stle ORLANDO
May 15-19, 2022

Early career and student posters

The posters are located in the Walt Disney World Swan and Dolphin Resort - Atlantic Hall.

Early Career Posters

3742462: 3D CFD investigation of Mixed Lubrication

Ruchita Patel, Zulfiqar Khan, Adil Saeed, Bournemouth University, Bournemouth, Dorset, United Kingdom, Vasilios Bakolas, Schaeffler Technologies AG & Co. KG, Herzogenaurach, Herzogenaurach, Germany

Most of the mechanical components such as cams, gears, tappets, and rolling bearing elements are called non-conformal contacts, and mainly works under Mixed Lubrication (ML) region. This is the crucial state of lubrication from where all failure processes such as scuffing, micropitting, and wear develop due to poor lubrication between contacting surfaces. The flow of lubricant at the interface of the rough contacting surfaces can be defined by the Reynolds Equation. However, it is doubtful that this Reynolds equation can efficiently work for mixed lubrication. Accurate prediction of pressure distribution in ML requires a correct mathematical description of lubrication problems involving asperity contact boundary conditions. In this research work, the Reynolds equation and its applicability in the simulation of rough lubricated surfaces working under the ML region have been investigated using computational fluid dynamics (CFD).

3647495: Using Ionic Liquids as Catalysts in the Process of Biodiesel Synthesis and its Application in the Preparation of Metalworking Fluids

Roshanak Adavodi, Petro Eksir Asia, Esfahan, Republic of Iran

Metalworking fluids are used in metal removal processes such as cutting and grinding and in metal forming processes such as drawing, rolling, and stamping. Also, Metalworking fluids are used as a coolant to reduce the heat generated by the process. Bio metalworking fluid (high degradability, optimal lubrication, high viscosity index, and oxidation stability could be mentioned as advantages of bio metalworking) is introduced as an alternative to petroleum products of metalworking. These fluids can be prepare from synthetic esters which include biodiesels and fatty esters. Fatty acid esters are prepared by the reaction of fatty acids with alcohol in the presence of an acidic catalyst. In this study, ionic liquids are used as solvents and catalysts in esterification processes and the obtained esters are used as a raw material in the bio metalworking fluids producing process and their tribological properties are evaluated.

3669312: Tribological Test of Tungsten Disulfide Solid Lubrication Exposed to Simulated Space Environment

Ayaka Takahashi, AIST, Tsukuba, Ibaraki, Japan

Solid tungsten disulfide film can be use as a longer endurance lubrication than proven space lubricant at high vacuum with elevated temperature. Other space environmental properties also need to be evaluated in order to make tungsten disulfide to be option for space use. High-level radiation applied irradiation to the surface of tungsten disulfide coated on a SUS316L stainless steel substrate. It was confirmed that the coefficient of friction was low even after high-level radiation irradiated.

3738792: Robustness of Coatings in Fuel-Lubricated Mechanical Interfaces

Monica Ferrera, Stephen Berkebile, ARL DEVCOM, Aberdeen, MD, Auezhan Amanov, Ruslan Karimbaev, Sun Moon University, Asan Campus, Asan New City, Republic of Korea

Coatings promote tribological advantages by protecting steel surfaces within fuel-lubricated component interfaces. Thermal spray allows for a balance of high hardness and wear resistance with toughness in deposited coatings. However, the coatings tend to have rough surfaces and porosity. We demonstrate that ultrasonic nanocrystalline surface modification (UNSM) can reduce roughness and increase wear resistance in these coatings. Coating material was deposited onto circular flats of hardened AISI 52100 steel using high-velocity oxyfuel thermal spray. Tribometer evaluation was conducted against an Al2O3 counter body. This paper focuses on ball on flat linear reciprocation in an inert gas environment. We investigated the mechanical and wear properties of various coatings through scanning electron microscopy, energy-dispersive microscopy, and 3D surface profilometry. This study highlights a consistent method of coating evaluation for enhanced performance in varying fuel environments.

3730974: Improved Throughput and Analysis of Scratch Test Results via Automation and Machine Learning

Hannah Lim, John Curry, Michael Dugger, Sandia National Laboratories, Albuquerque, NM

A data analysis automation interface that incorporates machine learning (ML) has been developed to improve productivity, efficiency, and consistency in identifying and defining critical load values when a scratch test is performed. Optical examination of the scratch by a human operator is currently used to determine where the critical load values occur. However, the vagueness of the standard has led to varying interpretations and nonuniform usage by different operators at different laboratories where the test is implemented, resulting in multiple definitions of the desired parameter. Using a standard set of training and validation images to create the dataset, the critical load can be identified consistently amongst different laboratories using the automation interface without requiring the training of human operators. When the model was used in conjunction with an instrument manufacturer's scratch test software, the model produced accurate and repeatable results and defined LC2 values in as little as half of the time compared to a human operator. When combined with a program that automates other aspects of the scratch testing process usually conducted by a human operator, scratch testing and analysis can occur with little to no intervention from a human beyond initial setup and frees them to complete other work in the lab.

SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525.

Student Posters

3729068: On a Roll: The Influence of Combined Rolling and Sliding on Metal Oxide Antiwear Additive Performance

Daniel Delghandi, Parker LaMascus, Robert Carpick, University of Pennsylvania, Philadelphia, PA, Mohammad Yazdanparast, Andrew Jackson, Robert Wiacek, Pixelligent, Baltimore, MD

Lowering the viscosity of gear oils can yield up to 2.5% in energy savings but comes at the cost of increased wear due to greater surface contact between the gears. Along the gear tooth contact, combined rolling and sliding occurs at a range of ratios, meaning versatile antiwear additives are needed to protect the gears. Metal oxide nanocrystals (NCs) are a class of gear oil dispersible antiwear additives with the potential of enabling low viscosity lubrication. Through the mechanism of tribosintering, the metal oxide NCs form ceramic tribofilms that protect surfaces from adhesive wear. Nonetheless, current literature is relatively lacking in fundamental studies exploring tribosintering within the context of lubrication. To expand on these fundamentals, we investigate the effects of combined sliding and rolling on the tribosintering of metal NCs. ZrO2 tribofilms are produced via in situ Mini Traction Machine (MTM) testing and then analyzed ex situ. Comparing slide-roll ratios (SRRs) representative of gearbox conditions of interest for future applications, we observe a positive correlation between tribofilm growth rates and SRR. However, we also see thinner tribofilms with higher SRRs, illustrating the different roles of sliding and rolling in tribofilm formation. These results give further insight into the growth kinetics of tribosintering, which can help enable low viscosity lubricants for harsh applications.

3727412: Tribosintering of Metal Oxide Nanocrystal Anti-Wear Additives: Effect of Nanocrystal Composition

Parker LaMascus, Daniel Delghandi, Robert Carpick, University of Pennsylvania, Philadelphia, PA, Mohammad Yazdanparast, Andrew Jackson, Robert Wiacek, Pixelligent, Baltimore, MD

In challenging tribological conditions like those of gears and bearings, lubricant designers must weigh energy losses incurred by churning viscous oils with the risk of wear and failure. To increase operating lifetimes while maximizing energy efficiency, metal oxide nanocrystals (NCs) dispersed in gear oil can form a solid, protective tribofilm that prevents scuffing of the underlying substrate and alleviates wear. However, unlike other well-studied anti-wear additives like zinc dialkyl dithiophosphates (ZDDP), metal oxide NCs do not have a commonly accepted governing anti-wear mechanism. The proposed mechanisms which do exist are more often descriptive than predictive, hindering the active engineering of tribofilm performance. Using a Mini Traction Machine, we examine the anti-wear performance of dispersed metal oxide NCs. We compare ZrO_2, ZnO, and TiO_2 NCs while keeping other experimental parameters constant. Through a combination of in situ and ex situ analysis, we show that tribofilm performance metrics – wear prevention and film growth rate – are correlated with the bulk melting point of the metal oxide NC, supporting a tribosintering mechanism of film formation. These results provide a more rigorous and general ability to engineer metal oxide tribofilms.

3736173: Lubrication and Degradation of Stern Tube Seals Used with Environmentally Acceptable Lubricants

Tom Briggs, Imperial College London, Oxford, United Kingdom

Marine stern tube seals serve to retain lubricant in the stern tube as well as to prevent water ingress into the ship. The stern tube houses bearings which support the propellor shaft, meaning the stern tube system as a whole experiences very high fluctuating loads, especially if the propellor is operating semi-submerged. The stern tube seals experience misalignments as a result of the loading and as a result of other factors, which adds to already severe operating conditions due to the presence of both oil and water, a large pressure drop across the seal and high temperatures in the seal-shaft contact. Stern tube seals are typically radial lip seals made of fluor-elastomers. The lip seal element generally demonstrate poor performance in terms of component life, especially when compared to their automotive counterparts. The use of EALs also appears to shorten seal life. This project aims to understand the lubrication mechanisms of oil-water seals and link the breakdown of lubrication to the damage observed in the field. Failed seals typically demonstrate cracking and blistering of the sealing face as well as significant reductions in material hardness near the area of visible damage. The material near the sealing face also appears impregnated with fluid. Ultimately, the aim is to better understand how seal damage progresses to inform stern tube system design as well as to better predict seal failure.

3736425: Effects of Whirl and Axial Motion on Ball Bearing Turbocharger Dynamics

Benjamin Conley, Farshid Sadeghi, Purdue University, West Lafayette, IN

Ball bearing turbochargers (TCs) incorporate an angular contact ball bearing cartridge to reduce friction and oil consumption, thus contributing to the overall efficiency of internal combustion engines. In this investigation axial and radial TC rotor motion was experimentally measured and used to calibrate a simulation of the TC rotor-bearing system, allowing for a detailed study of the operating conditions inside the bearing. Eddy-current proximity probes were used to measure the radial motion at both ends of the TC. The radial motion shows a whirling behavior with significant subharmonics at low speed. The axial motion of the rotor was also measured and found to have a similar frequency spectrum to the whirl. To study the bearing dynamics, a complete TC model was developed which includes the mass distribution and flexibility of the TC rotor and squeeze film dampers (SFDs) which support the bearing cartridge. The whirl and axial motion of the test rig were reproduced with the simulation and found to have a significant effect on the loading and rolling behavior of the individual balls, particularly when clearance exists in the bearing. Simulation results revealed that a light preload and modifications to SFDs to reduce subharmonics minimized sliding of the balls which should contribute to lower bearing friction and improved overall life.

3744600: Characterization Equipment Development to Study Contact Mechanics of Syringe Systems in Deep Cold Storage

Adam DeLong, Kylie Van Meter, Brandon Krick, Florida State University, Tallahassee, FL, Nestor Rodriguez, Guillaume LEHEE, Becton Dickinson, Franklin Lakes, NJ

As technology advances new medical developments can be supported, like the storage and transportation of syringe systems that require temperatures below -40˚C. Along with these advancements, characterization equipment to study the contacting surfaces within a syringe will need to be optimized. This study focuses on the development of a liquid nitrogen cryostat coupled to an adaptive optics system to observe contact behavior between glass or polymer syringe barrels and rubber stoppers during thermal cycling down to -60˚C. The liquid nitrogen cryostat is capable controlling the temperature of the system between 60˚C to -100˚C with a precision of +/-1˚C at cooling/heating rates between 1 to 10oC per minute. The Adaptive optics consist of a HD camera with a spatial resolution of 4.35 microns. The equipment allows the user to study in situ barrel-stopper contact behavior of syringe systems during freezing and thawing.

3744563: Comprehending Nano Scale Corrosion Behavior using Multi-Layered Perceptron for Regression

Saugat Tripathi, Ashutosh Pitkar, Miao Wang, Ran Zhang, Zhijiang Ye, Miami University, Oxford, OH

Corrosion, caused naturally by interaction with environmental factors, impacts almost 3.4% of the global GDP. The complexity and lack of understanding of the nucleation process of corrosion pose significant challenges to predicting and mitigating this issue. Several ongoing researches suggest a close relationship between the crystal physical features like orientation and electrochemical properties associated with corrosion within the crystal lattice. This work aims to exploit deep learning (DL) techniques with multi-layered perceptron (MLP) for regression to create a quantitative model that can predict the nano corrosion behavior of a crystal. Data obtained from scanning electrochemical cell microscopic (SECCM) and electron backscatter diffraction experiments are utilized to train and test the model. The outcomes validate that the developed model can predict corrosion behaviors with satisfying accuracy and demonstrate that the surface corrosion behaviors are related not only to the crystal orientation but also to the ups and downs of the surface.

3743669: Simulation of Nanoscale Corrosion on Silver Surface

Ashutosh Pitkar, Saugat Tripathi, Ran Zhang, Miao Wang, Zhijiang Ye, Miami University, Oxford, OH, Hang Ren, Yufei Wang, The University of Texas Austin, Austin, TX

Corrosion is a serious problem faced by the industry. Just in the US, about 3% of resources are consumed to respond to the material degradation due to corrosion. As a result, it is necessary to study the mechanisms involved in understanding the underlying physics and chemistry that drives the corrosion processes for metals and alloys, such as silver, for example. In our research, localized experimentation techniques including Scanning Electrochemical Cell Microscopy (SECCM), Atomic Force Microscopy (AFM), Electron Back Scattering Diffraction (EBSD), Scanning Electron Microscopy (SEM), were conducted to provide experimental insight into the nucleation process. However, it is difficult to visualize the ongoing chemistry at the corrosion interface as the reactions occur on very small scales. At this scale, effects of the material microstructure, such as the grain orientations, atomic proximity to grain boundary, etc., need to be considered. To achieve this aim, we conducted Molecular Dynamics (MD) simulations of the corrosion process on silver surfaces and understand the nucleation of corrosion on surfaces with different crystal orientation and grain boundary.

3740981: Process-Property Relationship of Plasma Enhanced Atomic Layer Deposited Titanium Vanadium Nitride coatings and RF Bias Voltage

Santiago Lazarte, Kylie Van Meter, Tomas Babuska, Tomas Grejtak, Brandon Krick, Florida State University, Tallahassee, FL, Md. Chowdhury, Nicholas Strandwitz, Lehigh University, Bethlehem, PA, Mark Sowa, Veeco ALD, Waltham, MD, Alexander Kozen, University of Maryland, College Park, MD

We recently discovered that titanium vanadium nitride (TiVN) Plasma-enhanced atomic layer deposited (PEALD) coatings can achieve ultralow wear rates. These multifunctional films are hard, chemically resistant, thermally stable and conductive and can be deposited conformally on complex surfaces and devices at thicknesses ranging from a few nm's to a few hundred nm's. However, the ultralow wear nature of these materials is dependent upon unknown processing variables. Here, we study tribological properties of films deposited with different RF bias voltages. Brittle delamination failure was observed in some cases, resulting in premature failure. A tribometer with in situ scanning white light interferometer was used to study the evolving wear and fracture of the films. Results suggest that the interface performance is related to residual stress in the nitride coatings.

3739859: Surface Roughness Effects on Stick-Slip Friction in Hydraulic Cylinder Rod Seals

Katherine Kwasny, Milwaukee School of Engineering, Milwaukee, WI

Hydraulic cylinders are the primary linear actuators in fluid power equipment. They incorporate piston and rod seals. Piston seals isolate rod and cap-end pressures within a cylinder. Rod seals retain the fluid within a cylinder as it extends and retracts. In addition, rod seals must resist extrusion, operate in harsh environments, and minimize stick-slip friction. Rod seal stick-slip is characterized by a stop-start motion of the rod. This movement can produce vibration, noise, and machine oscillations. Machine oscillations are a particular concern in cranes, telescopic lifts, and utility trucks because boom instability affects machine control and operator safety. In this investigation, we examined the effects of fluid properties and surface roughness on seal stick-slip friction. Variations in cylinder forces were measured for several fluids with slipper and U-cup seals. The relationship between the surface roughness, the stick slip, and actuation force is examined.

3744771: Programming a Custom Instrument to Conduct Friction Tests at Clutch-Gear Interface and Evaluate the Performance of Different Oils

Ashutosh Pitkar, Anthony Krcik, Mark Sidebottom, Miami University, Oxford, OH

Clutch systems require appropriate lubrication to perform optimally and operate as expected during their life span. The performance of the lubricative oil used for this purpose must be tested to ensure the desired behavior is achieved. The oil's performance oil is acquired by conducting frictional testing and reporting the frictional coefficient at the clutch-plate gear interface. A custom clutch instrument was developed to test this instrument. This work emphasized the software interface required to control essential parameters of the test such as applied force, motor velocity, and oil temperature that may affect the friction coefficient of the clutch plate interface. MATLAB was used to develop a user-friendly application. This allowed the user to perform various tests with different oils at different configurations. The results of the experiment were saved externally for the user to analyze.

Early Career and Student Posters

3725313: Tribological Behaviour of Automotive FM and AW Oil Additives, Optimized for Steel, When Used in Non-Common Materials

Gerard Cañellas, Ariadna Emeric, Angel Navarro, Lluís Beltran, Industrial Química Lasem, Castellgalí, Spain, Mar Combarros, IQL, Castellgalí, Barcelona, Spain, Montserrat Vilaseca, Eurecat, Manresa, Spain, Jordi Vives, UPC Manresa, Manresa, Spain

Latterly, carbon dioxide emission reduction has become a hot spot. The growing environmental awareness has matured into worldwide treaties stablishing emission limits. To achieve the necessary reductions some actions are being considered such as vehicle fleet electrification, being friction and weight reduction and new fluid requirements some key aspects, since these directly contributes to higher vehicle autonomy. Because all the changes in the automotive industry, in the recent years, new component designs and materials have been continuously incorporated in vehicle production. The use of new pieces and materials has triggered a huge number of tribological challenges for current oil formulations, commonly designed to work with steel. In this poster, a methodological study of the tribological performance of some market-available AW and/or FM additives for vehicles containing an internal combustion engine and, also, for their transmission is exposed. The aim is to evaluate the behaviour of steel-optimized additives in front of other materials. In this case, aluminum-steel and nylon-steel contacts. The characterization consists in monitoring the tribofilm formation and the friction by means of a microtraction machine (MTM rubbing + in-situ interferometry method). Also, wear is evaluated by an optical 3D measurement system.

3730751: Superior Macro-scale Tribological Performance by the Synergetic Effect of Graphene Quantum Dots and Aqueous Glycerol in Self-mated Steel Contacts

Irfan Nadeem, Mitjan Kalin, University of Ljubljana, Ljubljana, Slovenia

Reducing friction is an utmost concern in the modern world due to its great prospect to reduce energy consumption and environment-friendliness. Glycerol provides superlubricity in industrially relevant sliding contacts such as steel and diamond-like carbon (DLC). With growing interest in green lubricants, we studied the synergetic effect of graphene quantum dots with aqueous glycerol for improved lubrication performance between self-mated steel contacts in a reciprocating sliding motion. For comparison, the lubrication performance of aqueous glycerol with other graphitic (nano and micro) materials was also studied. The results show that the aqueous glycerol with GQDs show superior dispersion stability and significantly reduced the friction and wear by 84% and 63%, respectively. This striking decrease in the coefficient of friction and wear is discussed in this paper. This work demonstrated that GQDs based green nano lubricants have a great potential to replace conventional environment polluting lubricants and paved the way for further investigation to get a deep insight into active lubrication mechanisms.

3731130: A Microscale Study of Friction on Diamond-Like Carbon

Srijan Banerjee, Caleigh Schmidt, Hannia Vidal Camacho, Brian Borovsky, St. Olaf College, Northfield, MN, Seong Han Kim, Pennsylvania State University, University Park, PA

Diamond-like carbon (DLC) is known to achieve an extremely low friction state called "superlubricity". This desirable property is, however, very sensitive to environmental conditions such as the amount of water or hydrogen in the surrounding atmosphere. At St. Olaf College, we use measurements of friction and shear stress within microscopic high-speed sliding contacts to understand the chemical reactions governing superlubricity in DLC. This research is in collaboration with researchers at Pennsylvania State University under Dr. Seong Kim. Our custom microtribometer combines an indenter probe and shear-mode quartz crystal microbalance (5 MHz). Changes in the resonance properties of the crystal as functions of shear amplitude provide quantitative measurements of elastic and dissipative friction forces and contact area. We present initial results on the variation of friction with load and relative humidity for silicon oxide spheres (100 um diameter) against DLC coatings. We observe high friction at all humidity levels (5% to 40% RH) with coefficients near unity for the maximum elastic force. Dissipative forces exhibit an unexpected viscous drag response, proportional to the velocity of motion. These results will be compared to macroscopic measurements performed at Penn State. Future work will vary the partial pressure of hydrogen in the atmosphere to more fully explore conditions that can lead to low levels of friction. This research is supported by NSF Grant CMMI #1912210.

3736455: Lubricating Oils from Upcycled Plastics (LOUPs): A Tribological and Surface Analytical Study of their Lubrication Mechanisms

Seungjoo Lee, Istiaque Alam, Ali Erdemir, Texas A&M University, College Station, TX

Upcycling of plastic wastes into high-value added products is an eco-friendly practice for reducing plastic pollution. Here, we developed a new breed of high-quality lubricants derived directly from plastic wastes and demonstrated their unique lubrication properties. Specifically, comparative tribological studies of the novel lubricating oils upcycled from plastic wastes (LOUP) confirmed equal or much superior tribological performance when compared to traditional-mineral and synthetic base oils. Systematic tribological testing was performed under ASTM G99 conditions using a pin-on-disc tribolmeter. It was found that the average coefficient of friction obtained using LOUP oils was comparable to the traditional base oils while the average wear scar diameter of ball samples tested in LOUP was significantly lower than the ones tested in conventional mineral oils but was comparable to the high-performance synthetic base oils such as PAO 10. In an attempt to unravel the fundamental tribochemical interactions leading to superior friction and wear performance in the presence of LOUP oils, comprehensive surface and structure analytical studies were conducted and the presence of carbon-rich tribofilms on rubbing surfaces was confirmed. Overall, our studies indicated that LOUP may help in reducing plastic pollution, and at the same time providing an alternative means for future lubricating oils.

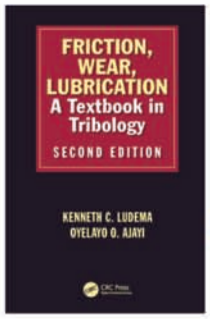
20% Discount Available* with discount code DFL20

2022 STLE Annual Meeting Education Courses

CRC Press is pleased to provide a list of books for 2022 STLE Annual Meeting Education Courses. These books can be ordered globally with free shipping! Enjoy 20% with code DFL20 at checkout.

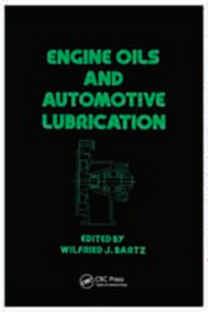
Lubricant Additives

Chemistry and Applications, Third Edition
Edited by **Leslie R. Rudnick**
June 2017 • 722pp
hb: 978-1-498-73172-0: ~~$375.~~
$300.00 | **Course Name:** Advanced Lubrication 301: Advanced Additives
www.routledge.com/9781498731720
Course Name: Advanced Lubrication 301: Advanced Additives



Friction, Wear, Lubrication

A Textbook in Tribology, Second Edition
By **Kenneth C Ludema, Layo Ajayi** October 2018 • 294pp
hb: 978-1-482-21017-0: ~~$93.95~~
$75.16 | **Course Name:** Advanced Lubrication 302:
www.routledge.com/9781482210170

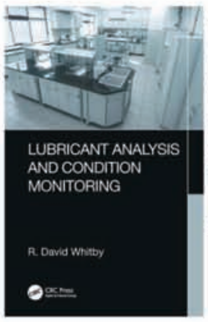


Engine Oils and Automotive Lubrication

Edited by **Wilfried J. Bartz**
October 2019 • 832pp
pb: 978-0-367-40270-9: $74.95
$59.96 | **Course Name:** Automotive Lubrication 202
www.routledge.com/9780367402709

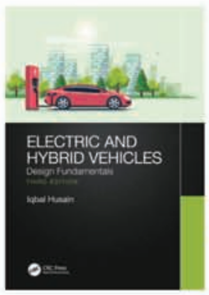
Lubrication Fundamentals, Revised and Expanded

By **Don M. Pirro, Martin Webster, Ekkehard Daschner**
March 2016 • 608pp
hb: 978-1-498-75290-9: ~~$180~~.
$144.00 | **Course Name:** Basic Lubrication 101
www.routledge.com/9781498752909



Lubricant Analysis and Condition Monitoring

By **R. David Whitby**
December 2021 • 398pp
hb: 978-1-032-15669-9: ~~$150.~~
$120.00 | **Course Name:** Basic Lubrication 102
www.routledge.com/9781032156699

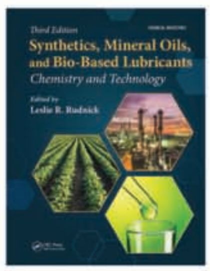


Electric and Hybrid Vehicles

Design Fundamentals
By **Iqbal Husain**
February 2021 • 498pp
pb: 978-0-367-69393-0: ~~$56.95~~
$45.56 | **Course Name:** Electric Vehicles (New!)
www.routledge.com/9780367693930

Basics of Hydraulic Systems, Second Edition

By **Qin Zhang**
March 2019 • 338pp
hb: 978-1-138-48466-5: ~~$160.~~
$128.00 | **Course Name:** Hydraulics 201
www.routledge.com/9781138484665



Synthetics, Mineral Oils, and Bio-Based Lubricants

Chemistry and Technology
Edited by **Leslie R. Rudnick**
February 2020 • 1194pp
hb: 978-1-138-06821-6: ~~$375.~~
$300.00 | **Course Name:** Synthetics 203, 204
www.routledge.com/9781138068216

Metalworking Fluids

Edited by **Jerry P. Byers**
September 2017 • 529pp
hb: 978-1-498-72222-3: ~~$200~~
$160.00 | **Course Name:** Metalworking Fluids 115, 240
www.routledge.com/9781498722223

Visit Us at Booth #224

Early Career and Student Posters

3740228: Effect of Cation-anion Pair on Contact Angle for Phosphonium Ionic Liquids

Ting Liu, Ashlie Martini, University of California Merced, Merced, CA; Md Hafizur Rahman, Pradeep Menezes, University of Nevada-Reno, Reno, NV

The wettability of ionic liquids (ILs) is relevant to their use in various applications. However, a mechanistic understanding of how the cation-anion pair affects wettability is still evolving. Here, focusing on phosphonium ILs, wettability was characterized in terms of contact angle using experiments and classical molecular dynamics simulations. Both experiments and simulations showed that contact angle depends on the anion and increased as benzoate > salicylate > saccharinate. Further, the simulations show contact angle decreased with alkyl chain length for these anions paired with five different tetra-alkyl-phosphonium cations. The trends were explained in terms of adhesive and cohesive energies in the simulations, and then correlated to the atomic-scale differences between the anions and cations evaluated.

3740208: Varnish Removal Efficiency of Commercial Cleaners

Andrew Velasquez, Ashlie Martini, University of California, Merced, Merced, CA, Zhen Zhou, Chevron Lubricant, Richmond, CA

Varnish accumulation resulting from lubricant degradation can adversely affect the efficient operation of lubricated mechanical systems. There are various chemical cleaners commercially available that claim to remove varnish, but data enabling quantitative comparisons of the performance of these cleaners are not available. This article reports the use of a custom test system that enables in situ imaging of varnish removal to directly compare nine commercially available chemical cleaners in a blinded study. Multiple qualitative and quantitative metrics were used to evaluate the performance of the cleaners. A wide range of varnish removal efficiency was observed from cleaner to cleaner, from complete varnish removal in just a few hours to almost no removal after tens of hours of testing. The results demonstrated the utility of the test rig for characterizing and measuring varnish removal and emphasized the importance of quantitative data when selecting a chemical cleaner for a given application.

3740108: Surface Integrity and Fretting Wear Study of Additively Manufactured Inconel 625 subjected to Surface Strength Improvements

Manisha Tripathy, Ali Beheshti, George Mason University, Sterling, VA

Surface enhancement processes like shot peening (SP) and laser peening (LP) are being extensively used in harsh environment applications to improve the mechanical and surface behavior of parts. With the rapid growth of the metal additive manufacturing industry, it becomes necessary to rigorously study the additively manufactured components trying to achieve comparable or even superior properties with reference to their conventional counterparts. This study showcases a detailed microstructural, surface property and high-temperature fretting wear behavior of additively manufactured and traditionally manufactured Inconel 625 subjected to SP and LP processes. Surface morphology, mechanical/tribological properties as well as advanced characterization techniques like XRD, EBSD, and TEM were employed to collate the changes due to the different types of peening processes.

3739749: Dynamometer Testing of Hydraulic Fluids in an Axial Piston Pump Under Simulated Backhoe Loader Trenching Conditions

Hassan Malik, Milwaukee School of Engineering, Milwaukee, WI

The standard method for determining the efficiency of hydraulic equipment is specified in ISO 4409 "Hydraulic fluid power – Positive displacement pumps, motors, and integral transmissions – Methods of testing and presenting basic steady-state performance." Steady-state performance is assessed by measuring input torque and output flow at constant speed, displacement, temperature, and differential pressure. In this investigation the efficiency of a variable displacement axial piston pump was evaluated using several hydraulic fluids of varying viscosity and shear stability under dynamic conditions.

A simulated backhoe loader trenching cycle was used to investigate how fluid properties affect pump performance. Pump swashplate position, outlet pressure, and rotational frequency were input to simulate a soil trenching and sideloading duty cycle. The results from the dynamic duty cycle test were compared to steady state measurements collected under the same conditions. Dynamic models of the pump inlet were developed to investigate the effects of fluid properties on pump performance. These models included terms for resistance, inertance, and capacitance, analogous to the classic transmission line models used for analyzing electrical systems. The findings provide insights into the effects of fluid properties on pump dynamics.

3739748: An Investigation of Varnish Formation and Removal in a High Pressure Piston Pump

Shriya Reddy Kalijaveedu, Milwaukee School of Engineering, Milwaukee, WI

Modern hydraulic fluids are capable of providing extended service life due to excellent oxidation stability. However, they may be susceptible to producing varnish forming compounds that have poor low temperature solubility. The precipitation of varnish in hydraulic systems at low temperatures can cause several problems including hydraulic valve malfunction, heat exchanger deposits and short filter life.

In this investigation the tendency of hydraulic fluids to form deposits and the effectiveness of varnish removing additives will be evaluated using the JCMAS P 045 High Pressure Pump Test. This standard specifies a test method for measuring the oxidation stability of hydraulic fluids. It also specifies a method for determining the degree of fluid deterioration. In the first phase, a series of 500-hour tests were conducted on a reference fluid to evaluate the repeatability of the test method. In the second phase an oil that produces high concentrations of varnish was evaluated in the P 045 test rig. A large amount of varnish was formed in the hydraulic system. A varnish removing additive was blended into new hydraulic oil at 10% concentration and circulated through the P 045 test rig at 50°C for 100 hours. The system was drained and disassembled for inspection. Results are reported.

3740256: Modeling the Effect of Polymer Structure and Chemistry on Viscosity Index, Thickening Efficiency, and Traction Coefficient

Pawan Panwar, Ashlie Martini, University of California, Merced, Merced, CA, Emily Schweissinger, Stefan Maier, Stefan Hilf, Sofia Sirak, Evonik Industries, Hanau, Germany

The chemistry and structure of base oil and polymer additive molecules in lubricants directly affect viscosity index (VI), thickening efficiency (TE), and traction coefficient (TC). However, the relationship between molecular properties and these key performance metrics is still not fully understood, inhibiting design of fluids with potentially improved performance. This study used molecular dynamics simulations to identify structure-property-function relationships for lubricants of similar viscosity consisting of different polymers having chemistries consistent with commercially available products. Then, simulation calculated VI, TE, and TC were validated by experimental measurements. The differences in VI, TE, and TC between the fluids were investigated by simulation-calculated multiple structural properties of the polymers. Finally, simulations were used to develop simple models to rapidly predict these properties which can ultimately guide design of new lubricants or additives.

3739461: Graphite Lubrication in Rolling Contact

Carina Morstein, Karlsruhe Institute of Technology KIT, Karlsruhe, Germany

Solid lubricants are used in applications where conventional liquid lubricants reach their limits. One of the well-known solid lubricants is graphite, but its underlying lubrication mechanism is still under debate. This poster aims to shine light onto the mechanisms, properties, and limits of graphite lubrication under high mechanical load (> 1 GPa) under rolling motion. Previous experiments under sliding motion revealed the in situ formation of a thin carbon layer. This carbon layer was found to be crucial for a low coefficient of friction (CoF) of 0.10 and exhibited a turbostratic structure revealed by transmission electron microscopy (TEM) analysis. For the current studies, the type of motion has been changed from sliding to rolling. This allows the experiments to be comparable to the real-life application in rolling bearings in terms of both the contact pressure and the type of motion. The experiments were conducted with a mini traction machine (MTM), where the slip-to-roll-ratio (SRR) can be tuned. Already a SRR of 5% is sufficient to reciprocate the formation of a similar carbon layer as under pure sliding, but with an increased lifetime. A distinct material transfer of the graphite coating from the plate onto the counter body has been observed, leading to the formation of a thin tribolayer on the sphere. The influence of the SRR on the tribofilm formation, CoF, and the lifetime of the coating will be thoroughly investigated.

3647748: Modeling Sputtering Deposition of MoS_2: Effect of Sputtering Deposition on the Microstructure

Sergio Romero Garcia, Ashlie Martini, University of California, Merced, Merced, CA

Dry film lubricants, such as molybdenum disulfide (MoS_2), are currently used to coat space components that operate in extreme environments. However, it is known that the friction and wear behavior of MoS_2 are affected by the presence of oxygen and water making it difficult to predict coating life. This is a significant issue because coatings must be tested in earth ambient conditions before moving to space. To address this issue, we propose the investigation of doped MoS_2 via the development of Molecular Dynamics (MD) simulations to describe the effect of the microstructure and dopants on the tribological performance of MoS_2 in environments that mimic ambient and space conditions. The outcome of this project will be critical for the future development of solid lubricants that can extend their useful life not only in space conditions but also earth like worlds.

3667477: Phosphonium Based Ionic Liquids as Additives for Water-Based Lubricants

Md Hafizur Rahman, Soumya Sikdar, Pradeep Menezes, University of Nevada-Reno, Reno, NV, Ting Liu, Ashlie Martini, University of California, Merced, Merced, CA

Water is an abundant resource that utilized as a lubricant historically and still today for some applications. However, most lubricants are petroleum-based oils due to their superior lubrication properties: high viscosity, low density, high thermal stability, better corrosion resistance. Despite this, there are efforts to replace petroleum-based oils with environmentally benign lubricants due to environmental pollution, so water as a lubricant is again receiving significant attention. Recently, water-based lubricants formulated with suitable additives, such as ionic liquids, have shown promising tribological performance. The present work investigated the effect of water-miscible, phosphonium-based ionic liquid with varying concentrations as additives for water-based lubricants. Results showed that the friction, wear, and corrosion performance was significantly increased by incorporating phosphonium-based ionic liquid additives. The mechanisms for improved performance were investigated.

3668970: Tribological Performance of Burnished Lamellar Solid Lubricants in Low Viscosity Hydrocarbons

Euan Cairns, Aditya Ayyagari, Diana Berman, Samir Aouadi, Andrey Voevodin, The University of North Texas, Dripping Springs, TX, Stephen Berkebile, US DEVCOM ARL, Aberdeen Proving Ground, MD

Transitioning to a multi-fuel capability of modern combustion engines has generated a need for new sources of lubrication inside fuel pump assemblies. Low-viscosity fuels pose a tribological challenge when used in fuel injection systems, as they provide lower lubricity when compared to diesel fuels. Lamellar solid lubricants may become a secondary source of lubrication when applied to such components. However, their tribological behavior in fuel environments is unknown. In this report, we compared wear performance of several lamellar solid lubricants tested in ethanol and dodecane environments. The results showed that the tribological performance of the solid lubricants depends on their composition and environment. MoS2 coatings provide the best performance overall. Possible lubrication mechanisms are discussed. The discussions of these mechanisms are supported with SEM/EDS and Raman spectroscopy analyses of the tribological contacts.

3669033: Nanotribology of High Entropy Alloy Thin Films

Gokay Adabasi, Mehmet Baykara, University of California, Merced, Merced, CA, Koichi Tanaka, Aditya Deshpande, Suneel Kodambaka, University of California, Los Angeles, Los Angeles, CA

High entropy alloys (HEAs), consisting of five or more principal elements in similar equimolar ratios, are gaining rapid attention from the scientific community thanks to their intriguing combination of attractive mechanical properties with high thermal and chemical stability. In thin film form, HEAs exhibit potential for use as wear-resistant coatings that could endure harsh environmental conditions. Motivated in this fashion, we explore the fundamental tribological properties of HEA thin films ((VNbTaMoW)S2) on the nanoscale by way of atomic force microscopy experiments. In particular, we are able to observe connections between local film morphology and frictional behavior, opening the door to detailed studies of structure-property relationships in the nanotribology of HEA thin films.

Early Career and Student Posters

3669343: Protic Ionic Liquids and Mxene Nano-Layers for Sliding Steel-Ceramic Contact

Brandon Stoyanovich, Rochester Institute of Technology, Miami, FL

Frictional loses and wear are inevitable means in machine life. The researchers have been trying to minimize wear reductions and decrease frictional coefficients for quite some time. External lubricants have been known to increase efficiency and longevity of machinery. Ionic liquids have been proven to be successful neat lubricants or additives. Moreover, 2-D materials have shown important improvements when added to base lubricants. In this tribological study the protic ionic liquid, Eet (2-hydroxyethylammonium 2-ethylhexanoate) is used as a lubricant and lubricant additive across several conditions including Mxene (Fx and Mx). Seven different samples under similar conditions were tested using a ball-on-flat reciprocating tribometer. The use of neat Eet proved to help decrease frictional coefficients and wear. The addition of Mxene layers yielded a significant decrease in frictional coefficients across all conditions. The wear mechanisms and surface interactions will also be discussed.

3689020: Measurement of Foot Plantar Skin Strain Using Digital Image Correlation Methods for Diabetic Foot Assessment

Sarah Crossland, Claire Brockett, Peter Culmer, University of Leeds, Leeds, West Yorkshire, United Kingdom, Alexander Jones, David Russell, Leeds Vascular Institute, Leeds, United Kingdom, Heidi Siddle, Leeds Institute of Rheumatic and Musculoskeletal Medicine, Leeds, United Kingdom

Assessment of diabetic foot ulcer risk is a vital but challenging procedure. Tools to measure plantar pressure exist but these data have limited clinical utility. Plantar shear has promise to better predict ulcer risk but lacks measurement tools and an evidence base. Two methods using Digital Image Correlation (DIC) were developed to assess plantar foot strains during shod and unshod gait. The unshod method uses a speckle pattern applied to the plantar surface of the foot with transference stamping and imaged through a custom glass walkway. For the shod method, a plastically deformable insole with speckle patterned upper surface was developed through laboratory studies prior to a pilot study with three participants. In both methods, plantar strains were derived using DIC and segmented into anatomical regions for analysis. A pilot study with six participants was conducted, results show peak strains aligned with areas of high pressure and ulceration particular to each participant.

3746385: Metal-Ceramic Thick Coatings Through Controllable Flash Heating

Peter Renner, Hong Liang, Texas A&M University, College Station, TX

One of the challenges in producing conventional coatings is to reduce the porosity. Porosity affects coating properties and weakens adhesion between coating and substrate. As such, this research introduces an alternative approach which we have developed known as flash heating. This process uses plasma-induced heat transfer to selectively bond powder to a substrate. Ni-SiC coatings were developed for wear and hardness performance. These coatings have high melting points, but due to the localization of the heat input the coatings can be applied to lower melting point materials such as carbon steels without affecting the substrate. The substrate used was an ASTM A759 (quenched) carbon steel due to its high hardness and good wear performance. Results showed that the hardness in the coatings was increased by 121% compared to the substrate. Meanwhile, wear rate was reduced by as much as 80% in the coatings with respect to the substrate when an Al_2O_3 counterpart was used. Pure SiC coatings were also fabricated to show some limitations of this flash heating technique. The SiC coatings showed Fe diffusion from the substrate during coating fabrication which reduced the coating performance compared to the Ni-SiC coatings.

3745941: Tribometer Design Project

Anthony Krcik, Miami University, Oxford, OH

The subject of the proposed poster is a tribometer design project for an existing tribometer used to simulate automotive transmissions for the purpose of testing different oils and oil temperature to achieve the lowers wear rate possible. Currently the tribometer uses a load screw on the top of the chamber to apply a load to the clutch plates and a load cell to measure the force driven by a single speed DC motor. There is a torque cell on the vertical shaft connected to the underside of the chamber. Over the next two months, the goal is to modify the device by adding speed control, more precise load control, and a heating system to control temperature and better simulate transmission conditions. To do this a DC motor controller must be installed along with a pneumatic system to control force and a heating system. The poster illustrates the calculations made to select proper equipment and the physical modifications to the device. It will also contain relevant data gathered from testing to show the increased experimental possibilities frontier.