Synopsis

Electrified Tribology, a Critical and Evolving Area of our Industry

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Prof Amir Kadiric is a Professor of Tribology and Surface Mechanics in the Department of Mechanical Engineering at Imperial College London and a member of the Tribology Group. He also leads the SKF University Technology Centre for Tribology at Imperial College and chairs the executive committee of the Vehicle Futures Hub at Imperial. He obtained his first degree in Mechanical Engineering, followed by a PhD in Tribology in 2004 from Imperial College. He subsequently worked in SKF's R&D centre in the Netherlands, before returning to Imperial to take up a permanent academic staff position. He teaches Tribology and Mechanical Transmissions undergraduate courses at Imperial. His research interests include surface damage mechanisms, efficiency and reliability of EV transmissions, and contact mechanics.

Effect of Electric Potentials on Surface Damage in Lubricated Rolling-Sliding Contacts

Tribological components in engineering applications that employ electric machines, such as electric vehicles, are frequently subjected to unexpected electric potentials. Under full film lubrication, the damage caused by such potentials is relatively well-documented and understood. However, the impact of such voltages on the performance of rolling-sliding contacts under mixed lubrication conditions appears more complex and is poorly understood. This talk will explore some recent research conducted at Imperial across multiple projects aimed to better understand the effect of electric potentials on surface damage mechanisms in lubricated rolling-sliding contacts under mixed lubrication. The work primarily employs a ball-on-disc tribometer (MTM), which was suitably modified to apply controlled DC and AC voltages across the lubricated contact under set contact pressures, slide-roll ratios and film thicknesses. Ball and disc specimens were made of AISI 52100 bearing steel. Results are presented to investigate the effect of lubricant formulation, including both commercial ATFs and e-fluids and custom-made oils designed to isolate the effect of a single additive. The influence of voltage magnitude and the differences and similarities observed under the DC vs AC voltages are also explored. The results show that even relatively small potentials can significantly alter wear and tribofilm behaviour of the contact, but that the exact effect is strongly dependent on the lubricant chemistry. Findings are discussed in terms of a complex interaction between tribofilm growth, electric response of the contact and observed wear mechanisms.

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Norbert Bader studied mechanical engineering at Leibniz University Hannover. He obtained his PhD in the topic of Lubricant Rheology and Thermal effects in highly loaded Elastohydrodynamic Contacts (EHL). During his work at University Hannover he participated in several projects dealing with electrical effects in contacts, electrical measurement techniques in lubricated contacts, failure of lubricated contacts, lubrication mechanisms, grease influence on rolling element bearing behaviour and life, and failure mechanisms of rolling element bearings. Subsequently he joined the Surface Technology and Tribology (STT) group at the University of Twente. Here he focuses on research related to lubricated contacts, grease behaviour and modelling, friction in lubricated contacts, degradation of lubricated interfaces, electrical phenomena in lubricated systems.

Electric behaviour of lubricated contacts, challenges and chances

The strive for more efficient and compact systems has led to an increasing usage of electrical drives and systems, e.g., electric vehicles, automation, robotics. Furthermore, modern power electronics enable higher switching frequencies and higher voltages, increasing efficiency and raising mechanical dynamics. This leads to new and higher electrical loads on lubricated contacts, which are numerously present in such systems.
One of the most important components in these system is the lubricant, which directly may influence the insulation, electrical resistance, energy passage, and damage occurring in electrically loaded contacts.

In this talk we give an overview of current state of the art of electrical damages in the contacts (on the micro level) and the interaction of the micro and macro level system properties. Furthermore, we detail the factors that degrade the lubricant electrically and show which parameters (e.g., permittivity) that affect the lubricant-electric field interaction and thus contact behaviour.
We further detail the possibilities of using or monitoring electrical signals to gain information on film behaviour, bearing health, and lubrication state.

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Francesc (Cesc) Alomar joined Lubrizol in 2000 as Account Manager for MW customers around Europe and Middle East. In 2006 he was given responsibilities in selling and promotion of all Lubrizol Additives portfolio to his accounts, including all industrial additives plus engine oils, driveline, etc. In 2012 he was given responsibilities as Product Manager of Grease additives in Zone 2 (Europe, Africa, CIS and Middle East). Cesc holds a BSc in Chemistry (specializing in Materials Science) for the Barcelona University. Prior to Lubrizol, Cesc worked in the water treatment area in the technical department of a company now part of General Electric Water and right after that he expended close to seven years as Metalworking Product Manager and European Corrosion Protectives and Cleaners Product Manager at QUAKER CHEMICAL. In 2018 he was given the position of Product Manager for Metalworking additives as well. In 2023 he changed to be 100% dedicated to Grease Additives Product Manager.

Measurement of the Compositional Effect of Lubricating Greases on the Electrical Properties

It has been widely reported that by 2030, the majority of passenger vehicles sold in Europe will have electric drive motors for propulsion, either as the sole driving motor or as part of a hybrid electric vehicle transmission system.

New static and dynamic test methods have been developed to measure the conductivity of lubricating greases for use in electric drive motor bearings. This has allowed the exploration of the effects of grease composition on conductivity in terms of base oils thickeners and additives.

This paper will build upon what was presented at the 2018 and 2022 ELGI Annual Meetings and present test data on some formulations and ideas on how to develop improved greases.

Gustavo Sabogal
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Gustavo has been working in the lubrication world for the last twenty five years, the latest twenty one of them with SKF. With his baseline as mechanical engineer he started by building solid experience in field applications associated with lubricant selection and application, lubrication systems and lubrication management. For the last nine years he has been responsible for the technical development of the SKF aftermarket lubricants, which has allowed him to build a connection between theory and practice.

Preliminary Insights on vertical shaft grease lubricated bearings.

Have you ever considered that the orientation of a shaft should influence the behaviour of the grease inside, and therefore its maintenance routine and maybe even the design? At SKF we have had standard recommendations for a long time, but we have also recently started to dig deeper into this topic to better understand what really happens in such conditions. This presentation will maybe provide more questions than answers, but it's the first outcome of an ongoing research activity.

Richard (Rich) Baker
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Dr. Rich is the Director of TriboTonic Ltd which was established over 6 years ago to support tribology and petroleum companies across Europe through instrument sales, servicing and support. Prior to setting up TriboTonic Ltd, Rich worked for 16 years at PCS Instruments where he fulfilled a variety of roles covering sales, marketing and business development.

TriboTonic sells and supports PCS Instruments, Falex Tribology, Flucon and Metaspec specimens across Europe.

Rich has a strong engineering and mathematical background with a PhD in Mechanical Engineering from Imperial College London. He additionally supports the industry in an advisory capacity sitting on various industry boards and standards committees.

New Advances in Test methods for Electric Vehicles – Keeping up with the Electric Revolution

The rapid transition to electric vehicles (EVs) has prompted the need for specialised lubricants and greases tailored to the unique operating conditions of electric drivetrains. Unlike internal combustion engines (ICE), EV components such as bearings, electric motors, reduction gears, and power electronics present distinct challenges including higher rotational speeds, increased thermal loads, and the need for electrical compatibility. Running at higher speeds, loads, and under electrically induced environments are all now required to evaluate the new formulations perform in order to evaluate the thermal stability, electrical conductivity, dielectric strength, material compatibility, and wear protection under high-speed conditions.

This has led to requiring traditional tribology test instruments to be updated and adapted – or new instruments to be developed to test the requirements of these new lubricants and greases.

This presentation will showcase the limits of traditional test equipment used for ICE testing and the development of enhanced and new tribology test equipment to help support the critical role of tailored grease formulations in the search for enhancing efficiency, reliability, and component longevity.

Manuel Zuercher
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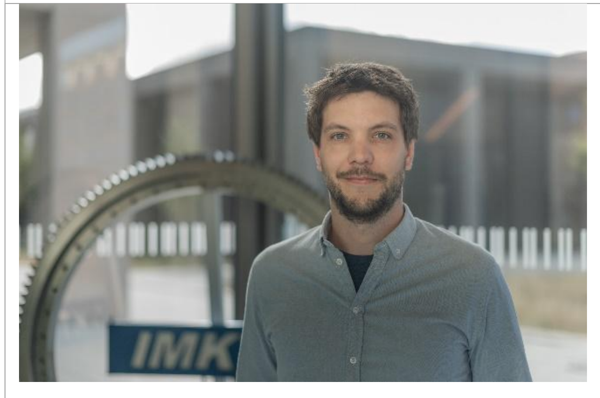
As an Advance Development Engineer at Schaeffler, Manuel Zuercher is part of the sustainability team and is responsible for lubricants. He deals intensively with the associated regulations and methodology. But is also responsible for the introduction of new sustainable products and product developments. Mr. Zürcher started in work in the field of tribology and lubrication with his Bachelorthesis "Carbon dioxide as Viscosity index improver in ionic liquids". From this point on, he remained loyal to the field and worked on the topic of white etching cracks in his master's and doctoral thesis.
After his time at the University of Erlangen, Nuremberg, he worked as a lubricating grease developer at a lubricant company for several years and then moved into sales for a short time as international sales manager. During that time, he already dealt with the topic sustainability which led to his current position at Schaeffler.

Electrification of bearings, basics and application-related developments in the industry

With the increasing electrification of industrial systems, the phenomenon of electric currents in rolling bearings has become a significant field of interest. Electric currents can flow through bearings in a wide range of applications – for instance, in the wheelsets of rail vehicles, in wind turbine generators, and in modern drive systems. Under unfavorable conditions, these currents can have a profound impact on both bearing lifetime and overall operational reliability.
The passage of current may result in various damage mechanisms on the raceways and rolling elements.
This presentation will begin by outlining the fundamental physical principles and mechanisms responsible for the occurrence of bearing currents.
A particular emphasis will be placed on the latest technological advancements and innovative solutions from the industry, designed to prevent or effectively manage electrical damage to rolling bearings.
The aim of this presentation is to raise awareness of the relevance of bearing electrification in current and emerging applications, and to introduce practical strategies for achieving greater reliability and extended service life of rolling bearings in electrically demanding environments.



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Volker Schneider has been Chief Engineer at the Institute of Machine Design and Tribology (IMKT), Leibniz University Hannover, since 2024, after working as a research assistant at the institute from 2017 to 2024. He holds a Bachelor of Science (2015) and a Master of Science (2017) in Mechatronics from Leibniz University Hannover. His research focuses on the electrical behaviour of rolling bearings, including the influence of bearing currents on service life, electrical modelling, friction analysis, and the optimisation of rolling bearing systems.

Understanding the Impact of Bearing Currents on Rolling Bearing Lifetime: Experimental Insights and an Extended Predictive Model

Electrical discharges in rolling bearings are a critical issue in converter-fed electric drives, as they can lead to surface damage, increased vibration, and ultimately premature bearing failure. In this study, the influence of harmful bearing currents on bearing lifetime was systematically investigated. Cylindrical roller bearings were subjected to defined electrical pre-stressing under controlled laboratory conditions, followed by endurance tests on a four-bearing fatigue rig. The results demonstrate a distinct relationship between discharge energy, the evolution of surface roughness, and the reduction of service life. Higher discharge energies intensify the grey frosting appearance and crater structures, which impair lubrication conditions and promote early fatigue damage.

To quantify this effect, the well-established ISO 281 lifetime calculation method was extended by introducing surface roughness as a key parameter via a modified viscosity ratio. This approach enables a more accurate prediction of the service life of electrically stressed bearings. The findings highlight that under mixed lubrication the deviations from reference tests remain moderate, whereas under full-film lubrication the lifetime reduction is substantial, indicating a shift in the dominant failure mechanisms. These results provide valuable insights for both fundamental understanding and practical lifetime assessment of bearings exposed to electrical currents in modern drivetrains.

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Dr. Mahdi Mohammad-Pour received his BSc in Mechanics in Heat and Fluid from Urmia University, his MSc in Energy Conversion from Urmia University, and his Ph.D. in Tribodynamics from Loughborough University. He started his first engineering job in 2004 as an R&D expert in Charkheshghar (ZF subsidiary in Iran). In 2009, he joined Urmia University of Technology, Iran, as a Lecturer. Then he joined Loughborough University in 2010 as a PhD student to work on the tribology and dynamics of automotive transmissions and differentials. Following positions in the School as a Post-Doctoral Research Associate and Lecturer in Dynamics, in 2018 he was appointed a Senior Lecturer in Dynamics. Dr. Mahdi Mohammadpour is a member of NAFEMS steering group, a Member of the editorial board of Shock and Vibration, and an Associate Editor of the International Journal of Powertrains (IJPT). His research has led to more than 70 journal papers and 10s of book chapters and conference presentations.

Combination of Experimental and Numerical Methods for Understanding Tribology of Electrified Bearings

Electrified contacts in EV applications introduce novel and less understood challenges, from new failure modes to new tribo-dynamic behaviour. Lack of validated numerical methods, and proven experimental approaches makes it difficult to fully understand the tribological phenomena present in these contacts, numerically simulate them or experimentally replicate and ultimately optimise.

This presentation outlines a methodology, comprising experimental methods and numerical approaches. They work hand in hand to address the abovementioned challenges and provide a platform for better understanding and optimising electrified contacts in bearings. This approach merges novel numerical methods with experimental rigs which can cover challenging conditions in terms of speed and bearing currents.

Liang Guo,
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Dr. Liang Guo is a Senior Researcher at SKF Research and Technology Development (RTD), working within the Tribology and Bearing Life team. His research focuses on elasto-hydrodynamic lubrication, contact mechanics, bearing life modelling, and electric discharge phenomena in electric vehicle applications.

Study on the Electric Discharge Behaviour in EV Motor Bearings

Electric current discharge in the motor bearings is becoming more of a concern with the move toward electric vehicles (EV), since it can damage bearing surfaces and potentially cause premature failures. A series of discharge tests were carried out utilising a self-improved ball-on-disc instrument under elastohydrodynamic lubrication regimes to better understand the nature of electric discharge in EV motor bearings. It demonstrates that the current test equipment can duplicate the electric discharge that occurred in EV motor bearings by contrasting the damaged sample surfaces with the returning bearings. In particular, the presentation will cover the design of the test rig, the acquisition and extraction of the discharge signal, the discharge voltage distribution, the analysis of the damage surface, the model that explains discharge damage, and potential mitigation measures

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Dr. Pondicherry holds a degree in engineering in Metallurgy and Materials Science from India, Masters in Nanotechnology from Germany, and a Doctorate in Tribology from Austria. Dr. Pondicherry has been working extensively in the field of Tribology for the past 16 plus years, and is associated with the Rheometry department at Anton Paar for the past 13 years. He has been actively involved in the scientific community, including STLE. In addition to authoring scientific publications, he has also authored book chapters and numerous white papers showcasing innovative test and analysis methodologies.

Rheology, Electro Rheology, and Electro-Tribology of Lubricating Greases

Rheology is the science of flow and deformation in materials, commonly used to assess viscosity, viscoelasticity, and the time- and temperature-dependent behaviour of greases. These rheological properties can also significantly affect the tribological performance of lubricants. While most lubricating oils behave as Newtonian fluids, greases exhibit both viscous and elastic characteristics, making rheological understanding crucial for selecting or developing suitable lubricants for specific applications. This work begins with fundamental rheological concepts and progresses to more advanced testing methods. It then focuses on experimental data from electro-rheological and electro-tribological studies on specialised greases. Rheological measurements were conducted using a modular compact rheometer with a 25 mm plate-plate setup. Tribological tests employed type 7200 angular contact bearings lubricated with various oils and greases. For electro-tribological analysis, impedance was measured under static and dynamic conditions using an LCR meter (L = inductance, C = capacitance, R = resistance). Extended Stribeck curves were generated to reveal changes in the electrical behaviour of the tribosystem with varying sliding speeds and to identify transitions between lubrication regimes. Additionally, voltage ramp tests determined the breakdown voltage of the greased tribosystem at different velocities. These combined investigations enable the mapping of electro-tribological properties of greases and help correlate them with advanced surface characterisation, offering deeper insights into lubricant behaviour under dynamic conditions.

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Fabrice Ville is a tribologist at INSA Lyon (LaMCoS), where he teaches mechanical engineering and leads research on the durability and efficiency of lubricated mechanical systems. His work combines experimental tribology and modeling to address contact fatigue, wear, scuffing, and energy/thermal behaviour, with applications to gears and rolling contacts. He collaborates with ECAM LaSalle (LabECAM) and industry partners and regularly contributes to the tribology community through talks and publications.

Tribology of Lubricated Mechanisms: A Way to Sustainability

Gears and rolling element bearings play a crucial role in many mechanical systems. Improving their durability and energy efficiency (particularly under extreme conditions) is necessary to ensure sustainability.
This presentation describes the integrated analyses developed at INSA Lyon in collaboration with ECAM LaSalle, combining experiments on dedicated test benches and multi-scale numerical modelling. Our research focuses on contact damages (wear, scuffing, rolling contact fatigue) and power losses and thermal behaviour in lubricated mechanisms.
Test benches measure, for example, friction, temperature and damage under representative operating conditions. At the same time, simulations incorporate surface finish and contact mechanics in order to formulate durability criteria, as well as thermal aspects and power losses for energy efficiency. These models predict crack initiation, scuffing and rolling contact fatigue, as well as frictional losses and temperature, for example.
The knowledge gained guides responsible design, health monitoring and maintenance strategies, thereby extending component life, reducing energy consumption and improving reliability in all industrial applications.

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Morteza Abedini is a researcher and group leader at the University of Duisburg-Essen, specialising in wear, tribocorrosion, and protective coatings. He earned his PhD from the University of Tehran, where his research focused on the interaction between corrosion and slurry erosion. Following this, he served as an assistant professor at the University of Kashan. Supported by research funding from DAAD and DFG, he has conducted extensive studies in Germany on the electrochemical behavior of materials subjected to cavitation-induced wear. His current research interests include sliding wear, cavitation erosion, coatings, and corrosion.

Wear–Corrosion Interactions and Material Degradation: An Overview of Tribocorrosion

Engineering *materials are frequently exposed to aggressive environments in which mechanical loading and electrochemical reactions act simultaneously. The resulting degradation is rarely the sum of wear and corrosion acting independently; instead, their interaction produces a synergistic effect that accelerates material loss, a phenomenon widely recognised as tribocorrosion. This coupled process leads to severe reductions in service life, increased maintenance costs, and elevated energy consumption, making it a critical factor in the performance of components across sectors such as transportation, energy generation, marine applications, and biomedical devices.*
The present contribution surveys the degradation mechanisms associated with three dominant wear modes—sliding wear, cavitation erosion, and slurry erosion—in the presence of corrosive environments. Mechanical removal of surface layers, as a key factor in wear-enhanced corrosion, continuously exposes fresh metal to corrosive attack through disrupting passive films, which enhances the kinetics of material dissolution. Emphasis is placed on the mechanistic understanding of these processes, including the role of electrochemical kinetics, passive film stability, and surface mechanical response under dynamic contact conditions.