis, Mengyuan Li; Investigation, Mengyuan Li; Resources, Mengyuan Li and Roger Lewis; Data curation, Mengyuan Li; Writing - original draft, Mengyuan Li and Roger Lewis; Supervision, Roger Lewis;



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Sciforum-207632: Tribocorrosion Behavior of Various Coatings on Duplex Stainless Steel

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Duplex steel pump plungers inside a piston pump working in harsh conditions require additively manufactured hard wear-resistant coating. Two types of hardfacing are compared for better tribocorossion behaviour aiming to reduce the failure rate caused by microstructurally-induced macroscopic anisotropy. Cylindrical plungers are performing constant reciprocating motion with 285 Rev/min. Lubricant selected is Shell Morlina 150; diameter of the plunger 76 mm; movement distance of the plunger 140 mm; linear velocity 1,3 m/s; working pressure – 180 bars; maximal temperature – 120^{o}C; medium is sour water (alkaline, with pH around 11, with traces of H_2S and NH_3). Plasma arc Directed Energy Deposition (DED-arc) with powder feedstock has been used for production of the machine parts with based metal X2CrNiMoN22-5-3 and two different outer layer: of WC /WOKA 3700 (with chemical composition - W Balance, Cr 24%, Ni 8%, C 6%, Fe< 0.5%) and the other possibility - Nickel Balance, Cr 16%, B 3.3%, Si 4.2% Si, C 0.7% and a minor amount of Fe. The microstructural evolution and wear mechanisms were analyzed via optical microscopy and EDX microanalysis. Data is gathered with hardness measurement and subsequently is determined the service lifespan.

In order to reduce the failure rate of the plungers, extra care is taken for assuring the metallurgical bonding of the base metal and the overlay. The hardness assessment is giving around 58-62 HRC. Microcracking detection is perfomed. The findings provide valuable insights into optimizing the tribological performance of coated duplex stainless steels in industrial machinery. Additive manufacturing DED-arc method gives possibility to obtain new materials which require intensive evaluation before putting into operation. Novel production techniques are proving to show superior materials characteristics while being much more cost effective.

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Sciforum-207636: Image-Based Predictive Modeling of Cavitation Wear Evolution for Service-Life Estimation

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Cavitation erosion is a complex tribological degradation process that significantly affects the durability and reliability of engineering materials operating in aggressive liquid environments. Accurate prediction of damage evolution is therefore essential for optimizing maintenance strategies and extending service life. This study presents a non-destructive methodology for predicting cavitation resistance by integrating surface image analysis, principal component analysis (PCA), and strength degradation modeling. The methodology was demonstrated using a sintered talc-based refractory ceramic containing natural zeolite as a representative material exposed to cavitation according to the ASTM G32 ultrasonic vibratory test. High-resolution surface images acquired after successive exposure intervals were analyzed to quantify damage development through morphological descriptors of cavitation pits. PCA was employed to reduce data dimensionality and identify the descriptors that most effectively characterize the evolution of surface degradation. Area, perimeter, and maximum pit diameter were identified as the dominant parameters governing damage progression, while less informative descriptors were excluded from further analysis. Based on the quantified surface deterioration, a predictive model describing compressive strength degradation was established, enabling estimation of the critical exposure time corresponding to a predefined residual strength level. The results demonstrated a nonlinear evolution of cavitation wear and showed excellent agreement between image-derived parameters and the predicted mechanical response. The proposed methodology provides an efficient framework for non-destructive monitoring of cavitation-induced degradation and supports predictive assessment of material performance without extensive mechanical testing. The approach can be applied to a wide range of engineering materials subjected to tribological damage mechanisms such as wear, corrosion, thermal shock or their combined action, offering a valuable tool for service-life prediction and reliability assessment.

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Sciforum-208373: Comprehensive Failure Analysis and Remaining Useful Life Prediction of Main Wind Turbine Bearings: A Multi-Parametric Approach

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This paper presents a multi-parametric approach for the failure analysis and remaining useful life (RUL) prediction of main wind turbine bearings, with a particular focus on in-service grease condition as a diagnostic variable. Wind turbine bearings operate under severe and variable loads, making them highly vulnerable to wear, contamination, lubrication degradation, and premature failure. Given the high cost and logistical complexity of wind farm maintenance, especially in offshore environments, the study emphasizes the value of condition-based and predictive maintenance strategies to improve reliability and reduce unplanned downtime.

The proposed methodology combines historical bearing temperature, gearbox temperature, power generation data, and grease analysis results to identify abnormal wear patterns and estimate the time remaining before a critical threshold is reached. Exploratory data analysis is used to detect trends, anomalies, and correlations, while supervised multiple regression is selected as the most effective predictive model in the initial testing phase. In addition, failure modes of bearing grease are systematically examined through failure modes and effects analysis (FMEA) and fault tree analysis (FTA), highlighting mechanisms such as oxidation, viscosity loss, contamination, moisture ingress, additive depletion, and incorrect lubrication practices.

Results from a study of nearly 260 bearings over 18 months showed that 27 bearings exhibited abnormal behavior, of which 16 later confirmed worsening trends. Visual inspection of selected cases validated the usefulness of the model for early detection. The study concludes that combining grease analysis with operational variables can significantly enhance bearing health assessment and support more effective maintenance planning.

Author contributions: Investigation, Jorge Alarcon;



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Sciforum-209725: Effect of Loading-System Inertial Mass on Friction and Wear of TiAlN-Coated Steel under Unidirectional Sliding

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Tribological behavior is determined not only by material properties and nominal testing parameters but also by the dynamic characteristics of the tribometer. Loading-system inertial mass may influence contact stability, surface evolution, friction, and wear even when nominal load and sliding conditions remain unchanged. This study investigates the effect of loading-system inertial mass on the wear behavior of TiAlN-coated steel. Dry ball-on-disc unidirectional sliding tests were conducted using TiAlN-coated steel discs against 3 mm diameter Si_3N_4 balls under a normal load of 7 N. Four loading-system inertial masses (0, 0.5, 2.5, and 4.5 kg) and four sliding radii (5.5, 7.0, 8.5, and 10 mm) were systematically distributed among four discs to improve reproducibility and minimize the influence of sliding radius. The linear sliding speed was maintained at 0.2 m/s. Each test lasted 2500 s, consisting of five 500-s steps, with a total sliding distance of 500 m. The coefficient of friction (COF) was continuously recorded. Wear volume was measured using a Bruker Contour GT-K0+ three-dimensional optical profilometer, while worn surfaces were analyzed by SEM/EDS and XRD. Loading-system inertial mass considerably affected both friction and wear. The 2.5 kg condition produced the lowest specific wear rate and COF, whereas the 0 kg condition resulted in the highest values. At 0 kg, extensive surface degradation involving fatigue wear, tribo-oxidation, material transfer from the counterbody, and abrasion resulted in severe coating destruction and exposure of the underlying steel substrate. In contrast, the 2.5 kg condition showed substantially less damage, with mild abrasion as the predominant wear mechanism and evidence of self-repair behavior. The results demonstrate that loading-system inertial mass significantly influences friction, wear, and surface degradation under comparable unidirectional sliding conditions, highlighting the importance of considering tribometer dynamics when interpreting laboratory wear-test results.

Author contributions: Conceptualization, Arash Kariminejad, Maksim Antonov and Irina Hussainova; Methodology, Arash Kariminejad and Maksim Antonov; Software, Arash Kariminejad and Maksim Antonov; Validation, Arash Kariminejad, Maksim Antonov and Irina Hussainova; Formal analysis, Arash Kariminejad, Maksim Antonov and Irina Hussainova; Investigation, Arash Kariminejad; Resources, Arash Kariminejad and Maksim Antonov; Data curation, Arash Kariminejad; Writing - original draft, Arash Kariminejad; Writing - review and editing, Arash Kariminejad, Maksim Antonov and Irina Hussainova; Visualization, Arash Kariminejad; Supervision, Maksim Antonov and Irina Hussainova; Project administration, Maksim Antonov and Irina Hussainova; Funding acquisition, Irina Hussainova;



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Sciforum-210265: Wear analysis of chromium based thermal spray protective coatings and hard facing on zero tillage blade material in simulated conditions

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The study experimentally investigated the effect of wear-resistant coatings as well as hardfacing by manual metal arc welding MMAW on EN-19 alloy steel which is used in the manufacture of superseder blades, also termed as zero tillage blades. After an extensive literature review, Cr2O3 based thermal coating and hardfacing were selected for deposition of a wear resistant layer over the surface of EN-19 alloy steel with the application of rodo jet gun spray technique and MMAW process. Experimentation was conducted on test samples using variable sliding velocities as well as load conditions with combinations carved out with the help of Taguchi's L9 array. After experimentation on Pin on Disk tribometer, samples were analysed using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). Uncoated, coated as well as hard faced samples were subjected to different sliding time intervals (5, 5, 10, 10, 15, 15, and 30 minutes) under sliding speeds (0.5, 1, and 2 m/s) at a different load value of 30, 40 and 50 N. Wear rate in terms of cumulative weight loss was also evaluated for all the test samples. The results were corelated with the help of SEM micrographs of the worn surfaces. It was observed that the samples coated by rodjet spray technique exhibited significantly less weight loss as compared to hardfaced and bare sample pins. Hence, the wear resistance of Cr_2O_3 based thermal coating was found to be better than the hard facing coating on substrate made up of EN-19 alloy steel and it was concluded that a new advanced technology named as the rodo-jet thermal spray process proved out to be a good and reliable technique for minimizing wear of tillage tool material.

Author contributions: Formal analysis, Manjot Singh Bedi; Supervision, Roshan Lal Virdi and Jasmaninder Singh Grewal;



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Sciforum-210489: Improving the Wear Resistance and Tribological Properties of Titanium and Aluminum-Based Alloys by Non-Destructive Electron Beam Processing

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The current research examines the influence of electron beam processing (EBP) parameters on the microstructure, physical, mechanical, and tribological properties of the surface layers of promising structural materials: titanium alloys (VT-1, VT-6) and an aluminum-matrix composite material (AlMg3 + 5 wt.% SiC). Titanium alloy specimens were manufactured by machining on CNC lathes. Composite specimens were produced using liquid-phase technology by mechanically mixing reinforcing particles into the matrix melt. Surface modification was performed in a wide range of modes: for titanium alloys, a submillisecond modulated electron beam was used on a SOLO setup with a temperature stabilized at 1400 °C, while for composite material samples, the linear energy ranged from 120–240 J/mm. It was experimentally established that the high-speed thermal cycle of EBP leads to a fundamental restructuring of the materials. Specifically, in VT-1 and VT-6 titanium alloy samples, a nanostructure consisting of acicular α-platelets formed, along with reduced initial surface roughness. In composite material samples, a 5–10-fold refinement of the matrix grains was observed with a uniform distribution of strengthening SiC particles. These structural changes significantly improved the performance of the treated samples. Titanium alloys demonstrated significant improvements in wear resistance and hydrophilicity (reduced contact angle), which is critical for their biomedical applications as implants. The surface hardness of composite materials after treatment increased by 11 %, wear decreased by 17.5 %, and the coefficient of friction and its root mean square deviation (RMSE) decreased by 32 % and 50 %, respectively (at a load of 2.5 MPa). Thus, electron beam machining is a versatile and highly effective method for forming precise, uniform, and wear-resistant surface layers on both homogeneous metal alloys and heterogeneous composite materials.

Author contributions: Conceptualization, Simon TUNG and Mikheev S. Roman; Methodology, Mikheev S. Roman; Resources, Simon TUNG; Writing - original draft, Mikheev S. Roman; Writing - review and editing, Simon TUNG;



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Sciforum-210584: Friction of composites based on antifriction Babbitt reinforced with TiNi particles

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Friction-induced vibrations affect the performance and service life of mechanical systems and contribute to noise generation. One way to address this issue is to develop anti-friction composite materials with the required tribological properties. This study investigated the effect of TiNi reinforcing particles on the tribological properties of Babbitt-based (SnSb11Cu6) composite materials during friction against a steel counterbody. Babbitt powder (400–500 μm) served as the matrix, while TiNi powder (<100 μm)—produced via the calcium hydride process—served as the reinforcement. This type of reinforcement was chosen for its high wear and corrosion resistance, superelasticity, and high loss tangent, which ensure vibration-damping properties. Composite materials containing 3 wt.% TiNi particles were fabricated using powder metallurgy. Tribological tests on the specimens were conducted under dry sliding friction conditions in an axial loading configuration, with a pin made of the material under investigation sliding against a rotating steel disk. Tests were performed with stepwise axial loading (1, 2, 3, 4, and 5 MPa) at a sliding speed of 0.5 m/s for each load level. Each specimen underwent a sliding distance of 300 m under each axial load, resulting in a total sliding distance of 1500 m. Studies have shown that reinforcing the antifriction matrix with 3 wt.% TiNi particles allows the friction coefficient to remain virtually unchanged while increasing wear resistance by 14.5%. The reduction in vibration and stabilisation of the friction process, attributed to the damping properties of TiNi, are particularly evident in the friction coefficient distribution density maps for the composite specimens at a load of 3 MPa. These results support the recommendation to use TiNi particles in the production of composite materials to enhance the performance of tribological assemblies, reduce vibration, and improve the stability of the friction process.

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Author contributions: Conceptualization, Igor Kalashnikov and Mikheev Roman; Methodology, Pavel Bykov, Igor Kalashnikov and Mikheev Roman; Software, Pavel Bykov, Ruslan Fedortsov and Dmitry Chernenok; Validation, Pavel Bykov, Ruslan Fedortsov and Dmitry Chernenok; Formal analysis, Ruslan Fedortsov; Investigation, Pavel Bykov, Ruslan Fedortsov and Mikheev Roman; Resources, Pavel Bykov and Dmitry Chernenok; Data curation, Dmitry Chernenok; Writing - original draft, Pavel Bykov, Igor Kalashnikov and Mikheev Roman; Writing - review and editing, Igor Kalashnikov and Mikheev Roman; Visualization, Igor Kalashnikov; Supervision, Igor Kalashnikov; Project administration, Igor Kalashnikov; Funding acquisition, Igor Kalashnikov;



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Sciforum-210652: Design and Performance Evaluation of Tungsten Carbide–Cobalt (WC–Co) Wear-Resistant Surfaces for Next-Generation Mechanical Components

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Progressive surface degradation leads to increased friction, surface loss, energy consumption, and early failure in mechanical components subjected to repeated contact, abrasive and sliding situations. In many tribological situations, conventional metallic surfaces may not be able to provide enough wear resistance, and the interactions of coating composition and tribological parameters are insufficiently studied. The purpose of this study is to design, optimise and evaluate the characteristics of tungsten carbide–cobalt (WC–Co) wear resistant surfaces on the next-generation mechanical components, in order to recognise the optimal coating composition, its thickness and the possibility of adjusting the tribological operating conditions. Coatings with 10-20 wt.% Co content and 80-90 wt. % WC were investigated on alloy-steel substrates for coating thicknesses of 150 – 300 μm. The tribological behaviour was evaluated under a range of loads of 20–60 N, speeds of 0.2–0.8 m/s and distances of 3000 m. The weightages $\alpha = 0.35$, $\beta = 0.40$, and $\gamma = 0.25$ were used for friction, wear, and hardness respectively using the multi-objective response surface optimisation. The optimised condition consisting of 88 wt. % WC, 12 wt. % Co with a thickness of 250 μm gave a result of 1320 HV, with its coefficient of friction being reduced from 0.58 to 0.34 and the specific wear rate decreased from 7.4×10^{-7} to 2.5×10^{-7} $mm^3/N{\cdot}m$. The surface roughness reduced from 1.85 μm to 0.92 μm and the predictive model's R^2 value was 0.94. The findings indicate that the optimised WC–Co surfaces can significantly improve the hardness, frictional behavior and wear resistance suggesting a plausible path for improving the service life of high contact mechanical components under challenging operating conditions.

Author contributions: Conceptualization, Helal Uddin; Methodology, Helal Uddin; Software, Helal Uddin; Validation, Helal Uddin; Formal analysis, Helal Uddin and MD. Sabbir Hossain; Investigation, Helal Uddin; Resources, MD. Sabbir Hossain and Md. Alamgir Hossain; Data curation, Helal Uddin and Md. Alamgir Hossain; Writing - original draft, Helal Uddin and MD. Sabbir Hossain; Writing - review and editing, Helal Uddin and Md. Alamgir Hossain; Visualization, Helal Uddin; Supervision, Md. Alamgir Hossain; Project administration, Helal Uddin, MD. Sabbir Hossain and Md. Alamgir Hossain; Funding acquisition, MD. Sabbir Hossain and Md. Alamgir Hossain;



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Sciforum-212584: Tribological Behavior of Micronized Carbon Fiber-Reinforced PP/PA6 Composites under Dry Sliding Conditions

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The tribological performance of polymer-based composites is governed not only by the characteristics of the matrix but also by the properties of the reinforcing phase and the imposed contact conditions. In this study, the friction and wear behavior of PP/PA6 blend composites containing micronized carbon fiber was experimentally investigated under dry sliding conditions. Composite specimens with different material configurations were produced and tested using a pin-on-disc system under various normal loads and sliding speeds. All experiments were performed under dry contact conditions over a constant sliding distance of 1000 m. The evolution of the coefficient of friction with sliding distance was continuously recorded throughout the tests, and the resulting tribological responses were comparatively examined with respect to the applied operating conditions. After testing, the wear tracks formed on the disc surfaces were characterized by optical microscopy, and the observed surface features were evaluated in relation to the measured friction behavior. This experimental approach enables the tribological response of micronized carbon fiber-reinforced PP/PA6 composites under varying contact and sliding conditions to be assessed without limiting the analysis to a single operating parameter. The study therefore provides a basis for understanding the role of micronized carbon fiber reinforcement in the friction and wear processes of PP/PA6-based thermoplastic blend composites and for evaluating their behavior under dry-sliding conditions.

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Author contributions: Conceptualization, Salih Hakan Yetgin; Methodology, Lars Ulke-Winter, Salih Hakan Yetgin and Yusuf Kepir; Validation, Lars Ulke-Winter and Salih Hakan Yetgin; Formal analysis, Lars Ulke-Winter and Yusuf Kepir; Investigation, Lars Ulke-Winter, Salih Hakan Yetgin and Yusuf Kepir; Resources, Lars Ulke-Winter, Salih Hakan Yetgin, Holger Seidlitz and Yusuf Kepir; Data curation, Lars Ulke-Winter, Salih Hakan Yetgin and Yusuf Kepir; Writing - original draft, Lars Ulke-Winter and Yusuf Kepir; Writing - review and editing, Lars Ulke-Winter, Salih Hakan Yetgin, Holger Seidlitz and Yusuf Kepir; Visualization, Lars Ulke-Winter and Yusuf Kepir; Supervision, Salih Hakan Yetgin; Project administration, Salih Hakan Yetgin; Funding acquisition, Lars Ulke-Winter, Salih Hakan Yetgin and Holger Seidlitz;



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Sciforum-212650: Tribological Behavior of Micronized Glass Fiber-Reinforced PP/PA6 Composites

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This study experimentally investigates the tribological behavior of polypropylene/polyamide 6 (PP/PA6) blend composites reinforced with micronized glass fiber under dry sliding conditions. Different composite configurations were prepared to evaluate the influence of micronized glass fiber reinforcement on the friction and wear characteristics of the PP/PA6-based material system. The tribological performance of the produced specimens was examined using a pin-on-disc test configuration under different normal loads and sliding speeds. All tests were conducted under dry contact conditions over a constant sliding distance of 1000 m. During testing, the variation in the coefficient of friction as a function of sliding distance was continuously monitored, and the resulting frictional responses were comparatively evaluated for the applied operating conditions. Following the tribological tests, the wear tracks formed on the counterface surfaces were examined by optical microscopy, and the observed surface features were considered together with the friction behavior. In this way, the study focuses on identifying the tribological response of micronized glass fiber-reinforced PP/PA6 composites under varying contact conditions and assessing the role of the reinforcement in the development of friction and wear behavior. The findings provide an experimental basis for understanding the dry-sliding performance of thermoplastic blend composites containing micronized glass fiber and for comparing their tribological response under different operating conditions.

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Author contributions: Conceptualization, Yusuf Kepir and Salih Hakan Yetgin; Methodology, Yusuf Kepir and Salih Hakan Yetgin; Validation, Salih Hakan Yetgin; Formal analysis, Yusuf Kepir; Investigation, Yusuf Kepir and Salih Hakan Yetgin; Resources, Yusuf Kepir, Lars Ulke-Winter, Holger Seidlitz and Salih Hakan Yetgin; Data curation, Yusuf Kepir and Salih Hakan Yetgin; Writing - original draft, Yusuf Kepir; Writing - review and editing, Yusuf Kepir, Lars Ulke-Winter, Holger Seidlitz and Salih Hakan Yetgin; Visualization, Yusuf Kepir; Supervision, Salih Hakan Yetgin; Project administration, Salih Hakan Yetgin; Funding acquisition, Lars Ulke-Winter, Holger Seidlitz and Salih Hakan Yetgin;



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Session 5. Emerging Trends in Tribology

Sciforum-177552: Performance Evaluation of Elliptical Journal Bearing Using ANN with Micropolar Lubricants

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This analysis presents an artificial neural network (ANN)-based framework for predicting the steady-state performance characteristics of journal bearings lubricated with micropolar fluids, with validation against conventional numerical methods. Initially, the Reynolds equation governing micropolar lubrication is solved using the Finite Difference Method (FDM). The caviatation (i.e. Swift–Stieber) boundary condition is applied to obtain pressure distributions, enabling accurate evaluation of steady-state performance characteristics under varying operating conditions, including eccentricity ratio (ε), characteristic length of micropolar fluid (l_m), and coupling number (N^2).

The numerical results generated through FDM are subsequently utilized to develop ANN models based on a dataset comprising more than 1560 input–output pairs. Three feed-forward ANN architectures—Levenberg–Marquardt, Bayesian regularization, and Scaled Conjugate Gradient—are implemented, and their predictive capabilities are systematically evaluated through comparison with FDM results.

The findings demonstrate that ANN models achieve substantial reductions in computational time and effort while maintaining high prediction accuracy. The maximum deviation between ANN predictions and FDM results is within 5%, indicating strong agreement and reliability. Furthermore, the trained ANN models exhibit robust generalization capability across the considered parameter range. Overall, the proposed ANN framework offers an efficient and accurate alternative for performance prediction and facilitates rapid analysis and design optimization of micropolar-lubricated journal bearing systems.



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Sciforum-184530: Physics-Informed Neural Network Framework for Predicting Friction and Wear Evolution in Lubricated Tribological Contacts under Variable Operating Conditions

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Reliable prediction of friction and wear in lubricated sliding contacts is essential for improving the durability and efficiency of mechanical systems. This study develops a coupled Physics-Informed Neural Network (PINN) framework for predicting friction coefficient and wear evolution in an AISI 52100 bearing-steel tribopair lubricated with polyalphaolefin (PAO) oil under variable operating conditions. The computational investigation considers contact pressures of 0.5–1.5 GPa, sliding velocities of 0.05–1.0 m/s, PAO lubricant viscosities of 20–100 mPa·s, surface roughness values of 0.05–0.50 μm, and material hardness values of 600–800 HV. The proposed framework treats friction and wear as coupled tribological responses rather than independent prediction tasks. Hertzian contact mechanics, Archard's wear law, and lubricant film-thickness relationships are incorporated into the PINN training objective to impose physically meaningful constraints on the predicted response. The model is trained and evaluated across systematically varied combinations of contact pressure, sliding velocity, lubricant viscosity, surface roughness, and hardness, with particular emphasis on generalization to operating conditions that are sparsely represented in the training data. A sensitivity analysis is performed to quantify the relative contribution of the investigated parameters to frictional response and wear progression and to identify conditions associated with increased wear and deterioration of lubrication performance. The physics-informed formulation is designed to improve physical consistency and reduce dependence on large datasets compared with purely data-driven approaches. By integrating contact mechanics, lubricant-film behaviour, and wear evolution within a unified learning framework, the proposed methodology provides an interpretable computational approach for coupled friction–wear prediction. The framework offers potential applications in lubricant selection, wear-rate estimation, tribological condition assessment, and reliability-oriented maintenance of lubricated mechanical systems.



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Sciforum-205583: ML-Metaheuristic Framework for Texture Optimization in Hybrid Thrust Bearings

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Hydrostatic thrust bearings are essential machine elements for supporting heavy axial loads in a wide range of industrial applications. This study investigates a surface texturing approach to improve the tribological behaviour of these bearings, with the aim of reducing friction-induced power losses of the hybrid thrust bearing. The governing Reynolds equation for the hybrid thrust bearing configuration is solved numerically using the Finite Element Method (FEM), enabling accurate modelling of the pressure distribution across the pad surface. Surface texturing is introduced on the thrust pad in the form of micro-radial grooves, a pattern chosen for its potential to modify lubricant flow behaviour and enhance film formation. Since textured surfaces are prone to cavitation, a mass-conservation-based algorithm is integrated into the numerical framework to accurately capture rupture and reformation of the lubricant film within the grooved regions. Comparative simulations show that the textured thrust pad, combined with the hydrodynamic lubricant film, yields a marked reduction in friction power loss relative to a conventional, non-textured bearing design. To extend this analysis and identify optimal texturing configurations, a decision tree-based machine learning model is applied to predict key performance parameters. The findings confirm that machine learning-assisted optimization enhances the overall tribological performance of hydrostatic thrust bearings, establishing a data-driven, computationally efficient framework for the design of surface-textured bearing systems.



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Sciforum-206205: Emergent Temperature Dependence of Friction from Quantum Many-Body Theory

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Friction is a nonequilibrium many-body dissipation process in which interfacial sliding excites collective lattice vibrations, with phonons representing the corresponding quantum excitations. Building on our previous phononic framework for friction-induced phenomena, including nonmonotonic velocity dependence, anisotropic friction, and the phononic Doppler effect, this work focuses on the microscopic origin of temperature-dependent friction. We develop a quantum many-body formulation based on nonequilibrium Green's functions and Feynman-diagram perturbation theory, in which frictional energy dissipation is resolved into harmonicity-induced phonon radiation and anharmonicity-induced phonon scattering through their corresponding self-energies. The theory reveals that phonon radiation dominates at cryogenic temperatures and produces finite friction even in the low-temperature limit. As temperature increases, anharmonic phonon scattering becomes progressively stronger and eventually overtakes radiation as the primary dissipation channel. At higher temperatures, scattering-enhanced damping suppresses the population of phonons excited by sliding, thereby reducing the total dissipated energy and producing a nonmonotonic friction-temperature relation. Molecular dynamics simulations of the friction system consisting of a silicon block sliding over another silicon substrate reproduce the predicted trend and confirm the simultaneous enhancement of phonon scattering and suppression of friction-excited phonons. By varying the anharmonic interaction strength, the framework further unifies the nearly constant, increasing, nonmonotonic, and decreasing temperature dependences reported for different materials. These results demonstrate that temperature-dependent friction emerges naturally from the competition among phonon radiation, phonon scattering, and the suppression of phonon excitation, establishing a quantum many-body route toward predictive modeling of frictional energy dissipation.



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Sciforum-207243: Development of Waste-Derived Carbon Functional Fluids for thermal management and tribological performance in electrified mobility

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The growing adoption of electrified mobility is increasing the demand for efficient battery thermal management systems (BTMS), since lithium-ion batteries are highly sensitive to temperature and require effective thermal regulation to ensure performance, durability and safety. Maintaining an optimal operating temperature is essential to avoid accelerated degradation and safety issues. Consequently, increasing attention is being devoted to the development of advanced multifunctional fluids that combine thermal-management and tribological functions, enabling improved heat dissipation, friction and wear mitigation. At the same time, circular economy strategies promote the valorization of biomass waste and municipal solid waste (MSW) as feedstocks for high-value materials [2-3]. Recent studies have also shown that the incorporation of nanomaterials into base oils is an effective approach to improve heat-transfer performance, reduce friction and wear, although achieving long-term stability remains a significant challenge.

SENCHAR project investigates the transformation of biomass waste and MSW into modified carbons through thermal and microwave-assisted pyrolysis, followed by activation and functionalization processes. The resulting carbons are incorporated into water-based (glycol/water mixtures) and oil-based (bio-based ester) functional fluids. The influence of carbon characteristics, including particle size, porosity and surface chemistry, is evaluated through their effect on key fluid properties, including thermal conductivity, viscosity, electrical conductivity, dispersion stability and tribological performance (wettability, friction and wear).

Preliminary results indicate that the effectiveness of carbon-enhanced fluids depends more on surface engineering than on carbon loading. Based on these observations, the project shows functionalization strategies that improve dispersion stability, thermal and tribological performance, highlighting the potential of carbons as multifunctional tribological additives.

In conclusion, SENCHAR demonstrates the conversion of biomass and MSW into high-value carbon materials for thermal and tribological applications. By linking waste valorization with the development of next-generation functional fluids, the project contributes to circular-economy strategies and supports the demand for sustainable technologies in electrified mobility.



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Sciforum-207443: Hybrid Spectral Graph Attention Learning for Intelligent Rolling-Bearing Fault Diagnosis Using Vibration Signals

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Rolling-bearing defects alter contact dynamics and generate characteristic changes in vibration responses, making vibration analysis an effective tool for condition monitoring and fault diagnosis. However, conventional machine-learning and deep-learning approaches generally process vibration signals as regular vectors or sequences and therefore do not explicitly model the relationships among fault-sensitive spectral components. This study proposes a hybrid spectral graph-attention framework for intelligent rolling-bearing fault diagnosis. Vibration recordings from the Case Western Reserve University (CWRU) Bearing Data Center and the HUST bearing dataset were harmonized into four common classes: healthy, inner-race fault, outer-race fault, and rolling-element fault. HUST signals were resampled from 51.2 to 48 kHz, while all signals were segmented into 4096-sample windows with 50% overlap and standardized at the window level. Each window was converted into a 16-node spectral graph, in which nodes represented frequency bands and edges connected first- and second-order neighboring bands. Eleven time- and frequency-domain descriptors were assigned to each node. A GATv2 encoder was evaluated in an end-to-end configuration with a multilayer perceptron classifier and as a graph-feature extractor coupled with support vector machine, random forest, and logistic regression classifiers. A leakage-aware temporal split was applied to CWRU, whereas HUST was evaluated using independent recording-level splits. The GATv2–logistic regression model achieved the best performance on both datasets. On CWRU, it obtained 98.12% accuracy and 98.43% Macro-F1, compared with 95.31% accuracy and 96.10% Macro-F1 for end-to-end GATv2. On HUST, it achieved 92.97% accuracy and 92.92% Macro-F1, outperforming the end-to-end model, which obtained 91.87% accuracy and 91.83% Macro-F1. These results show that spectral graph attention effectively captures discriminative relationships among vibration-frequency regions and that coupling GATv2 embeddings with logistic regression provides a consistent framework for intelligent bearing condition monitoring across heterogeneous datasets.

Author contributions: Conceptualization, Said . AMGHAR; Methodology, Said . AMGHAR, Abdellah Azmani and Benaissa AMAMI; Software, Said . AMGHAR; Validation, Said . AMGHAR and Benaissa AMAMI; Formal analysis, Said . AMGHAR; Resources, Said . AMGHAR, Kamal REKLAOUI and Benaissa AMAMI; Data curation, Said . AMGHAR; Writing - review and editing, Said . AMGHAR; Visualization, Said . AMGHAR; Supervision, Said . AMGHAR, Abdellah Azmani, Kamal REKLAOUI and Benaissa AMAMI; Project administration, Said . AMGHAR, Abdellah Azmani and Kamal REKLAOUI;



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Sciforum-207487: Computational Fluid Dynamics Investigation of Hydrodynamic Journal Bearing Performance Using TiO_2-Based Nanolubricants

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Hydrodynamic journal bearings are commonly used in high-speed rotating machines because they can support heavy loads, create low friction, and long service life. However, the performance of regular lubricants declines under tough operating conditions due to excessive heat and friction. This study looks at how well a hydrodynamic journal bearing works with SAE 20W40 engine oil that includes titanium dioxide (TiO_2) nanoparticles, using Computational Fluid Dynamics (CFD). A three-dimensional lubricant film model is created in ANSYS Fluent. In this model, the lubricant flow is steady, incompressible, and laminar. The effective thermo-physical properties of the nanolubricant are calculated using standard mixture models. The study evaluates how the concentration of nanoparticles and the journal's rotational speed affect hydrodynamic performance by analyzing pressure distribution, load-carrying capacity, temperature, frictional force, and lubricant flow characteristics. The CFD results show that adding TiO_2 nanoparticles improves the thermal conductivity and pressure generation of the lubricant. This leads to a higher load-carrying capacity and better heat dissipation compared to the base lubricant. Even though a small increase in viscosity causes a slight rise in frictional force, the overall performance of the bearing improves significantly due to better lubrication stability and thermal properties. The study concludes that TiO_2-based nanolubricants present a promising way to enhance the efficiency, reliability, and lifespan of hydrodynamic journal bearings in automotive and industrial rotating machinery.



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Sciforum-207502: Advancements in ultrasonic methods for in-situ lubricant monitoring.

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Monitoring lubricant condition, and thus machine health, has been a major focus of interest for several decades. Although various in-situ measurement techniques are available, including electrical capacitance, optical methods, acceleration measurements and acoustic emission, active ultrasonic techniques offer an unparalleled combination of diagnostic insight, non-destructive operation and non-invasive applicability. By actively transmitting an ultrasonic pulse, film thickness and viscosity can be measured in test rigs as well as in real machinery with only minimal modifications.

This presentation highlights recent advances achieved in ultrasonic technology in three areas: 1) tribological testing – the Triboacoustic Pin, a novel active sensing element integrated into tribological specimens was developed and validated against optical interferometry film-thickness measurements and Elastohydrodynamic theory; results from tribological tests with induced contamination during the experiment will also be presented. 2) bearing lubricant health assessment – film-thickness measurements in bearings combined with a sensor-data-driven digital twin model to predict bearing condition, including algorithmic advances beyond the current state of the art. 3) viscosity measurement – non-invasive ultrasonic measurement of lubricant viscosity at ambient pressure, at high pressures of up to 4000 bar, and during liquid phase changes while drying.

Together, these achievements demonstrate the potential of ultrasonic methods for condition monitoring, tribological testing, and lubricant development and design in a non-invasive manner.

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Sciforum-207518: Smart biolubricants derived from waste cooking oils: electrorheological and tribological response of cellulose nanofibril dispersions

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This work investigates the formulation and performance of smart biolubricants developed by dispersing cellulose nanofibrils (CNF) in waste cooking oils (WCO) of diverse origins: mixed origin (WM-WCO), common restaurant (CR-WCO), traditional fryery (FR-WCO), and fast-food restaurant (FF-WCO). Steady-state viscous flow tests were conducted at 25 °C under external electric fields up to 4 kV/mm to evaluate the electrorheological (ER) activity of 2 wt.% CNF dispersions.

Without an electric field, all formulations exhibited Newtonian behaviour. Upon application of an electric field, the dispersions acquired a highly pseudoplastic character. The ER effect was significantly more pronounced in biolubricants formulated with FF-WCO and FR-WCO, particularly at shear rates <10 s^{-1} and electric field strengths between 0.8 and 2.4 kV/mm. This superior performance is primarily attributed to the higher free fatty acid (FFA) content in these specific base oils, which enhances the ER structure-forming capacity. To further isolate the role of oil fractions, molecular distillation was utilized to separate FR-WCO and FF-WCO into heavy (residue, R) and light (distillate, D) fractions. Formulations based on the light fraction demonstrated a weaker ER effect at fields below 1.6 kV/mm while they surpassed both the crude oil and the heavy fraction at fields of 2.4 kV/mm and above. Additionally, FR-D formulation withstood electric fields up to 4 kV/mm without electrical breakdown.

Furthermore, tribological response was assessed under fully flooded conditions in axial bearings (5 N, 500 rpm) using 3.3 wt.% CNF dispersions in WM-WCO. Application of voltage (500 and 1000 V) induced instantaneous and reversible increases in the coefficient of friction (COF) proportional to the field strength, allowing for on-demand electro-active control of the COF. Under 1000 V, CNF dispersions achieved an extraordinary COF increment of 80.9%. These findings highlight the exceptional potential of CNF-based waste cooking oil formulations as tunable, highly responsive smart biolubricants.

Author contributions: Conceptualization, Claudia Roman, Moises Garcia-Morales and Miguel Ángel Delgado Canto; Methodology, Claudia Roman, Moises Garcia-Morales and Miguel Ángel Delgado Canto; Validation, María García-Pérez, Claudia Roman, Moises Garcia-Morales and Miguel Ángel Delgado Canto; Formal analysis, Miguel Ángel Delgado Canto; Investigation, Samuel David Fernández-Silva and María García-Pérez; Resources, Claudia Roman; Data curation, Samuel David Fernández-Silva and María García-Pérez; Writing - original draft, Samuel David Fernández-Silva; Writing - review and editing, María García-Pérez, Claudia Roman, Moises Garcia-Morales and Miguel Ángel Delgado Canto; Visualization, Miguel Ángel Delgado Canto; Supervision, Moises Garcia-Morales and Miguel Ángel Delgado Canto; Project administration, Moises Garcia-Morales and Miguel Ángel Delgado Canto; Funding acquisition, Moises Garcia-Morales and Miguel Ángel Delgado Canto;



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Sciforum-207831: Mechanistic Origins of Wet Adhesion in Mushroom-Shaped Microstructures: A Theoretical Study Interfacial Dynamics

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Bio-inspired adhesives that rely on mushroom-shaped microstructures exhibit remarkable wet holding forces [1], yet the physical origin of their performance remains incompletely understood, particularly under dynamic loading. Here we develop a theoretical framework that couples elasticity, capillarity, and viscous dissipation to describe the complete adhesion cycle of a single mushroom-shaped element interacting with a rigid substrate through an intervening liquid meniscus. The mushroom cap is modelled analytically as a thin Kirchhoff plate [2], yielding closed-form expressions for its deformation and for the meniscus evolution. Viscous contributions are captured through the Reynolds equation for thin-film flow, which governs the pressure distribution within the lubricating fluid layer as the gap evolves over time [3]. A key feature of the analysis is the identification of three distinct mechanical scenarios, each corresponding to a specific set of boundary conditions at the cap–substrate contact line. These scenarios collectively capture the full range of possible interfacial configurations, enabling a complete and accurate description of all phases of dynamic attachment and detachment: from initial meniscus bridging and contact growth during compression, to necking, cavitation, and final debonding during retraction. Our results identify three coexisting contributions: capillary pressure, viscous stresses, and suction-induced confinement. During compression, the meniscus shrinks and the contact area enlarges in a geometry dependent manner; during detachment, rate tunable viscosity can either amplify adhesion at high retraction speeds or promote release at low speeds. These findings offer a mechanistic explanation for the robustness and reversibility observed in biological wet adhesives.[1] A. E. Kovalev, M. Varenberg, S. N. Gorb, *Soft Matter*, **8**, 7560 (2012).[2] S. Timoshenko, S. Woinowsky-Krieger, *Theory of Plates and Shells*, McGraw-Hill, New York (1959).[3] B. J. Hamrock, S. R. Schmid, B. O. Jacobson, *Fundamentals of Fluid Film Lubrication*, Marcel Dekker, New York (2004).



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Sciforum-208752: Ion Adsorption and Hydration Superlubricity

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Friction and wear are accompanied by many aspects of production and life, from the micro- to the macroscale. Humans have been committed to reducing friction for thousands of years, saving energy and resources, protecting the environment, and improving service life. Aqueous lubricants play key roles in many mechanical, technical, medical, physiological, and biological applications, particularly over the past twenty years or so, their role in boundary lubrication has been widely studied. The role of hydrated ions in aqueous superlubricity has long been known. The structure of hydrated ion layers adsorbed on solid surfaces that determine the lubricating properties of aqueous lubricants is thought to be invariable in hydration lubrication. However, we prove that the ion surface coverage dictates the roughness of the hydration layer and its lubricating properties, especially under subnanometer confinement. In this study, we systematically evaluate the adsorption and lubrication properties of monovalent, divalent, and trivalent ions at microscale and macroscale conditions through using a surface force apparatus (SFA) and a universal mechanical tribometer (UMT), respectively. The hydration layer structure is characterized by an atomic force microscope (AFM), streaming current measurements and molecular dynamic (MD) simulations. Our results shed light on the origins of boundary superlubricity, with potential applications both for marine engineering and biolubrication.

Author contributions: Conceptualization, Tianyi Han; Methodology, Tianyi Han; Validation, Tianyi Han; Formal analysis, Tianyi Han; Investigation, Tianyi Han; Resources, Tianyi Han; Data curation, Tianyi Han; Writing - original draft, Tianyi Han; Writing - review and editing, Tianyi Han; Visualization, Tianyi Han; Supervision, Tianyi Han; Project administration, Tianyi Han; Funding acquisition, Tianyi Han;



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Sciforum-209350: Tribological Optimization of Self-Lubricating SiC/MoS_2 Hybrid Aluminium Matrix Composites via Laser Surface Texturing and Graphite Infiltration

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Introduction

Sliding-contact aluminium components frequently suffer premature failure due to high friction and wear, limiting their use in bearing, brake, and clutch applications. Hybrid metal matrix composites that combine structural reinforcement with intrinsic lubrication offer a promising route to overcome this limitation, yet the interplay between reinforcement composition and tribological response remains insufficiently quantified.

Methods

Aluminium matrix composites reinforced with silicon carbide (6–26 wt.%) and molybdenum disulfide (1.5–9.5 wt.%), with 1 wt.% magnesium as a wetting agent, were fabricated via two-step stir casting. Surfaces were subsequently laser-textured and graphite-infiltrated to promote lubricant retention. Tribological behaviour was assessed through pin-on-disc and dry sand abrasion tests across varying loads, supported by SEM analysis of worn surfaces; hardness and tensile testing characterized bulk mechanical response.

Results

MoS_2 addition up to 5.5 wt.% reduced the coefficient of friction from 0.68 to 0.38 and lowered wear rate by approximately 41%, with SEM revealing a transition toward more stable, lubrication-dominated sliding. SiC-rich compositions showed superior wear resistance under high contact loads via an abrasion-driven mechanism, while MoS_2-rich compositions performed best under moderate, friction-critical loads. Laser texturing combined with graphite infiltration improved lubricant entrapment and friction stability over extended cycles, without compromising strength: hardness and tensile strength reached 118 HV and 196 MPa at 21 wt.% SiC.

Conclusions

SiC and MoS_2 can be co-engineered within a single hybrid composite to deliver load-adaptive tribological performance alongside structural integrity, offering a design framework for self-lubricating components in aerospace and automotive sliding-contact systems.

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Sciforum-210372: Towards Electrically Assisted Lubrication Through Surface Engineering

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Electrically assisted lubrication is attracting increasing interest as a route towards adaptive tribological systems. However, establishing effective electric-field-assisted operation in lubricated metallic contacts remains challenging due to current flow between contacting surfaces. In this work, anodized aluminium was investigated as a means of modifying the electrical behaviour of lubricated tribological interfaces.

Several anodizing conditions were explored in order to generate surfaces with different characteristics while retaining the wear-protection capabilities typically associated with anodized aluminium. The resulting surfaces were subsequently evaluated under lubricated sliding conditions. Experiments were performed in a Physica MCR 302e rheometer using a ball-on-three-plate configuration, with the anodized aluminium samples acting as the plates and a stainless-steel bearing ball as the counterpart. The sliding tests were carried out using a model electro-responsive biolubricant under different applied potentials. The results revealed measurable changes in friction and wear behaviour in the presence of external electrical inputs, demonstrating that anodized aluminium surfaces can support electrically assisted operation under lubricated contact conditions. The observed electro-tribological response was influenced not only by the applied potential but also by the characteristics of the anodized surfaces, showing that the magnitude of the electrically induced effects depends strongly on surface engineering.

Overall, the findings support the feasibility of combining anodized aluminium surfaces with electro-responsive lubrication strategies to promote adaptive tribological behaviour. This approach may contribute to the development of next-generation lubricated systems in which friction and wear performance can be influenced through externally applied electrical potentials.

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Sciforum-213261: New trends in wear assessment of biomechanical components: challenges and achievements

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Introduction

Wear strongly affects the long-term performance of biomedical components, as material loss may lead to biological reactions and instability. Recently, 3D optical methods have provided new opportunities for evaluating wear. Nevertheless, the reliability of the results depends on the 3D scanning system, the reference geometry estimation and alignment strategy. This study investigates these aspects to improve the reliability of 3D wear evaluations.

Methods

Total hip and knee replacements (THR, TKR), including retrieved liners and laboratory-tested components, are analyzed to compare different approaches for 3D wear evaluation. The influence of digitizing systems, reference geometry and surface registration on the wear maps is investigated, through experimental campaigns. Different reference geometries are considered, including reconstructed ideal surfaces, scans of unworn components and nominal CAD models. For each case, suitable procedures are evaluated. The comparison highlights how different combinations of acquisition, reference and alignment methods can affect wear results and supports the definition of appropriate protocols.

Results

Based on the findings, specific wear assessment protocols are proposed for different categories of case studies. The protocols provide guidance on the most suitable 3D scanning techniques for different biocomponents (laser or structured-light scanning, frames number, fixed or moving scene, and use of targets or artefacts), as well as on the selection or reconstruction of the reference geometry and the alignment procedure (best-fit algorithms or specific geometrical features).

Conclusions

The proposed protocols support the selection of the most appropriate approach according to the characteristics and available data of each case study. For example, for retrieved total hip replacements, desktop laser or structured-light scanners with markers or reference artefacts are recommended. Alignment should preferably rely on measured unworn surfaces, while the reference geometry may be obtained from a pre-implantation scan, when available, or reconstructed from the nominal geometry of the retrieved component.

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