Mark Your Calendar!

Cleveland Marriott Downtown at Key Tower, Cleveland, Ohio (USA)

2023 STLE Tribology Frontiers Conference

November 12-15, 2023

Two Conferences Worth of Content in One Location

2023 STLE Tribology Frontiers Conference

Learn about the technical, environmental and social issues that will impact tribology research in the 21st Century.

For the seventh year, STLE is convening an international community to share tribology's most cutting-edge research. Engage with tribology's top minds and leave with a better understanding of how your company's products will fit into an ever-evolving technical future.

Conference Highlights:

- Daily Keynote Presentations
- Invited "Spotlight" Talks by noted Principal Investigators
- AI and Machine Learning in Tribology Session
- Early Career and Student Research Poster Competition
- "Beyond the Cutting Edge" Special Symposium (organized by the editors of Tribology Letters)

2023 STLE Tribology & Lubrication for E-Mobility Conference

Explore the latest technical challenges and commercial opportunities that will impact the future of electric vehicle technology.

Conference Highlights:

- Expert-led Presentations from Leading Companies and Organizations with an Interest in E-Mobility
- Networking Opportunities
- Panel Discussions on State-of-the-Art Developments in Electric Vehicle Technology and Lubrication
- Corporate Sponsorships

Watch for more information to come soon!

Visit **www.stle.org** for program updates.

stle
connect • learn • achieve

Society of Tribologists and Lubrication Engineers
840 Busse Highway, Park Ridge, Illinois 60068 (USA)
P: (847) 825-5536 | Web: **www.stle.org** | Email: **information@stle.org**
Follow us on:

THURSDAY

Call for Presentations

stle
MINNEAPOLIS
May 19–23, 2024

78th STLE Annual Meeting & Exhibition
Minneapolis Convention Center
Minneapolis, Minnesota (USA)

STLE's Annual Meeting & Exhibition is the industry's most respected venue for technical information, professional development and international networking opportunities. Each year STLE's conference showcases some 500 technical presentations, applications-based case studies, best practice reports and discussion panels on technical or market trends.

Education courses support professional development and prepare qualified individuals for STLE's certification programs. The annual trade show and Commercial Marketing Forum spotlight the latest products and services of interest to lubrication professionals.

Abstract Submission
If you are interested in presenting at STLE's 2024 Annual Meeting & Exhibition, submit a 100-150-word abstract at **https://stle2024.abstractcentral.com**. The list of topic areas is at the website as well. The call for presentations will be open by Aug. 1, 2023, and abstracts are due **Oct. 3, 2023.** Notification of acceptance will be sent in December 2023. While you do not need to prepare a full manuscript to be included on the meeting technical program, you are invited and encouraged to submit a manuscript for review and possible publication in STLE's peer-reviewed journal, Tribology Transactions.

For more information, please contact: **Genevieve Hedland-Hill** ***ghedland@bacon-hedland.com*** **630-428-2133**

If you're interested in exhibiting, sponsorship and other promotional opportunities through STLE, please contact Tracy Nicholas VanEe at ***emeraldcomminc@yahoo.com*** or 630-922-3459.

stle
• connect • learn • achieve
Society of Tribologists and Lubrication Engineers
840 Busse Highway, Park Ridge, Illinois 60068 (USA)
P: (847) 825-5536 | F: (847) 825-1456 | www.stle.org | information@stle.org
Follow us on:

Overview

Download the STLE Mobile App for the most up-to-date schedule. (pg. 15)

Thursday, May 25

Registration
6:30 am – 12:00 pm – **Convention Center Foyer**

Speakers Breakfast
7:00 am – 8:00 am – **Grand Ballroom**

Education Courses* (8:00 am – 5:00 pm)

- Electric Vehicles – **104B**

Technical Sessions (8:00 am – 12:00 pm)

7A • Lubrication Fundamentals VII: Nanoparticles and Coatings – **101A**
7C • Seals I – **102A**
7E • Tribochemistry IV – **102C**
7F • Biotribology I – **103A**
7G • Tribotesting III – **103B**
7H • Commercial Marketing Forum VII – **103C**
7I • Electric Vehicles VII – **104A**
7J • Metalworking Fluids V – **201A**
7K • Surface Engineering III – **201B**
7L • Grease III – **202A**
7M • Wear II – **202B**

Refreshment Break
10:00 am – 10:30 am – **Foyer**

Lunch (on your own) – 12:00 pm – 1:30 pm

Technical Sessions (1:30 pm – 6:00 pm)

8C • Seals II – **102A**
8F • Biotribology II – **103A**
8G • Tribotesting IV – **103B**
8I • Electric Vehicles and Engine and Drivetrain VIII – **104A**
8L • Grease IV – **202A**
8M • Wear III – **202B**

Refreshment Break
3:00 pm – 3:30 pm – **Foyer**

TIME	SESSION 7A Lubrication Fundamentals VII Room 101A		SESSION 7C Seals I Room 102A
8:00 am – 8:30 am	Influence of Lubricant Additive Urea-ZrP on Viscosity, K. Arole, p. 150		Modeling and Simulation of the Dynamic Sealing and Lubrication Mechanism of Rotary Shaft Seals, J. Grün, p. 151
8:30 am – 9:00 am	Macro Topography Effect on Friction in Presence of Surface Textures in Conformal Contacts, G. Vaitkunaite, p. 150		A Secondary Self-Opening Start-Up Clearance Seal, J. Tang, p. 151
9:00 am – 9:30 am	Tribological Properties of MoS_2 & Doped-MoS_2 Spray Coatings in Low Viscosity Hydrocarbons, E. Cairns, p. 150		Endurance Testing of Cylinder Rod and Piston Seals, P. Michael, p. 151
9:30 am –10:00 am	Tribological Properties of h-BN, Ag and MgO Nanostructures as Lubricant Additives in Vegetable Oils, M. Oramas, p. 150		Radial Lip Seal Friction Torque – A Suitable Lubricant-Elastomer Compatibility Indicator?, C. Wilbs, p. 151
10:00 am – 10:30 am	Break	Break	Break
10:30 am – 11:00 am	Performance and Lubrication Mechanism of New TiO_2 Particle-Based High-Performance Lubricant Additives, F. Dassenoy, p. 150		Rheological Sealing Material, H. Xu, p. 152
11:00 am – 11:30 am	Influence of the Dispersant on the Tribological Performance of MoS_2 Nanoparticles Used as Lubricant Additives, M. Benmansour, p. 150		A Test Rig for Performance Evaluation of Dry Gas Seals with Choked Flow, P. Jolly, p. 152
11:30 am – 12:00 pm	Balance Between Zirconia Antiwear Tribofilm's Growth and Removal is Tuned via Cooperative Behavior with Co-Additives, P. LaMascus, p. 151		Tribological Challenges of High Pressure H2 Compression Using Reciprocating Industrial Compressors, T. Ozkan, p. 152
			SESSION 8C **Seals II** **Room 102A**
1:30 pm – 2:00 pm			Modelling of the Pumping Rate Behavior of Shaft Sealing Counterfaces, M. Engelfried, p. 165
2:00 pm – 2:30 pm			Experimental Study of a Reverse Pumping Spiral Groove Face Seal, A. Medjahed, p. 165
2:30 pm – 3:00 pm			Tolerance Analyses on the Geometrical Parameters of Surface Textured Seals, M. Brase, p. 165
3:00 pm – 3:30 pm	Break	Break	Break
3:30 pm – 4:00 pm			Experimental Determination of the Benefits of Textured Mechanical Seals on the Service Life of Systems, L. Amami, p. 165
4:00 pm – 4:30 pm			Measurement of Leakage and Visualization of Seal Surface of Dry Gas Seals with a Simple Inner Ring Groove, M. Ochiai, p. 165
4:30 pm – 5:00 pm			Radial Shaft Sealing System Failure Mode – Shaft Lead, A. Heinl, p. 166
5:00 pm – 5:30 pm			Seals Business Meeting

SESSION 7E Tribochemistry IV Room 102C	SESSION 7F Biotribology I Room 103A	SESSION 7G Tribotesting III Room 103B	
Tribocorrosion in FLiNaK Molten Salt, J. Qu, p. 152	Optimizing Oral Lubrication Properties of Plant Proteins by Microgelation for Improved Functionality and Fat-Replacement, B. Kew, p. 153	Development of a Novel Sled Tribometer, J. Sandberg, p. 156	**8:00 am – 8:30 am**
Ultrahigh Tribocorrosion Resistance of Metals Enabled by Nano-layering, W. Wang, p. 152	Comparing Stiffness and Lubrication Properties of Triple Network Hydrogels to PAMPS/P(NIPAAm-co-AAm) Hydrogel and Ex-Vivo Cartilage, N. Ali, p. 153	Synergistic Influence of Epoxidation and Solid Lubricant Additives Incorporation on the Lubrication Performance of Inedible Mustard Oil, S. Sikdar, p. 156	**8:30 am – 9:00 am**
Novel Tribo-Corrosion Mechanisms of Laser Shock Peened Steel Manufactured by High-Pressure Deposition Additive Manufacturing Process, A. Ralls, p. 152	Modelling the Interaction Between Skin and Products with Application to Tactile Perception, M. Masen, p. 154	In Situ Deposition of Protective Films via Metastable Additive Molecules Carried into Sliding Interfaces by Lubricant Flow, H. Wise, p. 156	**9:00 am – 9:30 am**
Mechanochemical Decomposition of Tricresyl Phosphate (TCP) Between Sliding Ferrous Surfaces, E. Ogbomo, p. 153	Development of a Synthetic Skin Test Bed for the Assessment of Beauty and Personal Care Product Consumer Experience, P. Bramley, p. 154	Ball-on-Disk Tribological Testing in the Presence of an Electric Field, S. Thrush, p. 156	**9:30 am –10:00 am**
Break	**Break**	**Break**	**10:00 am – 10:30 am**
Aircraft Turbine Oil Antiwear Additive Reactivity with Aerospace Bearing Steels, A. Fletcher, p. 153	The Effectiveness of Chalk as a Friction Modifier for Finger Pad Contact with Rocks of Varying Roughness, K. Tomlinson, p. 154	Tribological Properties of Nanocrystalline Al-Mg Material Manufactured Using Cold Spray, A. Kushwaha, p. 156	**10:30 am – 11:00 am**
Off-Lattice Hybrid Kinetic Monte Carlo (kMC) Modeling of Film Growth at Solid-Liquid Interfaces, S. Ntioudis, p. 153	A Study on the Role of Synovial Fluid Constituents in Boundary Lubrication Mechanism at Articular Cartilage Surface, W. Li, p. 154	Tribological Performance of Aluminum Sheet Forming Lubricants, D. Sanchez Garrido, p. 157	**11:00 am – 11:30 am**
	Oral Frictional Properties of Plant and Eairy Proteins: Role of Saliva, F. Brown, p. 154	Comparison of Tribometer Reciprocating Performance Under Identical Conditions, C. Frazier, p. 157	**11:30 am – 12:00 pm**

	SESSION 8F Biotribology II Room 103A	SESSION 8G Tribotesting IV Room 103B	
	Haptic Tribometer Characterizing the Dynamic Contact Between the Human Finger and the Automotive Touchscreen, R. Shyti, p. 166	Grinding Method Process Under Lab Conditions to Evaluate Railway Microstructural Response, L. Wilches Peña, p. 168	**1:30 pm – 2:00 pm**
	Cellular Responses to Frictional Shear Stress, A. Pitenis, p. 166	Cast Iron Chef: The Final Season, A. McGhee, p. 168	**2:00 pm – 2:30 pm**
	Biotribological Characterization of the Physical Mechanisms at the Astringency Sensation Origin, I. Ammam, p. 166	Effect of Gas Environment and Test Speed on Reciprocating Wear Testing for Compressor Packing Seal Materials, J. Penaranda, p. 168	**2:30 pm – 3:00 pm**
Break	**Break**	**Break**	**3:00 pm – 3:30 pm**
	Biotribological Behavior of MXene-UHMWPE Composites, M. Marian, p. 166	Tribological Behavior of Bearing Materials in Water-Based Lubricants, J. Bosch Giner, p. 169	**3:30 pm – 4:00 pm**
	Investigating the Tribological and Corrosion Behavior of Co-Cr Alloy as an Implant Material for Orthodontic Applications, S. Saha, p. 168		**4:00 pm – 4:30 pm**
	Photo-Responsive Hydrogel Lubricity, A. Chau, p. 168		**4:30 pm – 5:00 pm**
	DECMA-1 Influence on the Mechanical and Tribological Properties of MDCK Monolayers, E. Guo, p. 168		**5:00 pm – 5:30 pm**

THURSDAY >>

TIME	SESSION 7H Commercial Marketing Forum VII Room 103C	SESSION 7I Electric Vehicles VII Room 104A	SESSION 7J Metalworking Fluids V Room 201A
8:00 am – 8:30 am	Locus Performance Ingredients – Learning to Utilize Biobased Sophorolipids in Metal Cleaning and Degreasing at Neutral pH, G. Smith, p. 157	High-Speed Elastohydrodynamic Traction and Film Thickness in Electric Vehicle Transmissions, A. MacLaren, p. 158	Advances in Bio-Based Metalworking Fluids – Addressing Formulation Challenges by Balancing the Use of Additives, L. Tekath, p. 160
8:30 am – 9:00 am	Chevron Oronite – Demonstration of H2-ICE Capable Engine Oil, D. Bansal, p. 157	Optimizing Electric Vehicle Transmission Efficiency Using a Thermally Coupled Gearbox Lubrication Model, J. Shore, p. 158	Application of High-Speed Tribology to Evaluate the Performance of Cutting Fluids on Ti-6Al-4V Under Machining Conditions, J. Secker, p. 160
9:00 am – 9:30 am	Nouryon – Nextgen Natura Derived Friction Modifiers, A. Jose Ortiz, p. 157	Study on the Discharge Behavior of EV Motor Bearings, L. Guo, p. 158	Enhancing Lubricity for Increased CGI Machining Speeds, A. Hadler, p. 160
9:30 am –10:00 am	PCC-Chemax – Novel Antiwear and Extreme Pressure Additives – A Designed Performance, D. Cooper, p. 157	Numerical Investigation of the Influence of Pitting Size on Electrical Properties of Roller Bearings, A. Zaiat, p. 158	Next-Generation Antiwear for Metalworking Fluids, L. Luz, p. 160
10:00 am – 10:30 am	Break	Break	Break
10:30 am – 11:00 am			
11:00 am – 11:30 am			
11:30 am – 12:00 pm			

TIME	SESSION 8I EV and Engine & Drivetrain VIII Room 104A
1:30 pm – 2:00 pm	Ring-Liner Testing in a Hydrogen Environment, P. Lee, p. 169
2:00 pm – 2:30 pm	The Engine Oil Effect on Fuel Economy Improvement in Different Test Types, K. Yang, p. 169
2:30 pm – 3:00 pm	Development and Testing of a Variable Hardness Piston Ring Coating for Improved Run-In, P. Lee, p. 169
3:00 pm – 3:30 pm	Break
3:30 pm – 4:00 pm	Electric Vehicle Fluid Interactions in AC and DC Environments, A. Velasquez, p. 169
4:00 pm – 4:30 pm	High-Temperature Thermoplastics in Electric Drivetrain Bearings, K. Farokhzadeh, p. 169
4:30 pm – 5:00 pm	How to Improve Engine Lifetime by Use of Premium Fuel, N. Doerr, p. 170
5:00 pm – 5:30 pm	Novel Sustainable Low-Viscosity Synthetic Base Fluids for E-Mobility, M. Liang, p. 170
5:30 pm – 6:00 pm	High Performance Synthetic Lubricants Designed for High-Speed e-Mobility Application, P. Ma, p. 170

SESSION 7K Surface Engineering III Room 201B	SESSION 7L Grease III Room 202A	SESSION 7M Wear II Room 202B	
		New Amine Phosphate Esters as Multifunctional Antiwear Additives, J. Dixon, p. 164	8:00 am – 8:30 am
	Grease Patterns After Rolling Contact, H. Qi, p. 162	RNT Wear Testing with Ultra-Low Viscosity Engine Oil on Full Bench Engine, M. Eggenstein, p. 164	8:30 am – 9:00 am
Making Surface Texture Meaningful: Case Studies in Surface Analysis for Tribological Applications, M. Malburg, p. 162	Dissipative Particle Dynamics Simulations of Thickener Fiber Formation Process and Behavior Under Shear Flow, H. Yanagisawa, p. 163	Wear of Aerospace Bearing Steels in Lubricated Reciprocating Tribotesting, M. Kirsch, p. 164	9:00 am – 9:30 am
How Can We Avoid PET Bottle Pile-Ups During Conveying by Better Understanding Friction and Adhesion Phenomena?, E. Georgiou, p. 162	Visualization of Grease Fluidity in a Ball Bearing Using Neutron Imaging Technology, K. Sakai, p. 163	The Use of the MTM Rig for Wear Testing, M. Smeeth, p. 164	9:30 am –10:00 am
Break	Break	Break	10:00 am – 10:30 am
Tribology: Adhesion, Friction, and Socioeconomy, P. Tomar, p. 162	Analyzing Wear and Additive Elements in Greases: XRF, RDE-OES or ICP-OES?, C. Rohbogner, p. 163	Effects of Trace Moisture Content on Tribo-Film Formation, Friction and Wear of CF-Filled PTFE in High-Purity Hydrogen, Q. Chen, p. 164	10:30 am – 11:00 am
Stick-Slip Friction: Mechanics, Mechanism, and Electroadhesion, P. Tomar, p. 152	Effect of Oxidation on the Lubricating Performance of Greases, G. S. Dodos, p. 163	Enhanced Metal Corrosion of Long-Life Antifreeze Coolants, H. Gao, p. 164	11:00 am – 11:30 am
	Film Thickness in Grease Lubricated Bearings: Effects of Grease Filling, Bearing Size and Grease Properties, P. Shetty, p. 163	Local Contact Pressure Governs Mild Wear Mechanisms at Multi-Asperity Interfaces, C. Leriche, p. 165	11:30 am – 12:00 pm

	SESSION 8L Grease IV Room 202A	SESSION 8M Wear III Room 202B	
	Quantum-Leap Grease Formulation Through Preform Chemistry, N. Iderkou, p. 170	An Investigation into the Tribological Performance of Wear Resistant PVD Coatings . . . , R. Lal, p. 171	1:30 pm – 2:00 pm
	Best Practices for Making Urea Grease from a Powdered Thickener, L. Huffman, p. 170	. . . Characteristics of Pitch & Poly-acrylonitrile-Based Carbon-Carbon Composites in Air and Nitrogen Environment Under Aircraft Taxi Conditions, A. Sharma, p. 171	2:00 pm – 2:30 pm
	Influence of Grease Thickener Types on the Film Formation, T. Kamihata, p. 170	Wear Characteristics of ZDDP Tribofilm, A. Fome, p. 171	2:30 pm – 3:00 pm
Break	Break	Break	3:00 pm – 3:30 pm
	Evolution of an Advanced Method for Characterization of Thermo-Oxidative Grease Failure, M. Matzke, p. 171		3:30 pm – 4:00 pm
	Oxidation and Grease Life in Rolling Bearings, P. Lugt, p. 171		4:00 pm – 4:30 pm
			4:30 pm – 5:00 pm
			5:00 pm – 5:30 pm

Session 7A | 101A

Lubrication Fundamentals VII: Nanoparticles and Coatings

Session Chair: Abhishek Kumar, University of California, Merced, Merced, CA

Session Vice Chair: Ramoun Mourhatch, Chevron Oronite LLC, Richmond, CA

8:00 am – 8:30 am

3831473: Influence of Lubricant Additive Urea-ZrP on Viscosity

Kailash Arole, Yan Chen, Adolfo Delgado, James Hubbard, Hong Liang, Texas A&M University, College Station, TX

Understanding the effects of functionalized nanoparticles on viscosity is fundamentally important to develop novel lubricants. In this research, we investigate the two-dimensional (2D) nanop0articles Zirconium phosphate (α -ZrP) functionalized by urea. Fluidic behavior was studied focusing on viscosity. Experiments were conducted using a rheometer with applied electric field. Results showed that the addition of nanoparticles reduced fluid shear and viscosity. While applying an electric field, viscosity further changed, i.e., increase.? Analysis indicated that the generation of dipoles in urea modified ZrP particles was responsible for the increase. Such change is attributed to the reorganization of those particles after applying the electric field. This presentation discusses the details of the alteration and principles behind it.

8:30 am – 9:00 am

3805242: Macro Topography Effect on Friction in Presence of Surface Textures in Conformal Contacts

Gerda Vaitkunaite, Erik Hansen, Johannes Schneider, Bettina Frohnapfel, Peter Gumbsch, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Surface textures have a proven effect on extending hydrodynamic regime features in mixed lubrication by improving load carrying capability of lubricant flow. However, the complex multi-physics and multi-scale interactions of textures in conformal contacts are not fully understood. Macrogeometry effects are often left out of consideration in the literature, even though their characterization is essential for the friction behavior. Thus, in this work, we propose pathways to control and observe macro topography features (waviness, pitch angle, curvature) and surface texturing effects on the Stribeck curve. The experimental pin-on-disk tribometer findings indicate that the combination of these effects can reduce friction up to 60% in the mixed lubrication regime. The experimental observations are extended by the numerical model presented in the abstract 3804989, which gives a new insight into a reproducible and robust design of macro topography and surface textures in conformal contacts.

9:00 am – 9:30 am

3824576: Tribological Properties of MoS_2 & Doped-MoS_2 Spray Coatings in Low Viscosity Hydrocarbons

Euan Cairns, Samir Aouadi, Diana Berman, Andrey Voevodin, University of North Texas, Denton, TX; Stephen Berkebile, US Army DEVCOM Army Research Laboratory, Aberdeen Proving Ground, MD

Emerging low carbon emission fuels, such as ethanol and synthetics, lead to a growing need for materials that can increase wear life of fuel pump components. Solid lubricants, such as molybdenum disulfide (MoS_2), can provide excellent tribological properties under specific environmental conditions. Previously, MoS_2 was found to have potential to be used, as a protective coating, in low viscosity hydrocarbon fuels. A coefficient of friction of less than 0.1 was seen in dodecane (a synthetic surrogate) and maintained for 100 m of sliding, whereas in ethanol, fast coating failure occurred. In this report, we show incorporation of dopant particles improves resistance of MoS_2 to failure in ethanol, where a low coefficient of friction is maintained for the duration of the test. Analysis of wear tracks and counterbody scars were performed using profilometry, optical microscopy, Raman and X-ray photoelectron spectroscopy, possible lubrication mechanisms are discussed.

9:30 am – 10:00 am

3834300: Tribological Properties of h-BN, Ag and MgO Nanostructures as Lubricant Additives in Vegetable Oils

Maria Victoria Granja Oramas, C. Fred Higgs III, Rice University, Houston, TX; Kollol Jogesh, Jaime Taha, University of Texas Rio Grande Valley, Edinburg, TX

There exists an ever-growing need for sustainable engineering solutions to improve emission control and energy efficiency of tribosystems. This study examines the tribological properties of two environmentally friendly oils, soybean and sunflower oil, with the addition of three different non-toxic nanostructures (h-BN, silver and MgO) at different concentrations. The friction and wear preventive properties of the mixtures are studied using a four-ball tribometer. The experimental results show that nanoparticles, added to vegetable oils at specific concentrations, exhibit good friction-reduction and anti-wear properties. The best operating mixtures are further studied after the tribological tests using an optical microscope, SEM, and EDX to elucidate the possible mechanisms of anti-friction and anti-wear when using the different nanoparticles.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3811476: Performance and Lubrication Mechanism of New TiO_2 Particle-Based High-Performance Lubricant Additives

Fabrice Dassenoy, Sophie Pavan, Galipaud Jules, LTDS/ECL, Ecully, France; Istvan Jenei, Stockholm University, Stockholm, Sweden; Stephan Wieber, EVONIK, Darmstadt, Germany

There has been growing interest in nanoparticles for tribological applications over the past 20 years. Studies have shown their remarkable lubricating properties, namely friction-reduction and anti-wear, especially when used as lubricant additives. TiO_2 nanoparticles present several advantages. In addition to be easy to produce and to have low preparation cost, they provide good anti-wear properties to the lubricant in some conditions where the performance of other additives are sometimes limited. In this work, the tribological performance of new TiO_2 particle based lubricant additives are presented. The tribofilms generated during the friction tests were characterized using X-Ray Photoelectron Spectroscopy (XPS) and Transmission Electron Microscopy (TEM). The way the TiO_2 nanoparticles additives behave and offer surface protection against boundary contact will thus be discussed.

11:00 am – 11:30 am

3806344: Influence of the Dispersant on the Tribological Performance of MoS_2 Nanoparticles Used as Lubricant Additives

Marina Benmansour, Fabrice Dassenoy, Jules Galipaud, Beatrice Vacher, LTDS/ECL, Ecully, France; Pavel Afanasiev, IRCE Lyon, Lyon, France; Lucile Joly-Pottuz, INSA Lyon, Lyon, France

Nanoparticles (NPs) are interesting lubricant additives to reduce friction. Their sizes allow them to enter easily in the contact. They are also much less chemically reactive than molecular additives. Sulfides NPs exhibit the highest friction and wear reduction. In this work, MoS_2 NPs have been studied in a PAO base oil. Excellent friction reduction properties were

observed at low temperature. However, at high temperature, the Brownian movement is amplified. The nanoparticles leave the contact and their tribological performance are degraded. Thereby, a PIB succinimide dispersant was added. This study aims to evaluate the influence of dispersant on the tribological properties of MoS_2 NPs. Tribological tests were carried out in boundary lubrication regime. Morphological and chemical analysis were made to correlate tribofilm composition, tribological performance and tests conditions. Our study reveals that the dispersant still permits the friction reduction at high temperature.

11:30 am – 12:00 pm

3813207: Balance Between Zirconia Antiwear Tribofilm's Growth and Removal is Tuned via Cooperative Behavior with Co-Additives

Parker LaMascus, Daniel Delghandi, Pranjal Nautiyal, Andrew Jackson, Robert Carpick, University of Pennsylvania, Philadelphia, PA; Meagan Elinski, Hope College, Holland, MI; Julia Griffin, Mount Holyoke College, South Hadley, MA; Lei Zheng, Robert Wiacek, Pixelligent, LLC, Baltimore, MD

Anti-wear additives permit energy efficient lubrication in gearboxes, bearings, and other tribological interfaces. We study ZrO_2 nanocrystals, which form anti-wear tribofilms in sliding regions. We extend prior work by examining the growth kinetics of ZrO_2 tribofilms with and without S- and P-based co-additives at a variety of realistic slide-roll-ratios. In a Mini Traction Machine (MTM) tribometer, we observe that ZrO_2 tribofilm growth is often interrupted, highlighting a competition between tribofilm growth and removal processes. When ZrO_2 is dispersed alongside co-additives, tribofilm removal intensifies, leading to a smoother morphology once the tribofilm thickness saturates. Since we also tend to observe lower traction when co-additives are present, we posit that smoother tribofilms contribute to greater surface separation. We also find that increased sliding speeds promote faster ZrO_2 tribofilm growth per cycle of contact, as does the presence of co-additives.

Session 7C | 102A

Seals I

Session Chair: Paul Michael, Fluid Power Institute, Milwaukee School of Engineering, Milwaukee, WI

Session Vice Chair: Hanping Xu, Ultool, LLC, Duluth, GA

8:00 am – 8:30 am

3812275: Modeling and Simulation of the Dynamic Sealing and Lubrication Mechanism of Rotary Shaft Seals

Jeremias Grün, Simon Felmeth, Frank Bauer, University of Stuttgart, Stuttgart, Germany

Rotary shaft seals are machine elements subjected to high dynamic loads. Their main task is to prevent undesirable fluid exchange between two areas. On gearboxes, for example, they prevent transmission oil from leaking into the ambient air. If the effect of cavitation is considered, a multiphase flow consisting of the three phases oil, oil vapor and air occurs in the sealing gap. The fluid flow characteristics vary with time and with speed. The aim of this contribution is to present modeling approaches and simulation methods for the computation of the transient multiphase flow in the sealing gap. This comprises the multiscale structural mechanical effects and the microscopic transient fluid flow processes in operation. Finite element analyses are applied to solve the structural mechanics. The flow processes are solved with computational fluid dynamics. Furthermore, experimental approaches for the verification and validation of the presented methods are discussed.

8:30 am – 9:00 am

3831169: A Secondary Self-Opening Start-Up Clearance Seal

Jing Tang, Hanping Xu, Ultool LLC, Duluth, GA; Sevki Cesmeci, Fuad Hassan, Georgia Southern University, Statesboro, GA

The start-up of pressure-generating systems, such as turbines, or other pressurization systems that provide stable pressurized fluid to downstream processes, relies on effective sealing, which in turn is affected by operational pressures. During prolonged start-up, the fluid leakage will result in inefficiency, contamination, and working fluid loss. A secondary self-opening startup clearance seal is proposed that includes a sleeve with a lip around an axis of rotation. The sleeve lip has zero or minimal clearance to the shaft at start-up, which helps increase the pressure of the pressures generating fluid system and can deform at nominal system pressure to create openings to eliminate friction and wear. The addition of secondary self-opening start-up clearance seal can shorten start-up time, reduce leakage and improve energy efficiency.

9:00 am – 9:30 am

3834075: Endurance Testing of Cylinder Rod and Piston Seals

Paul Michael, Fluid Power Institute, Milwaukee School of Engineering, Milwaukee, WI

Hydraulic cylinders convert the flow produced by a positive displacement pump into mechanical energy in the form of linear velocity and force. Long life can be achieved by cylinders when losses due to seal leakage are minimized. Control of leakage losses in cylinders requires an understanding of piston and rod seal wear. Piston and rod seal test rigs were constructed to permit the simultaneous evaluation of up to 16 single-acting rod seals and 4 double-acting piston seals. Endurance tests were conducted at high temperatures. Most seals showed minimal deterioration in leakage control throughout the duration of testing. When leakage occurred, it was associated with seal extrusion. Rod seal extrusion produced external leakage. Piston seal extrusion caused internal leakage and loss of cylinder position control. Seal lip profile and surface roughness were found to affect leakage. These findings are useful for improving the reliability and durability of hydraulic cylinders.

9:30 am – 10:00 am

3849023: Radial Lip Seal Friction Torque – A Suitable Lubricant-Elastomer Compatibility Indicator?

Christian Wilbs, Daniel Froelich, Matthias Adler, Freudenberg FST GmbH, Weinheim, Germany

The radial shaft seal (RSS) is a widely used machine element, e.g., in electric drive units or gearboxes in wind turbines to seal lubricants against the environment. Downtimes due to maintenance or even leakages must be avoided as far as possible. In particular, the complex interactions between the lubricant to be sealed and the radial shaft seal have a major influence on the reliability and service life of a radial shaft sealing system. It is therefore essential to ensure lubricant-elastomer compatibility under dynamic tribological stress by dynamic tests. The post-test analyses, e.g., seal wear or changes in material properties, provide information on the lubricant-elastomer compatibility. One possibility is the evaluation of the friction torque of the radial shaft sealing system. The paper presented here is to show how the friction torque measurements correlate with the damage mechanisms due to an existing incompatibility and how to predict the compatibility based on the friction.

10:00 am – 10:30 am – Break

7C

10:30 am – 11:00 am

3833033: Rheological Sealing Material

Hanping Xu, Jing Tang, Aaron Harcrow, Ultool, LLC, Duluth, GA; Jacqueline Johnson, Leonard Lee, Sharon Gray, Terekhov Yuryevich, UTSI, Tullahoma, TN

A rheological seal material is introduced that operates in high temperature applications. It is solid under installed conditions and flows at a threshold pressure. The stress inside the rheological seal material gradually decreases from system pressure to ambient pressure. It neither creeps nor sticks, is flexible to accommodate deformed sealing surfaces, fills microgrooves while maintaining contact for an effective seal, resists damage when rubbed on rough sealing surfaces without unduly increasing leakage due to wear. A test rig was built to detect leakage through a rheological gasket into a vacuum chamber. The results show that the rheological gasket can effectively seal helium at 400°C. Further material analysis reveals that the rheological gasket is stabilized at 1200°C, after 6~8% weight loss. Potential applications include, but are not limited to, sealing applications at temperatures above 400°C. Distribution is unlimited/ AFRL-2022-5168; Cleared 10/26/2022.

11:00 am – 11:30 am

3833540: A Test Rig for Performance Evaluation of Dry Gas Seals with Choked Flow

Pascal Jolly, Noel Brunetiere, Institut Pprime – CNRS – Université de Poitiers, Chasseneuil du Poitou, France

The present paper describes the design, construction and commissioning of a test rig dedicated to dry gas lubricated mechanical face seals. It is mainly composed of a 15kW electrospindle connected to a test cell via a torque meter. The maximum rotational speed is 60 krpm. It can operate with compressed air and a pressure differential up to 15MPa. The architecture of the test cell is based on an overhung rotor, supported by two high precision ball bearings, lubricated with grease. Two similar seals are tested in a back-to-back arrangement, with see-through rotating rings for infrared thermography. The stationary rings are textured and made of tungsten carbide. Their inner and outer diameters are 50mm and 64mm respectively. The test cell is equipped with many sensors. Thus, the performance of dry gas seals can be evaluated in severe operating conditions, for instance choked flow condition. The first results are presented.

11:30 am – 12:00 pm

3834144: Tribological Challenges of High Pressure H2 Compression Using Reciprocating Industrial Compressors

Tanil Ozkan, Jonathan Penaranda, Dover Innovation Laboratory, Houston, TX; Burak Bekisli, Dover Precision Components, Woodlands, TX

Safe and cost-efficient gas compression is essential in many industries and hydrogen is expected to have increased market share, as a consequence of decarbonization and sustainability trends in the emerging global energy economy. This presentation discusses the tribological challenges of high pressure H2 compression using reciprocating industrial compressors with special emphasis on high-performance engineering polymers and their composites employed as packing case and cylinder sealing components. Physical, mechanical, thermodynamical and tribochemical aspects of high pressure and high temperature hydrogen environment are considered from a technical perspective. Risk factors and special attributes directly associated with the use of hydrogen such as self-limiting diffusion, voiding, embrittlement, reducing gas effects, rapid depressurization and negative Joule-Thomson effect are also included in this discussion.

Session 7E | 102C

Tribochemistry IV

Session Chair: Nikhil Murthy, US DEVCOM Army Research Laboratory, Aberdeen Proving Ground, MD

Session Vice Chair: TBD

8:00 am – 8:30 am

3808686: Tribocorrosion in FLiNaK Molten Salt

Jun Qu, Xin He, Chanaka Kumara, Dino Sulejmanovic, James Keiser, Nidia Gallego, Oak Ridge National Laboratory, Oak Ridge, TN

In a molten salt reactor, the carbon-encapsulated fuel pebbles that would inevitably contact the reactor's stainless steel (SS) container wall during salt circulation, causing safety concern. In this study, tribocorrosion behavior of graphite sliding against 316H SS in a molten FLiNaK salt was investigated using a bench-scale tribometer. Accelerated wear loss was observed at a higher temperature because of a lower molten salt viscosity and a higher corrosion rate. A salt-starved condition produced more material loss than either the no-salt or the salt-flooded condition because neither a stable tribofilm nor a transfer film could be established in salt-starved conditions, leading to poor wear performance. Surface characterization revealed a chromium-rich top film and a nickel-accumulated but chromium-depleted interlayer on the SS surface inside the wear track, which is distinct from the molten salt–corroded SS surface that experiences chromium depletion as reported in the literature.

8:30 am – 9:00 am

3833050: Ultrahigh Tribocorrosion Resistance of Metals Enabled by Nano-layering

Wenbo Wang, Oak Ridge National Laboratory, Knoxville, TN

Nanostructured metallic multilayers (NMMs) offer great opportunity to simultaneously improve wear and corrosion resistance of metals. In this work, the wear, corrosion and tribocorrosion resistance of NMMs of Al/X (X= Mg, Cu, and Ti) were evaluated through experiments, finite element simulations, and density functional theory calculations. Transmission electron microscopy of deformed and degraded sample surfaces showed characteristic different deformation and degradation mode of all samples, governed by the synergistic effects of the mechanical and corrosion properties of the constituting materials. A finite element based computational model was developed to study the effects of constituting material on the material loss rate under various external mechanical and chemical loads. Finally, density functional calculations provide further insight on the material selection and design criteria for metallic multilayers toward enhanced performance under extreme environment.

9:00 am – 9:30 am

3836499: Novel Tribo-Corrosion Mechanisms of Laser Shock Peened Steel Manufactured by High-Pressure Deposition Additive Manufacturing Process

Alessandro Ralls, Jacob Frizell, Pradeep Menezes, University of Nevada, Reno, Reno, NV

The utilization of cold spray (CS) has greatly reduced the dilapidation of mechanical components used in mechanical assemblies. However, due to the non-uniform deformation of the accelerated particles, defects in the form of voids are quite common. As such, their performance is limited, especially when exposed to chemical-abrasion environments. This creates a need to understand their wear-corrosion mechanisms and how they can be essentially improved. In this work, we study the tribo-corrosion mechanisms of CS coatings and understand how their change in interparticle bonding mechanics can improve their tribo-corrosion performance. By subjecting these coatings to laser shock peening (LSP), it was found that the combination of surface densification and hardness

greatly reduced its wear loss. As such, it was determined that LSP is indeed a viable technique for post-process modification. The critical and novel changes in tribo-corrosion mechanisms were also identified and elucidated.

9:30 am – 10:00 am

3849044: Mechanochemical Decomposition of Tricresyl Phosphate (TCP) Between Sliding Ferrous Surfaces

Egheosa Ogbomo, Imperial College London, London, United Kingdom

Studies have shown that the major component of the tribofilms formed from TCP on steel is iron phosphate, which acts as a protective layer rather than polishing the rubbing surfaces. It has also been shown that organic polyphosphate or iron polyphosphates are eventually formed from TCP inside tribological contacts and are ultimately responsible for its antiwear performance on steel surfaces. At high temperature, TCP forms relatively thick (60–100 nm) thermal films on steel surfaces, but thinner tribofilms are usually formed inside rubbing contacts. This project has studied the mechanochemical decomposition of TCP being sheared between two ferrous surfaces (of varying chemistries) using LAMMPS and the ReaxFF force field to attempt to quantify the effects of shear stress and surface chemistry on the formation of the afore-mentioned tribofilms. The simulation conditions have ranged from 1-5 GPa, 300- 700 K, at sliding speeds between 10m/s and 50m/s.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3834074: Aircraft Turbine Oil Antiwear Additive Reactivity with Aerospace Bearing Steels

Alexander Fletcher, Mathew Kirsch, Daulton Isaac, Patrick Hellman, Air Force Research Laboratory, WPAFB, OH; Daesung Chong, University of Dayton Research Institute, Dayton, OH

Phosphate based antiwear additives are commonly found in aircraft turbine oils. These additives provide critical protection for engine mechanical components, such as bearings, in the mixed and boundary lubrication regimes by the formation of a protective tribofilm. One factor influencing tribofilm formation is the steel composition. Previous research indicated that certain bearing steels may be less reactive with phosphate additives leading to an increase of wear in non-EHL regimes. This study examines the reactivity of phosphate antiwear additives with various materials by measuring the post-test antiwear additive concentration. A turbine oil basestock was additized with phosphate antiwear agents. These fluids and the select bearing steels were subjected to long duration sliding-wear experiments inducing triboflim formation and antiwear additive consumption. By measuring the depletion of the additives, the rate of tribofilm formation on the bearing steels can be determined.

11:00 am – 11:30 am

3833624: Off-Lattice Hybrid Kinetic Monte Carlo (kMC) Modeling of Film Growth at Solid-Liquid Interfaces

Stavros Ntioudis, James Ewen, Daniele Dini, Imperial College London, London, United Kingdom; C. Turner, University of Alabama, Tuscaloosa, AL

Antiwear additives contained in lubricants form protective thin films on rubbing interfaces. Such films prevent direct metal-to-metal contact and contribute to the reliable operation of critical modern engineering systems (e.g., engines). The numerical investigation of protective thin films demands a theory capable of capturing significant atomistic processes (e.g., reactions, diffusion, adsorption). Nonetheless, it becomes computationally intractable to deploy methods of atomic level resolution (i.e., ab-initio or bond-order based) to study the properties of thin films beyond the early stages of growth. In this work, we present a hybrid off-lattice kinetic Monte Carlo (kMC) framework that promises to extend the simulation timescales beyond the nanosecond and up to the second/minute timescales. The novel modeling framework is used to study the long timescale morphological as well as structural/chemical properties of thermally grown tricresyl phosphate films on pristine iron surfaces.

Session 7F | 103A

Biotribology I

Session Chair: Marc Masen, Imperial College of London, London, United Kingdom

Session Vice Chair: Angela Pitenis, University of California, Santa Barbara, Santa Barbara, CA

8:00 am – 8:30 am

3832881: Optimizing Oral Lubrication Properties of Plant Proteins by Microgelation for Improved Functionality and Fat-Replacement

Ben Kew, Melvin Holmes, Evangelos Liamas, Anwesha Sarkar, University of Leeds, Leeds, Yorkshire, United Kingdom

With the resource-intense meat industry accounting for over 50% of food manufacturing emissions, plant protein consumption is an inevitable need of the hour. Despite its significance, the barrier to adoption of plant proteins is their off-mouthfeel, associated with high friction and consequently poor lubrication performance. We demonstrate that by transforming plant proteins into physically crosslinked microgels, it is possible to improve their lubricity enormously, evidenced by tribology using biomimetic tongue-like surface with atomic force microscopy, dynamic light scattering, rheology and adsorption measurements (QCM-D). Unprecedented findings supported by numerical modelling reveal that these non-lipidic microgels not only decrease friction in the boundary regime by an order of magnitude compared to native protein but also replicate the lubrication performance of high fat emulsions, thus pave a unique platform in designing next generation healthy, palatable, sustainable foods.

8:30 am – 9:00 am

3834114: Comparing Stiffness and Lubrication Properties of Triple Network Hydrogels to PAMPS/P(NIPAAm-co-AAm) Hydrogel and Ex-Vivo Cartilage

Nabila, Ali, Alison Dunn, University of Illinois at Urbana-Champaign, Urbana, IL, Connor Demott, Melissa Grunlan, Texas A&M University, College Station, TX

Earlier double network hydrogels (DN hydrogels) showed great potential for replacing cartilage. To explore that potential further, we discuss the frictional properties and stiffness of four triple-network hydrogels (TN hydrogels). The first and second networks of all the TN hydrogels are the same as the PAMPS/P(NIPAAm-co-AAm)(DN-AAm) hydrogel. They have four different co-monomers- PAAm (neutral), PAMPS (anionic), PAPTAC (cationic), and PMEDSAH (zwitterionic) as the third network. We compare the stiffness and frictional properties of the TN hydrogels, DN-AAm hydrogel, and cartilage samples. All TN hydrogels show greater elastic modulus than the DN-AAm hydrogel but lower than the cartilage samples except for TN-APTAC hydrogel (1437 kPa). Generally, in both DI water and FBS, the TN hydrogels exhibit a lower friction coefficient than DN-AAm hydrogel and cartilage. These results indicate that the hydrogels' stiffness and frictional properties are controlled by the final network.

7F

9:00 am – 9:30 am

3848864: Modelling the Interaction Between Skin and Products with Application to Tactile Perception

Marc Masen, Imperial College of London, London, United Kingdom

As we interact with objects and surfaces, mechanical stimuli propagate from the skin surface towards the mechanoreceptors, causing neurological signals to be sent to the central nervous system thus initiating a psychological and behavioral response. Cutaneous biotribological phenomena are currently not fully understood, and in this work, we present a numerical model aimed at better understanding tactile perception. This model simulates skin-surface interaction and the transmission of stresses, strains and energy to the tactile mechanoreceptors. The model was used to study a range of scenarios, including the touch-perception of textured surfaces and polymeric films. Touch of textured surfaces is strongly affected by the mechanical interlocking of textures with the fingerprint ridges. In the case of polymer films produce a specific tactile response depending on their adhesive properties, and in special cases stick-slip-like behavior is observed.

9:30 am – 10:00 am

3810768: Development of a Synthetic Skin Test Bed for the Assessment of Beauty and Personal Care Product Consumer Experience

Phoebe Bramley, University of Sheffield, Sheffield, United Kingdom

Beauty and personal care (BPC) products such as moisturizers can play a crucial role in maintaining skin health, treating various skin conditions and for aesthetics. Consumer preferences are widely driven by perceived sensory attributes, e.g., tactile or smell, whether this be during the opening of the product, or during application and drying. Understanding what determines the success of a product in terms of sensory perception therefore constitutes an essential part in the development of skin care products. In this project, a hydrophilic artificial skin model with the topography of human forearm skin was developed. The effect of skin texture, surface energy and hydration on the friction of dry and cream treated skin were evaluated, as well as the effect of time following cream treatment. Results were plotted against attribute ratings obtained through sensory panels, to identify trends and understand the role different skin properties play in the sensory perception of BPC products.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3812383: The Effectiveness of Chalk as a Friction Modifier for Finger Pad Contact with Rocks of Varying Roughness

Katherine Tomlinson, Ben Clarke, Tom Slatter, Roger Lewis, Matt Carre, University of Sheffield, Sheffield, United Kingdom

The application of chalk (magnesium carbonate) in rock climbing is common practice as climbers attempt to improve their grip by removing moisture from their hands with the aim of increasing friction at the finger-rock interface. This study investigated the effectiveness of chalk as a friction modifier by considering a range of rocks in combination with both dry and moist finger pads. The influence of load and surface roughness were considered by using a selection of different rocks (including sandstone, granite, limestone and carboniferous limestone) and a range of normal loads (5N, 10N and 15N). Preliminary results indicate that powdered chalk increases the friction for all finger pad contact with granite and dry finger pad contact with sandstone and limestone, however this increase in friction is not observed when contact is made with carboniferous limestone. This suggests that climbers should observe the rock type and humidity levels when considering the use of chalk in climbing.

11:00 am – 11:30 am

3832875: A Study on the Role of Synovial Fluid Constituents in Boundary Lubrication Mechanism at Articular Cartilage Surface

Wenxiao Li, Takehiro Morita, Yoshinori Sawae, Kyushu University, Fukuoka, Japan

To clarify the role of synovial fluid constituents in boundary lubrication mechanism existing at the articular cartilage surface, the angularly reciprocating tests with a spherical glass probe and fresh articular cartilage specimens were performed over a range of sliding speeds and extremely low contact loads. The contact pair was lubricated with different lubricants containing proteins, hyaluronic acid, and phospholipids as representative synovial fluid constituents to evaluate the lubrication ability of each constituent. Two different treatments: gentle washing with detergent and incubation in NaCl solution were applied to cartilage specimens to remove certain constituents and examine synergistical effects of synovial fluid constituents and the superficial area of articular cartilage. Results of the friction test indicated that serum proteins have an important role to reduce and stabilize the friction under the boundary lubrication condition.

11:30 am – 12:00 pm

3818435: Oral Frictional Properties of Plant and Eairy Proteins: Role of Saliva

Fran Brown, Alan Mackie, Anwesha Sarkar, University of Leeds, Leeds, United Kingdom; Qi He, Jochen Pfeifer, Mondelez International, Reading, United Kingdom

Creamy mouthfeel is often an important sensory attribute in confections, dairy products, sauces, etc. that controls consumer acceptability. Protein fortified food is known to generate undesirable 'dry' mouthfeel, which is more prominent in plant proteins. In vitro techniques using tribology show that 'dry' mouthfeel is linked to lubrication failure. This study used soft tribology to compared boundary friction properties of plant and dairy proteins in both the absence and presence of model saliva (protein: model saliva ratio: 4:1 w/w) to provide a physical mechanism behind such dry perception. Tribo-contact surfaces were glass-polydimethylsiloxane (PDMS) and QCM-D using PDMS-coated sensors and rheology data were used to contextualize results. Results indicated that tribological behavior is largely dictated by the proteins in contact, with addition of saliva only contributing to the dilution affecting mixed lubrication irrespective of the type of proteins.

The expertise, support and products you need for overcoming your formulation challenges.

Get the technical expertise, specialty chemicals and additives you need for innovation, when you need them, from the world's leading specialty chemical producers.

Partner with Sea-Land Chemical Company and get the technical expertise, products and innovative solutions for your chemical supply and product development needs.

Talk With a Sea-Land Technical Expert Today

info.sealandchem.com/STLE-2022

440-871-7887

Visit Us at Booth #221

SEA-LAND®
CHEMICAL COMPANY

Session 7G | 103B

Tribotesting III

Session Chair: Soumya Sikdar, University of Nevada, Reno, Reno, NV

Session Vice Chair: Alessandro Ralls, University of Nevada, Reno, Reno, NV

8:00 am – 8:30 am

3833790: Development of a Novel Sled Tribometer

Joakim Sandberg, Kalle Kalliorinne, Gustav Hindér, Andreas Almqvist, Hans-Christer Holmberg, Roland Larsson, Luleå University of Technology, Luleå, Sweden

Measurements of ski-snow friction is a delicate task due to the nature of snow and the ever-changing environment. In addition, the friction is low, and the equipment must be highly sensitive. Previous works report on tests ranging from small-scale model experiments performed in lab environment to experiments with full-sized skis outdoors. However, not many come close to replicating authentic conditions present during skiing. A novel sled tribometer was developed and the repeatability was evaluated using full-sized skis gliding at relevant speeds (~30 km/h) in a controlled environment indoors. The precision was determined adequate to differentiate between different ski-base structures and preparations. The precision is affected by vibrations induced by launching the sled. Fortunately, the problem can be reduced by launching the sled at a higher speed, and then allowing it to stabilize during deceleration before sampling the data used for analysis.

8:30 am – 9:00 am

3833407: Synergistic Influence of Epoxidation and Solid Lubricant Additives Incorporation on the Lubrication Performance of Inedible Mustard Oil

Soumya Sikdar, Md Hafizur Rahman, Pradeep Menezes, University of Nevada, Reno, Reno, NV

The trend of employing inedible plant-based oils as a base stock for bio-lubricant is rising due to the depletion of fossil fuels and environmental issues. Inedible mustard seed oil is abundantly available for bio-lubricant oil production. However, this oil suffers from poor oxidation stability. This research investigated the modification in inedible mustard oil's lubrication performance by epoxidation reaction as well as the incorporation of two solid lubricant additives namely graphene nanoplatelets (GNP) and hexagonal boron nitride (hBN) to form nano lubricants. These nano lubricants were evaluated for viscosity, presence of different functional groups, wettability, friction, and wear properties. The boundary lubrication regime was chosen for the friction and wear properties. The results from these properties showed improved lubrication performance of the mustard oil that could help in better energy conservation.

9:00 am – 9:30 am

3834203: In Situ Deposition of Protective Films via Metastable Additive Molecules Carried into Sliding Interfaces by Lubricant Flow

Harry Wise, Tobias Martin, Q. Jane Wang, Yip-Wah Chung, Northwestern University, Evanston, IL; Jack Loken, University of Wisconsin-Madison, Madison, WI

Cyclopropanecarboxylic-acid (CPCa), a surface-active, metastable additive, increases the rate of polymerization of hydrocarbon fluids at asperity contacts. Earlier investigations reduced wear on 52100 steel by introducing CPCa in polyalphaolefin (PAO-4). We explore how CPCa dissolved in dodecane, a liquid less viscous than PAO-4, impacts its wear protection on 52100 and D2 steel. Under pin-on-disk tribotesting for CPCa in dodecane, the wear coefficient for D2 is less than that for 52100. We attribute D2's performance to oligomeric/polymeric films catalyzed by more abundant surface chromium oxide. These films reduce wear when CPCa is removed. After tribotesting for 15 minutes with CPCa dissolved in dodecane, then replacing the fluid with pure dodecane, the wear coefficients of 52100 and D2 are less than that for each steel in dodecane for up to 30 and 75 minutes respectively. These observations suggest in-situ CPCa treatment as a strategy for wear protection during boundary lubrication.

9:30 am – 10:00 am

3834073: Ball-on-Disk Tribological Testing in the Presence of an Electric Field

Steven Thrush, Allen Comfort, James Dusenbury, US Army DEVCOM GVSC, Warren, MI

A ball on disk tribometer was augmented with a potentiostat enabling surface potential control to generate an electric field. The disk acts as the working electrode. The platinum wire counter electrode is held in place by a 3D printed ring of an electrically insulative material around the perimeter inside the oil cup. A reference electrode is placed between the working and counter electrode to monitor the electrochemical potential enabling precise control of surface potential. Esters with supporting electrolyte and friction modifiers were used to validate the experimental setup. Under certain surface potentials, friction reductions of as much as 70% were observed and active control of friction performance was achieved by adjusting surface potential. Stribeck curves were generated to understand the lubrication regimes of best performance in the presence of an electric field. Boundary lubrication tests were conducted to test the robustness of formed adlayers.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3834311: Tribological Properties of Nanocrystalline Al-Mg Material Manufactured Using Cold Spray

Amanendra Kushwaha, Manoranjan Misra, Pradeep Menezes, University of Nevada, Reno, Reno, NV

In the present work, nanocrystalline (NC) pure Al and Mg-doped Al materials were manufactured using cryomilling followed by a high-pressure cold spray (HPCS) process. The changes in the crystallite size of the milled powders and bulk samples were determined using the X-ray diffraction technique. The hardness tests of the bulk samples were carried out using a Vickers microhardness tester. Tribological properties were studied using a tribometer. The XRD analysis showed a decrease in crystallite size with increasing cryomilling time. This reduction in crystallite size resulted in increased hardness of the material. The increase in hardness produced a lower coefficient of friction and wear rate. The Mg-doped Al material showed superior hardness and tribological properties compared to the pure Al. The underlying mechanisms for the decrement in crystallite size and its effect on hardness, friction, and wear performance will be discussed.

11:00 am – 11:30 am

3834315: Tribological Performance of Aluminum Sheet Forming Lubricants

Daniel Sanchez Garrido, Novelis, Kennesaw, GA

Lubrication is an essential aspect of sheet metal forming. Currently, forming lubricants have mainly been developed for steel applications. However, as rolled sheet aluminum forming becomes more relevant in the automotive industry, it is important to characterize forming lubricants (current and new products specially developed for aluminum) to better understand their performance and compatibility. Here, various forming lubricants were applied on mill finish and textured aluminum sheets to characterize their tribological performance by measuring forming loads, friction, and surface evolution over a range of pressures. Results enable direct comparison between different forming lubricant types as well as provide valuable information to guide lubricant selection for aluminum sheet forming.

11:30 am – 12:00 pm

3834190: Comparison of Tribometer Reciprocating Performance Under Identical Conditions

Cole Frazier, Southwest Research Institute, San Antonio, TX

A number of different tribometers produced by different manufacturers are available to the industry as tools to understand friction and wear performance of lubricants or materials. While the basic principle of reciprocating testing is fundamentally the same, slight variations in how each tribometer achieves reciprocating conditions may vary tribometer to tribometer. In order to understand potential differences, data was collected on a Bruker UMT, SRV, TE77, and HFRR. Where needed, modifications were made such that all machines could test a 6mm ball and 10mm disk. Reciprocating frequency, temperature, applied load, and stroke length were fixed for all cases. In this presentation, major findings from the collected data will be presented.

Session 7H | 103C

Commercial Marketing Forum VII

Session Chair: TBD

Session Vice Chair: TBD

8:00 am – 8:30 am

3910686: Locus Performance Ingredients – Learning to Utilize Biobased Sophorolipids in Metal Cleaning and Degreasing at Neutral pH

Greg Smith, Locus Performance Ingredients, Richmond, VA

Metal cleaning is a critical function in metals market. Cleansing process and corrosion protection oils prior to coating is required. Legacy cleansing leans heavily on petrochemical based surfactants and solvents. Pressure on VOC's, Proposition 65 trace materials, and carbon footprint is driving the need to review biobased and environmentally friendly options. Technology in bio-based surfactants and solvents is rising to the challenge. Biosurfactants show efficacy in these applications, but the hurdle is to educate and teach formulators how to use new technology in formulations. Presentation will introduce Locus Performance Ingredients' Sophorolipids under our Amphi™ series of products. Formulas using LPI's Sophorolipids and co-surfactants will be reviewed with both tradition and biobased solvents. Claims data on cleaning compared to benchmarks will be presented including formulas, pictures, and quantitative grading of oil removal.

8:30 am – 9:00 am

3930934: Chevron Oronite – Demonstration of H2-ICE Capable Engine Oil

Dinesh Bansal, Chevron Oronite LLC, Richmond, CA

Hydrogen internal combustion engines (H2-ICEs) are being evaluated as a potential pathway to help lower carbon intensity in the transportation and power generation sectors. H2-ICEs offer several advantages to Original Equipment Manufacturers (OEMs); such as retaining the existing engine architecture and hardware, whilst achieving lower carbon emissions.In this presentation, we will demonstrate our efforts to help enable the energy transition by developing additive/lubricant solutions that can assist OEM efforts to deploy H2-ICEs and address the performance challenges they may introduce. Here we share some of the results of the fundamental bench-scale studies showing the effect of hydrogen on additive and lubricant formulations.The findings of our studies will help advance our efforts to offer a robust and reliable lubricant additive technology to OEMs and our customers for use in hydrogen internal combustion engines without increasing the maintenance complexity for the fleet owners.

9:00 am – 9:30 am

3909498: Nouryon – Nextgen Natura Derived Friction Modifiers

Alvaro Jose Ortiz, John Dixon, Nouryon, Houston, TX

Engine oils and transmission fluids will continue to trend to lower viscosity to capture fuel economy benefits. Modern hardware as well as tighter regulations are requiring formulators to use lower sulfur, phosphorus, and ash levels components to assure performance and durability. Nouryon has a more than 20-year track record in developing friction modifiers for the lubricants industry and it keeps innovating. This time, Nouryon will present its latest research on ashless organic friction modifiers focusing on solutions that bring additional benefits and properties as well as synergetic effects when interacting with other components to help its customers optimize the performance of their formulations.

9:30 am – 10:00 am

3909912: PCC-Chemax – Novel Antiwear and Extreme Pressure Additives – A Designed Performance

Denise Cooper, PCC Chemax, Inc, Piedmont, SC

Sustainable production, eco-friendly raw materials, high bio-content, low toxicity on par with excellent performance, stability, seal compatibility, low volatility are some of the key challenges facing manufacturers of modern industrial lubricants. Growing expectations of final users require new solutions and more flexible approach from not only formulators but also raw materials' producers such as PCC Group. This presentation will focus on the architecture of phosphorus-based products – EXOfos and Rokolub used as extreme pressure and antiwear additives. We will specifically discuss impact of molecular design on final products' characteristics. PCC Group has over 40 years of experience in production of additives for: MWF, industrial lubricants and synthetic base stocks. A dedicated R&D team can address and accommodate various requests for new products and offer technical support.

Synthesis and laboratory testing performed at PCC Se Poland.

10:00 am – 10:30 am – Break

Session 7I | 104A

Electric Vehicles VII

Session Chair: Hyeok Hahn, Chevron Lubricants, Richmond, CA

Session Vice Chair: TBD

8:00 am – 8:30 am

3833903: High-Speed Elastohydrodynamic Traction and Film Thickness in Electric Vehicle Transmissions

Alexander MacLaren, Hugh Spikes, Amir Kadiric, Imperial College London, London, United Kingdom

Elastohydrodynamic (EHD) lubrication films in Electric Vehicle (EV) gear tooth and roller bearing contacts frequently operate at high entrainment speeds, where thermal power and high-shear rheological effects lead to excursions from classical film thickness and traction predictions. Quantifying these and correcting classical models for application to high-speed reduction gearboxes with low-viscosity lubricants in EVs, is paramount in the optimization of both efficiency and reliability. In this study, a new test rig, the EHD-HS by PCS instruments, is used to measure film thickness and traction at entrainment speeds up to 20 m/s by optical interferometry in a ball-on-disc contact. Film thickness maps of the contact are also obtained using the Spacer Layer Imaging Method (SLIM). This talk explores key implications of high-speed EHD effects for EV drivetrain efficiency and surface damage, in the context of gear churning losses, for which reliable models at EV-speeds are not yet available.

8:30 am – 9:00 am

3834025: Optimizing Electric Vehicle Transmission Efficiency Using a Thermally Coupled Gearbox Lubrication Model

Joseph Shore, Amir Kadiric, Imperial College London, London, United Kingdom

We present a systematic study to evaluate the effects of lubricant properties and gearbox design on power losses in a typical EV transmission. The study uses an updated, thermally coupled lubrication model to predict gear mesh, gear churning and bearing losses in an EV transmission employed in a popular passenger EV. The model uses measured oil rheology as input allowing it to differentiate between nominally similar oils. A new empirical gear churning model and an updated bearing loss models are employed to account for high speeds encountered in EVs. Predictions are compared to measurements made on the said vehicle during real world driving as well as dynamometer tests. The relative significance of gear, bearing and churning losses under different vehicle operating conditions as well as WLTP cycle are identified and the potential impact of oil properties and gearbox design on these losses is illustrated.

9:00 am – 9:30 am

3825698: Study on the Discharge Behavior of EV Motor Bearings

Liang Guo, Thijs Nijdam, Henk Mol, Lieuwe de Vries, SKF BV, Houten, Netherlands

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 utilizing 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 analysis of the damage surface, the model that explains discharge damage, and potential mitigation measures.

9:30 am – 10:00 am

3807461: Numerical Investigation of the Influence of Pitting Size on Electrical Properties of Roller Bearings

Anatoly Zaiat, Karim Khaled Ibrahim, Marcel Neu, Eckhard Kirchner, Institute of Product Development and Machine Elements, Darmstadt, Germany; Florian Michael Becker-Dombrowsky, Technical University of Darmstadt, Darmstadt, Hesse, Germany

Accurate modeling of the capacitance of rolling element bearings is of increasing significance in recent years, e.g., in the context of bearing damage estimation in electric machines. The capacitance of the elastohydrodynamic contact represents a part of a multi-physical state, which is most influenced by the occurring fluid flow. The occurrence of surface irregularities greatly affect the fluid flow, changing the capacitance in response. As experiments on test rigs show, the occurrence and severity of surface irregularities can be detected in the measured capacitance, allowing a precise assessment of whether and when a bearing needs to be replaced, thus reducing machine downtime and increasing resource efficiency. Therefore, in this work, the influence of pittings on the electrical properties of a two-dimensional line contact is presented for the first time. Depth, width and size ratio of pitting/rolling element are varied and finally the results are compared with real surface damage.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3835060: Electric Vehicle Drive System Specialty Fluids

Anant Kolekar, Valvoline LLC, Lexington, KY

The recent growth in electric vehicle (EV) market has significantly impacted the automotive industry along with the lubricant industry. EV requirements are unique compared to Internal Combustion Engine Vehicles (ICEVs) where electrical, thermal, extreme pressure and foam performances are becoming more critical. Drive System Fluids (DSFs) target vital EV requirements to improve friction reduction, overall efficiency, electrical compatibility and insulation, and electric motor and drive system heat transfer. Tribological testing for EV DSFs are conducted to evaluate the performance and further understand the effect of chemical properties of these specialty lubricants. Different formulations were compared by designing and developing benchtop tests, transmission rigs and full vehicle tests. There were significant improvements in the overall vehicle efficiency (up to 3%) and reductions in operating temperatures (up to 8.5°C).

11:00 am – 11:30 am

3848522: Vehicle Electrification Trends and Traction Inverter

Ayush Lal, Aptiv, Pickering, Ontario, Canada

The presentation will give the audience a background on vehicle electrification, its current scenario and trends in electrification. Later, it will also deep dive in discussion about traction inverter, which is one of the essential components on an electric vehicle as it converts DC current from the battery to AC to drive an electric motor. A portion of the presentation will be discussing about 800V SiC inverters and how cooling plays a critical role in thermal management of inverters. We will be discussing about key industry players in the current scenario and impact of electric vehicles on the environment, including CAFÉ (Corporate Average Fuel Economy) requirement of the US government.

Session 7J | 201A

Metalworking Fluids V

Session Chair: Nicole Clarkson, Barentz North America LLC, Lisle, IL

Session Vice Chair: Bridget Dubbert, Engineered Lubricants Company, Maryland Heights, MO

8:00 am – 8:30 am

3830552: Advances in Bio-Based Metalworking Fluids – Addressing Formulation Challenges by Balancing the Use of Additives

Lea Tekath, Michael Stapels, Kao Chemicals GmbH, Emmerich and Rhein, Germany

This presentation focuses on a systematic approach to enable development of a diverse range of bio-based oil metalworking fluids by balancing the use of different additives. The multifunctional additives identified increase formulator's options to include more sustainable and high-performing components to meet the latest formulation requirements and demonstrate the criticality of using the appropriate emulsifier and amino alcohol chemistry. Novel, eco-friendly and hazard-free metalworking fluids that incorporate bio-based oils are an attractive alternative to mineral oil. Bio-based oils are readily biodegradable, renewable, and have excellent lubricity. However, poor oxidative stability and compatibility with additives creates several formulating challenges. The benefits of the emulsifier and amino alcohol chemistry identified can be explained through structure-property relationships and can be used by formulators to develop metalworking fluids that are sustainable and high-performing.

8:30 am – 9:00 am

3811283: Application of High-Speed Tribology to Evaluate the Performance of Cutting Fluids on Ti-6Al-4V Under Machining Conditions

Jack Secker, Chris Taylor, University of Sheffield, Sheffield, United Kingdom; Edward Jones, Hangsterfer's Labs. Inc., Mantua, NJ

Manufacturers are resistant to changing metalworking fluid due to uncertainty of performance from ineffective testing options. These consist of full-scale production tests, which are resource intensive and overly specific, or traditional benchtop tribometers, which are unable to simultaneously recreate extreme cutting zone conditions. By simplifying tool-workpiece geometry whilst maintaining the high speed and force required to excite extreme pressure additives and generate high temperatures, the pin-on-lathe setup is able to better replicate the lubricant's environment. In this study, a pneumatic piston applies a TiN PVD coated carbide pin in a pin-on-flat type contact on lathe-mounted Ti-6Al-4V tubes. Cutting fluid performance is assessed based on the measurement of coefficient of friction, wear, subsurface damage and tool temperature across a range of speeds, pressures and fluid concentrations to determine the effects of lubricity and heat control compared with traditional tests.

9:00 am – 9:30 am

3833702: Enhancing Lubricity for Increased CGI Machining Speeds

Amelia Hadler, Johnnie Thomlison, Britt Minch, The Lubrizol Corporation, Wickliffe, OH; George Georgiou, GEO2 SQUARED Consulting, Windsor, Ontario, Canada

Compacted graphite iron (CGI) is a material with significant growth projections for use in heavy duty truck, automotive, rail, and marine engine applications due to its high strength and power density. However, the unique metallurgy of CGI makes it significantly less machinable than conventional irons which has negatively affected adoption within the industry. The metallurgical desulfurization of CGI as compared to the lubricating presence of sulfur in conventional irons requires machining speeds of 30% slower and significantly lowers tool life. A series of milling experiments were conducted on CGI using a variety of lubricity additives. These experiments demonstrated that top-performing additives give distinct advantages in CGI machining as measured by tool wear and production speed, indicating that the use of enhanced lubricity additives enables faster CGI machining.

9:30 am – 10:00 am

3808552: Next-Generation Antiwear for Metalworking Fluids

Lucas Luz, Solvay, Paulínia, São Paulo, Brazil

The new generation of machine tools, increasing usage of lighter alloys for weight reduction, and more regulations demanding better classification of chemicals are the drivers to develop new additives to enable fluid formulators to overcome some of today's and future most pressing challenges. Phosphorus technology still plays an important role when it comes to surface protection and although it is a very well-known technology there is still room for innovation. This presentation is going to introduce Phosphorus technologies under development and the relationship between their structures and performances.

10:00 am – 10:30 am – Break

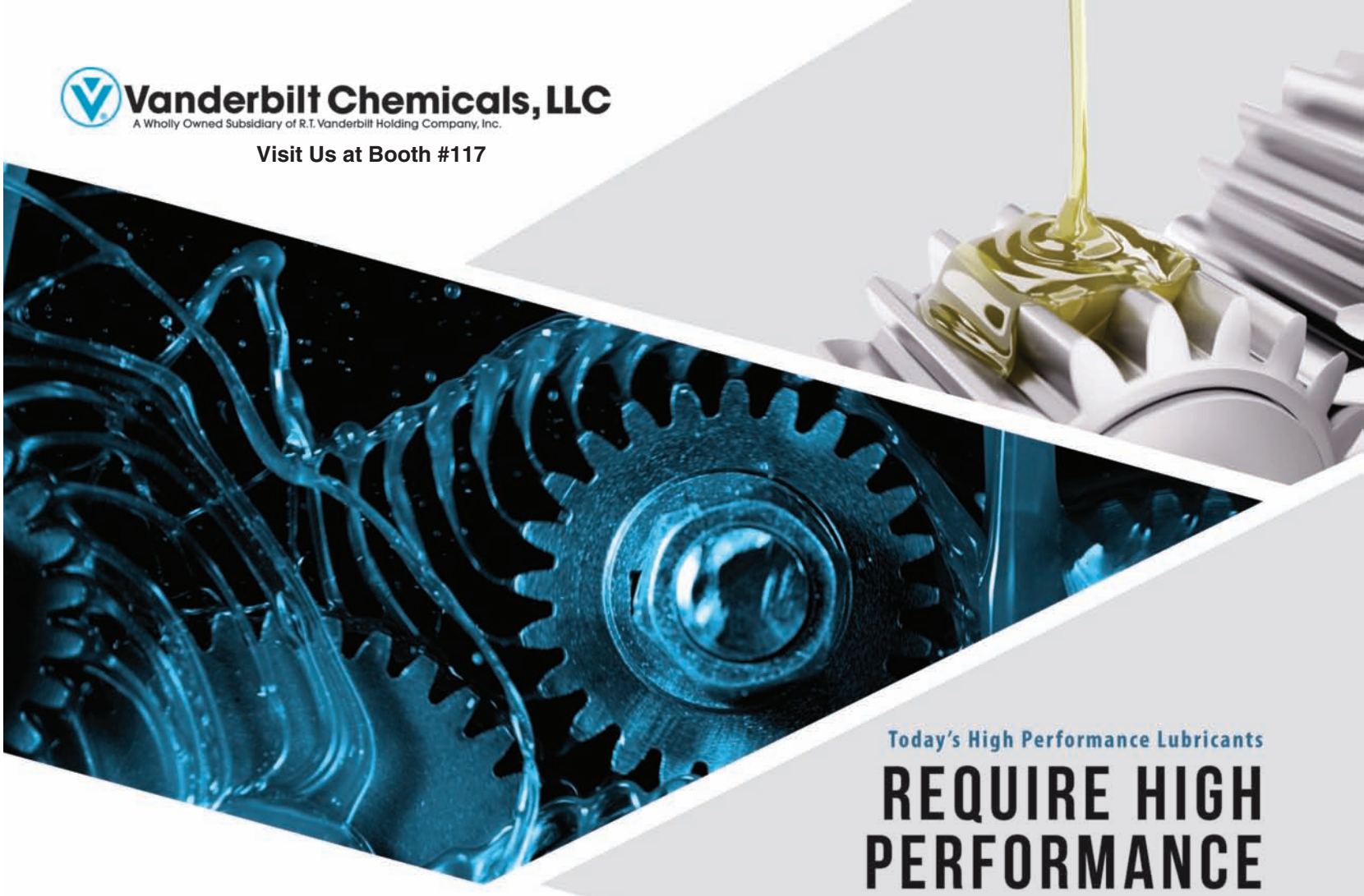
STLE Member Ambassadors …

your connection to the community.

STLE's Annual Meeting welcomes a diverse group of individuals, including long-standing members/attendees, newcomers, and first-time attendees. As an attendee, we encourage you to reach out and connect with our Member Ambassadors, who are fellow industry peers that can help answer general questions about STLE and facilitate introductions to other members of our community, which will provide you an opportunity to network and build relationships. You can connect with these volunteers who will be wearing black **"Member Ambassador"** buttons throughout the week and will also be available at the STLE membership booth in the Convention Center foyer across from the Registration Desk.

Vanderbilt Chemicals, LLC
A Wholly Owned Subsidiary of R.T. Vanderbilt Holding Company, Inc.

Visit Us at Booth #117



Today's High Performance Lubricants

REQUIRE HIGH PERFORMANCE ADDITIVES

WE HAVE OVER 50 LUBRICANT ADDITIVES AVAILABLE TO MEET YOUR SPECIFIC REQUIREMENTS.

Our technical staff can help you create superior products.
Contact us to find out how...

- ANTIOXIDANTS
- FRICTION REDUCERS
- BASESTOCK/ BASESTOCK MODIFIERS
- EP - ANTIWEAR AGENTS
- METAL DEACTIVATORS
- RUST INHIBITORS
- GREASE PRECURSORS

UL REGISTERED FIRM
DQS Inc.
VANDERBILT CHEMICALS, LLC
CERTIFIED TO ISO 9001:2015
10002461

Vanderbilt Chemicals, LLC
A Wholly Owned Subsidiary of R.T. Vanderbilt Holding Company, Inc.
30 Winfield Street, P.O. Box 5150, Norwalk, CT 06856
(203) 853-1400
(203) 853-1452
petro@vanderbiltchemicals.com
www.vanderbiltchemicals.com

Session 7K | 201B

Surface Engineering III

Session Chair: Uday Venkat Kiran Kommineni, University of North Dakota, Grand Forks, ND

Session Vice Chair: Pial Das, University of North Dakota, Grand Forks, ND

Session Starts at 9:00 am

9:00 am – 9:30 am

3804786: Making Surface Texture Meaningful: Case Studies in Surface Analysis for Tribological Applications

Mark Malburg, Digital Metrology Solutions, Columbus, IN

What is the roughness of North America? The answer depends on the context. Do we care about the heights of the mountains or do we care about having traction for our tires. In surface roughness measurement we have a similar problem: modern instruments can measure texture over such a range of shapes and details that the "correct" answer is much harder to define. In this talk we will discuss how advances in surface measurement and analysis, such as resolution, filtering, form removal, etc., both improve results and lead to complications. We introduce approaches to texture analysis that produce meaningful information from the millions of data points. Relevant tribological case studies in lubricant retention, gasket sealing, wear analysis, etc., will explain how to specify and standardize texture analysis to produce consistent, reliable measurement results.

9:30 am – 10:00 am

3812254: How Can We Avoid PET Bottle Pile-Ups During Conveying by Better Understanding Friction and Adhesion Phenomena?

Emmanouil Georgiou, Hellenic Air-Force Academy, Athens, Greece; Dirk Drees, Falex Tribology, Rotselaar, Vlaams Brabant, Belgium; Lais Lopes, Christian Gerlach, Procter & Gamble Services Company S.A., Grimbergen, Belgium

A common problem in bottle manufacturing is the pile-up of bottles during conveying, due to static electrification caused by localized friction. To minimize such phenomena, a thin lubricant layer is applied onto the bottles. The absence of this layer increases the risk of localized sticking phenomena and pileups. In this work, an attempt is made to study the frictional behavior of commercially available PET bottles, with and without lubrication by using a high precision and light load technique. By analyzing the complete tribological pattern of the tangential force and not just averaged values, localized sticking events can be identified. In addition, by performing indentation-retraction measurements the electrostatic forces in a bottle-to-bottle contact can be measured. By combining light load friction and adhesion methods, a better understanding of PET sticking phenomena can be achieved which then can be translated in optimizing (minimizing) the amount of lubricant to be used.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3832761: Tribology: Adhesion, Friction, and Socioeconomy

Pankaj Tomar, IGDTUW/GGSIPU, New Delhi, Delhi, India

Tribology is a science of rubbing for materials and energy balances. The 21st Century is promoting sustainability for advancement of decent work and economic growth. The surface science, supramolecular chemistry of rubbing environment, and mechanical properties integrate TRIBO performance. The surfaces, interfaces, and interphases have been evolved by Nature for bionic functional materials in reducing energy consumptions. The mechanical loading, thermal loadings, biochemistry, and state variables altogether regulate interfacial supramolecular adhesion. The lowering surface energy and surface tension of hydrophobic interface creates a platform for functional non-stick functional coatings. The academic content may summarize socioeconomic retrospective role of tribology for advancement of academic innovation.

11:00 am – 11:30 am

3833336: Stick-Slip Friction: Mechanics, Mechanism, and Electroadhesion

Pankaj Tomar, IGDTUW/GGSIPU, New Delhi, Delhi, India

The stick-slip friction is ubiquitous in daily life for doing mechanical work in gait at slipping and sticking oscillatory contacts. The mechanical interlocking of skin texture on technological substate in a heterogeneous environment is a mechanism for providing stick-slip friction during human kinematics. Static friction of mechanically interlocked interphases is dependent on the real area of contact, asperities shear strength, temperature, and physiochemical indicators. The crushing of asperities peaks under applied or created loadings evolves sticking and slipping boundaries termed stick-slip friction. The stick-slip friction of the violin binds emotional intelligence for the achievement of human performance. The tactile friction, electroadhesion, and man-machine interface of Android mobile phones or smart digital devices have been noticed by author for researching for tribological performance.

Session 7L | 202A

Grease III

Session Chair: William Tuszynski, The Unami Group, Quakertown, PA

Session Vice Chair: Victoria Parker, Sasol Chemicals, Lake Charles, LA

Session Starts at 8:30 am

8:30 am – 9:00 am

3835074: Grease Patterns After Rolling Contact

Hao Qi, L.B. Foster, Burnaby, British Columbia, Canada

Film splitting is a research topic normally studied in the field of fluid mechanics. In an attempt to adopt the results of these studies to railroad grease applications, a series of laboratory experiments were conducted to study the efficiency of grease transfer and tackiness. During the tests, the grease products formed unique patterns after exposure to rolling shear stresses. These patterns align with previous research for so-called grease finger patterns. To further explore this phenomenon, a series of greases were tested using the same condition, including greases with various thickeners and oils. The results show that various greases exhibit distinct unique patters, which we attempted to categorize. These patterns are the result of very delicate physical and chemical interaction between oil and thickeners. It is proposed that this phenomenon and a

simple experimental set-up could be used as an additional tool to advanced techniques.

9:00 am – 9:30 am

3810505: Dissipative Particle Dynamics Simulations of Thickener Fiber Formation Process and Behavior Under Shear Flow

Honami Yanagisawa, Takashi Noda, NSK Ltd., Fujisawa-shi, Kanagawa, Japan; Tomoya Hasegawa, Hitoshi Washizu, University of Hyogo, Kobe-shi, Hyogo, Japan

Elucidating the relationship between microscopic structure and physical properties of lubricating greases is important for the development of high-performance greases. In this study, the formation process of thickener fibers and their behavior under shear flow were simulated by dissipative particle dynamics (DPD). As a result, it was confirmed that thickener fibers are oriented in the flow with dispersing due to shear, which is consistent with the conventional theory. Furthermore, quasi-SAXS simulations were performed for the fiber dispersion state, and it was found that the fiber behavior was calculated by DPD in qualitative agreement with the scattering change measured at SPring-8.

9:30 am – 10:00 am

3811289: Visualization of Grease Fluidity in a Ball Bearing Using Neutron Imaging Technology

Kazumi Sakai, Rui Ogata, Shuhei Yamada, Nobuharu Kimura, ENEOS Corporation, Yokohama, Japan; Yoshihiro Matsumoto, Comprehensive Research Organization for Science and Society, Tokai, Japan; Keisuke Kurita, Japan Atomic Energy Agency, Tokai, Japan

Neutron imaging technique was applied to visualize grease fluidity in bearings which determines the bearing torque property. Two types of lithium (Li) greases with different thickeners (Li complex and single Li soap) were used in this study. The Li complex grease was superior in lowering bearing torque related to energy-saving performance. After bearing rotations, neutron radiography and computed tomography measurements of the greases distributed in the bearings were performed. Adhesion of the Li complex grease to bearing balls was quite limited, and most of the grease stayed on cage surfaces between the balls; adhesion of single Li soap grease to bearing balls was remarkable. The neutron radiography with bearing rotations was also conducted to capture the moment of the grease flow. The observation with bearing rotations revealed that single Li soap grease flows gradually not from the beginning of bearing rotations. Based on these results, the lubrication mechanisms will be proposed.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3811764: Analyzing Wear and Additive Elements in Greases: XRF, RDE-OES or ICP-OES?

Christoph Rohbogner, Thomas Fischer, OELCHECK GmbH, Brannenburg, Germany

The elemental analysis in grease samples is standard in their analysis. However, there is no international standard available describing procedures. Thus, numerous often similar approaches are used in commercial laboratories. We have compared XRF, RDE-OES and ICP-OES analyses of different greases. In contrast to lubricant or fuel analysis, where international standards for OES analyses are published, no such procedures specifically for grease analyses using OES methods have been elaborated so far. Thus, differences in results between laboratories using different methods may be obtained. This is often revealed at round robin tests. We have compared results using XRF, RDE-OES and ICP-OES. The latter method using modern microwave assisted sample preparation.

11:00 am – 11:30 am

3813040: Effect of Oxidation on the Lubricating Performance of Greases

George S. Dodos, ELDON'S S.A., Athens, Greece

The evolution of oxidation products during oxidative deterioration may affect the lubricating properties of greases and thus the proper functioning of the lubricated machinery. In this study, a number of lubricating greases of various contemporary chemistries were employed and were subjected to accelerated oxidative deterioration under identical conditions. FTIR measurements were performed in order to detect relative changes that occur under these oxidizing conditions and to control the degree of oxidation per grease type. Subsequently, the oxidized samples were further analyzed and alterations in their tribological performance were assessed by carrying out determinations mainly under boundary lubrication in a four-ball tester. Differences in other fundamental parameters were also examined (e.g., dropping point, consistency) as part of a more comprehensive comparative assessment.

11:30 am – 12:00 pm

3831450: Film Thickness in Grease Lubricated Bearings: Effects of Grease Filling, Bearing Size and Grease Properties

Pramod Shetty, Robert Meijer, Jude Osara, University of Twente, Enschede, Netherlands; Rihard Pasaribu, Shell Project and Technology, Amsterdam, Netherlands; Piet Lugt, SKF Research and Technology Development, Houten, Netherlands

Film thickness is one of the important parameters that determine grease and bearing life. Understanding the parameters that govern the film thickness in bearings is vital to choose the operating conditions for the bearings. In this study, the film thickness is measured in a deep groove ball bearing using greases having different consistencies, viscosities, and thickeners, with different filling percentages, and in various-sized bearings. Results show that grease consistency has a significant influence on the replenishment of the contact; the low-consistency grease yielded higher film thickness than the high-consistency grease. The bearings of different sizes showed different film thicknesses, indicating that bearing geometry also influences lubricant replenishment in the contact. It is also observed that the initial quantity of grease in the bearing does not affect the film thickness in the early hours of bearing operation.

Session 7M | 202B

Wear II

Session Chair: Mathieu Renouf, Universite De Montpelllier, Montpellier, France

Session Vice Chair: TBD

8:00 am – 8:30 am

3814171: New Amine Phosphate Esters as Multifunctional Antiwear Additives

John Dixon, Ezio Amerio, Alina Filin, Rudy Venderbosch, Nouryon, Deventer, Netherlands

Industry trends and regulations demand a move towards ashless (or low SAPS) additives that ensure wear reduction while enabling the use of lower viscosity oils and improve energy efficiency. In this paper we report the development of a new class of amine phosphate esters as antiwear additives with good oil solubility and low phosphorous content. The lubrication properties are investigated by means of HFRR and the four-ball wear test, which showed excellent wear protection at lower treat rate compared to the industry standard zinc dialkyldithiophosphates (ZDDPs). We show that the selection of the amine moieties not only unlocks the ability to optimize independently wear and friction performances, but provide access to multifunctional AW additives – TBN, detergency, friction modifier. The combination of these attributes makes such products desirable candidates for a variety of lubricant applications including engine oils, hydraulic fluids, transmission oils, EV fluids and greases.

8:30 am – 9:00 am

3814203: RNT Wear Testing with Ultra-Low Viscosity Engine Oil on Full Bench Engine

Matthias Eggenstein, Shell Global Solutions, Hamburg, Germany; Peter Berlet, IAVF Antriebstechnik, Karlsruhe, Germany

Reducing greenhouse gas emissions is a key enabler for mitigating the impact of climate change. Increasing efficiency by lowering friction in available technologies is a quick step. Internal combustion engines (ICE) have significantly increased efficiency over the last decades. The crankcase lubricant plays an important role in reducing the ICE internal friction and improving efficiency. Lower viscosity oils result in thinner oil films reducing friction. However, there is concern very low viscosity may result in wear of engine components, as the oil film breaks, and contacts are operated in mixed or boundary lubrication regimes. Wear testing using the radio-nuclide-technology (RNT) provides precise real time measurement of wear in dedicated contacts. The wear behavior of different engine components has been investigated on a bench engine operated on a SAE 0W-12 engine oil. Various operational points and drive cycles were investigated to understand wear levels depending on operation mode.

9:00 am – 9:30 am

3819630: Wear of Aerospace Bearing Steels in Lubricated Reciprocating Tribotesting

Mathew Kirsch, Air Force Research Laboratory, Wright Patterson Air Force Base, OH

The aerospace bearing steels M50 (AMS 6491) and 52100 (AMS 6440) were subjected to reciprocating sliding wear tests both at room and elevated temperatures. Tests were conducted with fully formulated turbine engine oils containing phosphate based anti-wear additives as well as with an un-additized base stock. Additionally, M50 was subjected to multiple tempering conditions to investigate the dependence of wear on hardness under boundary lubrication. Post-test analysis of the surfaces was conducted to determine wear mechanisms and to examine the effect of oil additives on the wear rates of each material. An average wear area was calculated for each of the test conditions for comparison.

9:30 am – 10:00 am

3832512: The Use of the MTM Rig for Wear Testing

Matthew Smeeth, Clive Hamer, PCS Instruments, London, United Kingdom

A series of wear tests have been made using an MTM rig. The wear rate of any lubricated contact is dependent on a large number of factors, including, surface roughness, lubricant composition, environment, operating conditions, temperatures, etc. Since wear, in itself, is not an intrinsic property of a system, different wear tests can give very different results. Interpretation of different bench test results can be difficult and misleading conclusions can sometimes be drawn. Since the ability of a wear test to discriminate between lubricant formulations containing relatively small differences in additive concentrations is of paramount importance to any formulator, this information is detailed. A variety of typical anti wear additives have been used to study wear. Results show that the tests developed can produce measurable wear within a reasonable period of time. The repeatability and relative merits of the test methods employed are discussed.

10:00 am – 10:30 am – Break

10:30 am – 11:00 am

3832581: Effects of Trace Moisture Content on Tribo-Film Formation, Friction and Wear of CF-Filled PTFE in High-Purity Hydrogen

Qian Chen, Kyushu University, Fukuoka, Fukuoka, Japan

Carbon fiber (CF) filled polytetrafluoroethylene (PTFE) composites are widely used as piston ring materials for reciprocating hydrogen gas compressors. This study was aimed to investigate the effects of trace moisture content of hydrogen gas on tribological behavior of CF-filled PTFE composites. Sliding tests were carried out on pin-on-disk tribometer installed within an atmosphere-controlled chamber using a composite pin and a stainless-steel disk. The moisture contents of the hydrogen gas environment were controlled from 1ppm to 40 ppm while the contact pressure and sliding speed were set at 1MPa and 2m/s, respectively. The results showed that tribological behavior was significantly affected by trace moisture content. Specific wear rates of the composite pin tended to increase as the water content increased. Similarly, the average coefficient of friction increased while increasing the moisture content from 1 ppm to 20 ppm. However, it decreased with the further increase of water.

11:00 – 11:30 am

3812387: Enhanced Metal Corrosion of Long-Life Antifreeze Coolants

Hong Gao, Shell Global Solutions (US) Inc., Houston, TX

Corrosion protection is one of the critical performances of antifreeze coolants in transport and electric vehicles. The extended service life and compatibility with a wide range of metallic materials in the vehicles provide even more challenges on improving the corrosion performance of the liquid. This presentation highlighted the typical corrosion mechanisms in the cooling system and corresponding test methods. The enhanced corrosion protection was demonstrated with advanced long-life coolant technologies.

11:30 am – 12:00 pm

3813013: Local Contact Pressure Governs Mild Wear Mechanisms at Multi-Asperity Interfaces

Cyrian Leriche, ARCNL, DIemen, Noord-Holland, Netherlands

Wear causes surfaces to be irreversibly damaged; incurring significant economic cost. For single asperity contact between silicon-based materials –which are important in the MEMS industry- gradual attrition and fracture have been identified as the main wear mechanisms. To understand what mechanisms control the wear behavior of Si3N4-on-Si multi-asperity interfaces, we used the AFM topography difference method. We studied 'non-repeated' Si3N4-on-Si wear, imposing two different stroke lengths and found–over the full contact area – a transition in dominant wear regime as the local interfacial contact pressure decreased: from subsurface damage to atomic attrition. The wear per unit sliding distance induced by the short strokes is much higher than that sustained during long strokes, likely due to impact wear. Our method and results address a key challenge in tribology: to bridge fundamental insight into wear based on nanoscale studies to industrial applications.

Session 8C | 102A

Seals II

Session Chair: Lassad Amami, CETIM, Nantes, France

Session Vice Chair: Maximilian Engelfried, University of Stuttgart, Stuttgart, Germany

1:30 pm – 2:00 pm

3812371: Modelling of the Pumping Rate Behavior of Shaft Sealing Counterfaces

Maximilian Engelfried, Matthias Baumann, Frank Bauer, University of Stuttgart, Stuttgart, Germany

The term "lead" covers harmful structures on sealing counterfaces of rotary shaft seals. When the shaft is rotating, lead structures cause the shaft to pump oil through the sealing gap. Depending on the direction of rotation, leakage or insufficient lubrication of the sealing contact may occur. Therefore, the detection of such structures is an essential step in the quality assurance of shaft sealing counterfaces. This contribution presents correlation studies between the results of a new structured-based analysis method for macroscopic lead structures and the functional behavior of sealing counterfaces. The new approach describes the geometries of the measured structures on the shaft surface by means of statistically determined parameters. For the correlation studies, experimental pumping rate tests were carried out with sealing counterfaces with different lead characteristics.

2:00 pm – 2:30 pm

3833697: Experimental Study of a Reverse Pumping Spiral Groove Face Seal

Abdel-Salem Medjahed, Noel Brunetiere, Antoinette Blouin, Institut Pprime, Futuroscope Chasseneuil Cedex, France; Bálint Pap, Safran, Colombes, France

Reverse pumping face seals are designed with spiral grooves located at the low-pressure side (inner radius) pumping the fluid toward the high-pressure side to make the seal operating with no leakage. In addition, the grooves allow hydrodynamic pressure generation making the seal working in full film regime when the rotational speed is high enough. In this work, a face seal composed of grooved rotor sliding versus a transparent sapphire disk is experimentally studied. The location of the interface between the air pumped in the seal thanks to the groove and the pressurized liquid in the test rig is analyzed by an optical method. In addition, an infrared camera is used to measure the temperature of the sliding surfaces at different operating conditions. The impact of the air pumped in the sealing interface on the seal performance (leakage, friction and temperature) is studied.

2:30 pm – 3:00 pm

3829259: Tolerance Analyses on the Geometrical Parameters of Surface Textured Seals

Markus Brase, Matthias Wangenheim, Leibniz University of Hannover, Garbsen, Germany

Surface texturing is an effective method to control the friction level of dynamic seals. Texturing During Moulding (TDM) is an innovative method to manufacture surface textured seals in large quantities. Within this process, the negative of the desired surface texture is applied to the mould by laser ablation. The texture, defined by dimple diameter, distance and depth, is transferred from the mould to the seal during injection moulding or vulcanization. However, due to the laser and moulding process, geometric tolerances in both dimple dimensions and general seal dimensions occur. The objective of this study is the identification of the influence of those geometric tolerances on the friction level of surface textured seals. For this purpose, the contact pressures and dynamic frictional forces of piston seals in pneumatic cylinder are investigated both simulative and experimentally for a large variety of surface textures.

3:00 pm – 3:30 pm – Break

3:30 pm – 4:00 pm

3806295: Experimental Determination of the Benefits of Textured Mechanical Seals on the Service Life of Systems

Lassad Amami, CETIM, Nantes, France

Seals are essential for the proper functioning of compressor, turbine, pumps, turbomachinery. The improvement of rotary machines performances depends especially on leak performance, durability, seal technology and its adaptation to dynamic solicitations. The objective of this study is to compare, experimentally, the performance of three new types of textured mechanical seals (triangle shape) with other smooth (non-textured) mechanical seals in terms of friction torque and leakage rate. The tests were carried out on a test bench dedicated to mechanical seals. The various test parameters, namely pressure, temperature, speed, leakage in the operating regimes were recorded and will be described in the article. The experimental results showed several sealing regimes (dry, mixed, hydrodynamic) of the mechanical seals depending on the depth of the textures. These results were also correlated with microscopic visualizations and metrological measurements.

4:00 pm – 4:30 pm

3846279: Measurement of Leakage and Visualization of Seal Surface of Dry Gas Seals with a Simple Inner Ring Groove

Masayuki Ochiai, Tokai University, Hiratsuka, Kanagawa, Japan

In this study, an inner peripheral ring groove was added to the generally used spiral groove for one-way rotation and the T-shaped groove for double-rotation, and air leakage was measured and compared. In addition, the flow of air flowing through the seal gap was confirmed by visualization experiments, and the effect of the inner ring groove on air leakage was verified experimentally.

8C

4:30 pm – 5:00 pm

3850067: Radial Shaft Sealing System Failure Mode – Shaft Lead

Adrian Heinl, Christian Wilbs, Daniel Froelich, Matthias Adler, Freudenberg FST GmbH, Weinheim, Baden-Württemberg, Germany

Lead structures on the shaft counter surface can cause premature failure of the radial shaft sealing system or to a reduced lifetime. Depending on the operation conditions and the lead characteristics the lead structures generate an axial pumping effect of the fluid. This leads either directly to leakage or poor lubrication conditions and therefore to an increased wear of the sealing lip. The shaft lead measurement is often performed according to the thread method defined in the RMA-OS-1-1. This method provides only little information about the lead characteristic and therefore the influence on the sealing system and especially the lead origin. This paper shows, how lead structures can be measured and quantitatively analyzed. Furthermore, the correlation between lead structures, leakage and the lead origin is explained. Those insights show hoe to avoid shaft lead and ensure a reliable sealing system performance.

5:00 pm – 5:30 pm

Seals Business Meeting

Session 8F | 103A

Biotribology II

Session Chair: Marc Masen, Imperial College of London, London, United Kingdom

Session Vice Chair: Brandon Krick, Florida State University, Tallahassee, FL

1:30 pm – 2:00 pm

3809745: Haptic Tribometer Characterizing the Dynamic Contact Between the Human Finger and the Automotive Touchscreen

Rexhina Shyti, Roberto Vargiolu, Hassan Zahouani, Laboratoire de Tribologie et Dynamique des Systèmes, Ecully, France; Pascale Nays, Renault Group, Paris, France

Although touchscreen technologies are ubiquitous, sole a few studies have focused their work on investigating the bio-tribology that lies under the interaction between the finger and the touchscreen. The device aims at assessing the dynamic contact between the fingertip and the touchscreen, it leads to a natural interaction between them to access the dynamic friction parameters such as the finger position, the velocity, and the dynamic contact area without constraining the finger's movement. The sensors paired with the haptic tribometer enable the measurement of the normal and tangential force, and the skin vibration by dint of an augmented finger developed within the laboratory. Coupling information garnered from the friction and vibration measurements with knowledge of the fingertip properties, as well as knowing the gesture employed, permit a better comprehension of tactile perception.

2:00 pm – 2:30 pm

3869334: Cellular Responses to Frictional Shear Stress

Angela Pitenis, Allison Chau, Kevin Ogbonna, Juan Manuel Uruena, University of California, Santa Barbara, Santa Barbara, CA

The ability of mucin networks to provide adequate lubrication in sliding contact with abiotic materials, such as contact lenses, can be significantly diminished to the point that patients report discomfort during use. Designing implant materials and surfaces that emulate the tribological behavior of natural mucin networks is paramount to improving patient comfort. In this work, we developed contact lens like hydrogel probes with controllable surface architectures to determine the extent to which frictional shear stresses could be mitigated by surface gel layers. We conducted tribological testing with hydrogel probes both with and without the surface gel layers against mucin-producing corneal epithelial cell monolayers. Experiments using hydrogel probes with surface gel layers were correlated with lower frictional shear stresses and less cell death than hydrogels without surface gel layers. These studies may assist in the design of more biocompatible implants, including contact lenses.

2:30 pm – 3:00 pm

3809804: Biotribological Characterization of the Physical Mechanisms at the Astringency Sensation Origin

Ianis Ammam, Roberto Vargiolu, Cyril Pailler-Mattei, Hassan Zahouani, Laboratoire de Tribologie et Dynamique des Systèmes – Ecole Centrale de Lyon, Lyon, France; Clément Nivet, Francis Canon, INRAE, Dijon, France

The astringency result from a loss of oral lubrification due to the aggregation of the mucosal pellicle by tannins. We recently proposed a new hypothesis on the molecular mechanism involved in this sensation, which is based on of the MUC1 protein. To evaluate this new hypothesis, we worked on an in vitro bilayer model simulating the oral mucosa composed of elastic hydrogel substrate (8kPa) and a cell layer recreating the oral epithelium by expressing MUC1 protein. This new in vitro model is very close to the oral mucosa in vivo from a physico-chemical perspectives: elasticity, wettability, roughness, protein adhesion. In addition, a micro-tribometer has been developed to perform in vitro friction tests and measured friction coefficient at the micrometric scale. We observed the role of saliva and the effect of astringent components on oral lubrication through the evolution of the in vitro friction coefficient on the mucosa model.

3:00 pm – 3:30 pm – Break

3:30 pm – 4:00 pm

3810348: Biotribological Behavior of MXene-UHMWPE Composites

Max Marian, Pontificia Universidad Católica de Chile, Macul, Región Metropolitana, Chile; Klara Feile, Benedict Rothammer, Bartz Marcel, Wartzack Sandro, Friedrich-Alexander-University Erlangen-Nuremberg (FAU), Erlangen, Germany; Andreas Rosenkranz, Universidad de Chile, Santiago, Chile

MXenes are a relatively new class of 2D transition metal carbides, nitrides and carbonitrides receiving increasing attention in tribological applications due to their self-lubricating character. A prospective application of MXenes is their addition to UHMWPE with the overall purpose to improve the biotribological behavior of polymeric components of load-bearing implants. Within this study, Ti3C2Tx-UHMWPE composites with varying MXene content were biotribologically analyzed using pin-on-disk tribometer tests. Thereby, a friction reduction by up to 22% compared to pure UHMWPE was demonstrated. The determined wear rates of the disks considerably decreased by up to 43% due to the addition of MXenes. Furthermore, the composite-disks reduced the wear rates of the tested CoCr-pins by up to 19%. Both the reduction of friction and wear underline the great potential of MXenes as a reinforcement phase in UHMWPE to improve the biotribological behavior and service life of biomedical applications.


STLE Learning Management System

Access content in a more user-friendly experience.

Use the online learning platform to find a variety of educational resources specific to what you need to learn or enhance your professional development. This platform features opportunities to accrue learning experiences and expand your skillset. The system offers the following:

- Webinars
- Learning Pathways
- Short courses
- Industry Insights
- Annual Meeting digital proceedings.

Access the STLE Learning Management System at **www.pathlms.com/stle**.

For more information, contact STLE director of professional development Rebecca Lintow at ***rlintow@stle.org***.

stle
• connect • learn • achieve

Society of Tribologists and Lubrication Engineers
840 Busse Highway, Park Ridge, Illinois 60068 (USA)
P: (847) 825-5536 | F: (847) 825-1456 | www.stle.org | information@stle.org
Follow us on:

8F

4:00 pm – 4:30 pm

3830758: Investigating the Tribological and Corrosion Behavior of Co-Cr Alloy as an Implant Material for Orthodontic Applications

Sudip Saha, Kommineni Uday Venkat Kiran, Sougata Roy, University of North Dakota, Grand Forks, ND

Effectiveness of wrought cobalt-chromium alloy as a dental implant was investigated through systematic tribological, immersion, and corrosion tests. Artificial saliva solution was prepared with varied pH levels. Effects of artificial saliva on Co-Cr samples were investigated by potentiodynamic polarization and continuous immersion tests. Tribological tests were conducted using a ball-on flat type reciprocating test rig against steel ball with different sliding velocities for both dry and saliva lubricated contact conditions. Oxide layer generation during dry contact conditions and formation of P and Ca enriched tribofilm originated from the artificial saliva played crucial role in tribological behavior of Co-Cr samples. In lubricated contacts, increased sliding velocity resulted in decreased friction coefficient which can be attributed to more homogeneous material transfer from ball to flat and artificial saliva-induced tribofilm formation on the Co-Cr flat wear track region.

4:30 pm – 5:00 pm

3830887: Photo-Responsive Hydrogel Lubricity

Allison Chau, Sophia Bailey, Kseniia Karnaukh, Javier Read de Alaniz, Angela Pitenis, University of California, Santa Barbara, Santa Barbara, CA

Stimuli-responsive hydrogels have a wide range of applications (e.g., drug deliver, soft robotics). Recently, light has been used to control swelling kinetics through the incorporation of spiropyran molecules into hydrogel networks, resulting in light-induced actuation and bending. However, the tribological properties of these photo-responsive hydrogels remain largely unknown. In this work, spiropyran-methacrylate was conjugated with acrylamide to form copolymerized hydrogel networks. In visible light, the photoswitch is hydrophobic in its spiro form. Once irradiated with UV light, isomerization to its hydrophilic merocyanine form occurs, inducing macroscopic hydrogel swelling. Using a microtribometer, we characterized the friction coefficient before and after irradiation. Based on these findings, we hypothesize that the deswelling-swelling transition is responsible for changes in the tribological properties of photo-responsive hydrogels, leading to decreases in friction coefficient.

5:00 pm – 5:30 pm

3853624: DECMA-1 Influence on the Mechanical and Tribological Properties of MDCK Monolayers

Emily Guo, Kyle Schulze, Auburn University, Auburn, AL; Steven Chisolm, Thomas Angelini, University of Florida, Gainesville, FL

Most of the research regarding e-cadherins (epithelial cadherin) and the use of DECMA-1, an e-cadherin antibody, are mainly for cancer research studies. By blocking e-cadherins, a protein responsible for cell-cell adhesion, the growth of tumors and cancerous cells can be hindered. However, these studies put a limit on the usage of DECMA-1 to confirming the presence of e-cadherins and hindering tumor growth. By affecting how much adhesion exists between cells, the properties of the cell monolayer itself should also change. By varying the dosage of DECMA-1 given to a monolayer of MDCK cells, the changes to the behavior of the cells were observed via confocal microscopy. Differences between the linear and rotational movement of the cell monolayer were observed.

Session 8G | 103B

Tribotesting IV

Session Chair: Juan Bosch Giner, The University of Akron, Akron, OH

Session Vice Chair: Amanendra Kushwaha, University of Nevada, Reno, Reno, NV

1:30 pm – 2:00 pm

3834410: Grinding Method Process Under Lab Conditions to Evaluate Railway Microstructural Response

Luis Wilches Peña, Valentina Castano, Miguel Vélez, Universidad EIA, Medellín, Antioquia, Colombia; Jaime Carvalho, Juan Sánchez, Hugo Santana, John Valencia, SENA, Centro de Tecnología de la Manufactura Avanzada, Medellín, Antioquia, Colombia; Alejandro Toro Betancur, Universidad Nacional de Colombia, Medellin, Antioquia, Colombia

Over the last years grinding processes have been used as a maintenance strategy to repair railways affected by Rolling Contact Fatigue. However, high plastic deformations and thermal impacts during grinding could be related to the beginning and evolution of microstructural changes called White Etching Layers (WELs). WELs have been related to surfacing damages responsible to railway significant life reductions. To study WELs, a grinding method process under lab conditions was designed. The method proposed is based on an adapted commercial polishing machine, where several load cells and thermocouples were assembled to railway sections fixed to the machine. Acquisition data from the sensors was made using signal conditioning, and ADC modulus circuits. An acquisition data card allows data storage and visualization in a HDMI screen. Information obtained from this method will be useful to understand the mechanisms responsible to WELs evolution.

2:00 pm – 2:30 pm

3834337: Cast Iron Chef: The Final Season

Alexander McGhee, University of Wisconsin-Madison, Madison, WI; Kylie Van Meter, Brandon Krick, Florida State University, Tallahassee, FL

The first known use of cast iron cookware was during the Han Dynasty in China, around 220 A.D, and ever since chefs have debated the best surface treatment. Surprisingly, this question has remained largely untouched by experimental tribologists, yet many of the current recommendations for cast iron seasoning claim certain oils give superior wear resistance. In this study, we utilize a high-temperature reciprocating tribometer with a stainless-steel counter surface to simulate cooking action. Tribological characterization of the cast iron pan as well as analysis of the morphology of surface and sliding interface give insight into the ideal seasoning conditions for cast iron cookware. Additionally, the surface properties such as hydrophobicity, wear resistance, and hardness will be compared to one another with consideration given to the polymer structure of the various oils.

2:30 pm – 3:00 pm

3835228: Effect of Gas Environment and Test Speed on Reciprocating Wear Testing for Compressor Packing Seal Materials

Jonathan Penaranda, Burak Bekisli, Tanil Ozkan, Dover Precision Components, Houston, TX

The tribological behaviors of dynamic polymer seals are influenced by the tribochemistry characteristics of the sliding contact, and these chemical characteristics are mainly influenced by the gas environment in which they operate. However, this variable is often not well understood, and the selection of wear-resistance polymer materials primarily

depends on field experience. An additional challenge when testing compressor packing seal materials is the sliding speed. Typical reciprocating compression operates at a linear speed between 2- 4 m/s, while most environmentally controlled reciprocating lab-scale wear tests operate between 0.005 and 0.2 m/s. In this paper, we will compare the wear performance of typical compressor seal materials on different sliding speed ranges and gas environments to discuss the main differences between the wear behavior observed for PTFE-based and PEEK-based compressor seal materials.

3:00 pm – 3:30 pm – Break

3:30 pm – 4:00 pm

3892830: Tribological Behavior of Bearing Materials in Water-Based Lubricants

Juan Bosch Giner, Christopher DellaCorte, The University of Akron, Akron, OH

Despite having generally low viscosities, water-based lubricants (WBLs) present potential advantages compared to traditional oil-based lubricants. They can perform two tasks, cooling electric components and lubrication of rotating parts. Unfortunately, little information is available regarding their tribological behavior in steels and emerging ceramic bearing materials. This presentation describes an ongoing effort to characterize WBLs through rheological and tribological tests and compare them with its commercially available candidates and traditional lubricants.

Session 8I | 104A

Electric Vehicles and Engine and Drivetrain VIII

Session Chair: Andrew Velasquez, Southwest Research Institute, San Antonio, TX

Session Vice Chair: Kora Farokhzadeh, DSM Engineering Materials, San Jose, CA

1:30 pm – 2:00 pm

3847574: Ring-Liner Testing in a Hydrogen Environment

Peter Lee, Southwest Research Institute, San Antonio, TX

As the world moves towards net zero, Hydrogen is again being considered as an alternative to conventional petroleum-based fuels. There are many ideas, but little is known about the effect of Hydrogen in oil, or its effect on engine components. SwRI has adapted a reciprocating rig and built a dedicated explosion proof test cell in which to perform tribology experiments in a controlled Hydrogen environment. Pin on plate, and ring on liner components in engine oil were investigated. This work is in its infancy, but the test set-up and initial results will be presented.

2:00 pm – 2:30 pm

3903915: The Engine Oil Effect on Fuel Economy Improvement in Different Test Types

Kongsheng Yang, William Anderson, Kristi Engelman, Guoqing Cao, Afton Chemical Corporation, Richmond, VA

Climate change awareness greatly increased the desire to reduce CO_2 emissions. Modern engine manufacturers and lubricant manufacturers have demonstrated that CO_2 emission reduction can be achieved by increased fuel economy. There are multiple ways to measure engine oil fuel economy including motored engine and vehicle testing. Motored engine friction testing is a well-established methodology to demonstrate the effectiveness of lubricants to reduce the internal friction of an engine and provide fuel economy benefit. Likewise, fuel economy may be tested by vehicle chassis dyno test like the GM Oil Efficiency Evaluation (GMOEE). The GMOEE was introduced to the GM dexos™1 Gen 3 specification using a WLTC drive cycle after 500 miles aging. In this presentation, both engine oil component and fluid properties are able to improve fuel economy in both motored friction and vehicle fuel economy testing.

2:30 pm – 3:00 pm

3879003: Development and Testing of a Variable Hardness Piston Ring Coating for Improved Run-In

Peter Lee, Southwest Research Institute, San Antonio, TX; Lake Speed Jr., Total Seal Piston Ring, Concord, NC

Rings & liners must run-in before reaching optimum performance & oil control. A top softer run-in coating is better for removing asperities and gives optimum surfaces after which a lower harder durable coating is best. So, a dual coating is required. WC/C on CrN is available but not always successful due delamination problems. Therefore, engines are often operated with no piston ring coating or a single durable coating which is not optimum. Work by SwRI developed a durable low friction Ti-Si-C-N coating. In a full vehicle fuel economy savings of 0.82% were obtained. The Ti-Si-C-N coating is 'tuneable' during the deposition process giving a softer top layer. Being the same coating with different hardness applied in one process removes delamination concerns. Coatings were tested in a tribometer and liner surfaces analyzed (3D & SEM) to find the best coating. SwRI worked with Total Seal Piston Ring to install the variable hardness piston rings in a NASCAR engine to observe improved horsepower.

3:00 pm – 3:30 pm – Break

3:30 pm – 4:00 pm

3867560: Electric Vehicle Fluid Interactions in AC and DC Environments

Andrew Velasquez, Carlos Sanchez, Peter Lee, Cole Frazier, Southwest Research Institute, San Antonio, TX

The tribology field has been established in determining performance of lubricants operating within internal combustion engines (ICE), with the backing of many standardized agencies. There is increasing demand for electric vehicles (EV) from government and civilian entities, and the lubricants market has been unable to effectively study how their fluids will perform in an electrified environment. This remains a key factor in EV performance, as studies have shown that lubricants function differently in the presence of electricity. Therefore, a standardized lubricant qualification method was modified to operate in an electrified environment with alternating (AC) and direct (DC) type currents. Three different EV fluids were exposed to similar operating conditions that would be seen in gearbox systems within EV's. To evaluate EV fluid performance, the friction and wear of the interacting standardized components were analyzed.

4:00 pm – 4:30 pm

3889385: High-Temperature Thermoplastics in Electric Drivetrain Bearings

Kora Farokhzadeh, Adnan Hasanovic, Geert Vanden Poel, John Papadopoulos, Trevor Spence, Matt Marnell, DSM Engineering Materials, San Jose, CA

High-temperature polyamides (PAs) play a key role in making e-mobility safer, lighter, and more sustainable and are widely used in various applications incl. high-voltage drivetrains. High-voltage and fast switching power electronics improve single-charge range and power density of electric drive units but increase the risk of electric discharge and premature failures in the bearings. Furthermore, compared to combustion engines, e-motors run transmission bearings at faster

speeds, exposing bearings to higher temperatures, and mechanical/thermal stresses. This talk focuses on glass- and carbon-fiber reinforced Stanyl PA46 EV bearing cages tailored for low friction, high wear resistance, dimensional stability, lightweight, high strength esp. at temperature (150-220°C), and creep resistance. Additionally, Stanyl PA46 grades are easy to mold and process with chemical resistance to lubricant/grease formulations. This enables manufacturers to maximize component reliability and lower production costs.

4:30 pm – 5:00 pm

3832947: How to Improve Engine Lifetime by Use of Premium Fuel

Nicole Doerr, Marcella Frauscher, Adam Agocs, Thomas Wopelka, Andjelka Ristic, AC2T research GmbH, Wiener Neustadt, Austria, Austria

To assess the influence of fuel quality on engine lifetime the wear performance of conventional fuel was compared to wear behavior of premium fuels containing elevated levels of FM. Engine bench tests were carried out with an artificially aged engine oil matching 25,000 km of operation. Wear formed during engine bench test was assessed by detection of wear particle concentration in the oil by ICP-OES and by radio isotope concentration method. Premium fuel showed significantly lower wear formation during engine bench tests. Oil aliquots sampled during engine bench tests revealed chemical changes during operation, measured by mass spectrometry. Transfer of FM from the fuel into the engine oil with proceeding engine operation time was revealed for premium fuels, leading to enhanced engine lifetime. This behavior was subsequently simulated in SRV® tribometer experiments, resulting in an efficient and economical laboratory method to support R&D.

5:00 pm – 5:30 pm

3832068: Novel Sustainable Low-Viscosity Synthetic Base Fluids for E-Mobility

Michael Liang, Ramesh Navaratnam, Patech Fine Chemicals, Dublin, OH

To meet the operational efficiencies of Hybrid (HEV) and Electric Vehicles (EV) technologies the transmission e-fluid requirement has moved toward low-viscosity fluids. Transmission e-fluids used in HEV, and EV are also in direct contact with different electrical components of the motor like battery, transmission gear, and integrated electric motors. This introduces new challenges of requiring excellent electrical and thermal properties of e-fluids to prevent the risk of electric short circuit and overheating. However, conventional low-viscosity base fluids have poor lubricity performance that reduce reliability and performance. In this study, we will demonstrate the benefits of synthetic esters to provide better heat transfer and di-electric properties than other base stock. In understanding these mechanisms, we were able to develop esters specifically for higher heat conductivity, low viscosity with excellent lubricity, and eco-friendly to achieve the goal of sustainability as well.

5:30 pm – 6:00 pm

3834981: High Performance Synthetic Lubricants Designed for High-Speed e-Mobility Application

Philip Ma, BASF, Tarrytown, NY

Automotive industry is moving rapidly toward electric vehicles. Off the shelf lubricant products for conventional vehicles are not optimized for the unique demands for e-fluids application, such as energy efficiency, electric conductivity, copper protection, aeration, extended gear/bearing protection etc. This presentation will highlight high-performance PAO-based formulations designed for high-speed e-fluid applications.

Session 8L | 202A

Grease IV

Session Chair: Lu Fang, University of Pennsylvania, Philadelphia, PA

Session Vice Chair: William Tuszynski, The Unami Group, Quakertown, PA

1:30 pm – 2:00 pm

3832174: Quantum-Leap Grease Formulation Through Preform Chemistry

Noura Smaili Iderkou, Novitas Chem Solutions, Tomball, TX

For decades grease is made via in-situ manufacturing whereby the thickening takes place in the presence of base oil at elevated temperatures that is energy intensive and is difficult to achieve grease consistency in the so-called soap kettle. We have found using pre-form thickeners grease making can be made much simplified/easier and consistent. This pre-form concept is built on the fact that the thickener is already formed and sized for optimal thickening in either powder or extrudate forms. The same concept can be extended to additives and components in which grease performance can be achieved without compromising the integrity of the grease with no softening or oil separation. This paper shall present a novel grease formulation entirely based on preform chemistry that can be used to achieve high load and demanding applications.

2:00 pm – 2:30 pm

3834150: Best Practices for Making Urea Grease from a Powdered Thickener

Lauren Huffman, Dow Chemical, Midland, MI

This talk with teach the best practices and challenges of making a urea-based grease from a powdered thickener.

2:30 pm – 3:00 pm

3811237: Influence of Grease Thickener Types on the Film Formation

Tomoki Kamihata, Kazumi Sakai, ENEOS Corporation, Yokohama, Japan

The film thickness of greases has a significant impact on bearing properties, such as the bearing torque. Therefore, for a detailed discussion of the lubrication mechanism, it is important to improve the accuracy of film thickness measurements. However, in the case of conventional equipment, the measurement methods of the thin film formed at lower speed range are technically limited. In this study, the film thicknesses of two types of urea greases, alicyclic and aliphatic ureas, were observed by using a high-accuracy film thickness observation equipment using optical interferometry technique. Alicyclic urea grease formed much thicker film compared to aliphatic one at lower speed range. This result suggests that the increase of the film thickness is attributed to the thickener structure of ureas. It seems that this phenomenon is caused by the intervention of large thickener particles and/or the thickener condensation in/around Hertzian contact areas, as successfully captured images.

3:00 pm – 3:30 pm – Break

3:30 pm – 4:00 pm

3813022: DIN 51830-2 – Evolution of an Advanced Method for Characterization of Thermo-Oxidative Grease Failure

Markus Matzke, Robert Bosch GmbH, Renningen, Germany; Olav Höger, Shell Global Solutions Germany GmbH, Hamburg, Germany; Thomas Litters, FUCHS Lubricants Germany GmbH, Mannheim, Germany; Jürgen Fischer, DIN Technical Committee on Mineral Oil and Fuel Standardization, Hamburg, Germany

Thermo-oxidation is a dominant degradation mechanism of greases in automotive applications. To ensure adequate lubrication across the complete vehicle life, the resistance to degradation must be quantified by appropriate test methods. Existing thermo-oxidative test methods for greases like DIN 51808 or ASTM D 8206 do not include contact with catalytic materials like brass or steel and the evaluation criteria do not indicate antioxidant depletion as initiation of structural grease failure. Therefore, the existing RSSOT method was enhanced by integrating catalytic contact materials steel and brass and application of a new evaluation criterion for grease failure. Additionally, it enables the calculation of the Arrhenius activation energy. This presentation summarizes the evolution of this method at the German Institute for Standardization (DIN) from the initial concept, a working group study to determine activation energies, an official round robin test to the final DIN standard.

4:00 pm – 4:30 pm

3829730: Oxidation and Grease Life in Rolling Bearings

Piet Lugt, SKF Research and Technology Development, Houten, Netherlands; Mikael Holgerson, Fredrik Reinholdsson, SKF, Gothenburg, Sweden

In this presentation the lubrication mechanism is described of lithium grease lubricated ball bearings in the bleed phase. Oxidation plays an important role and therefore grease life "in air" and grease life "in nitrogen" is studied in real bearings. It is shown that grease life is strongly dominated by oxidation but that this is by far not deterministic. Oxidation starts up at a certain time, the induction time, which is the point at which the antioxidants have been consumed. This induction time is a function of the bearing operational conditions and the oxygen concentration. Oxidation leads to loss of base oil and loss of lubricity, partly repaired by replenishment and oil release from the grease reservoirs (bleed).

Session 8M | 202B

Wear III

Session Chair: Yan Zhou, Quaker Houghton, Conshohocken, PA

Session Vice Chair: Mathieu Renouf, Universite De Montpelllier, Montpellier, France

1:30 pm – 2:00 pm

3833731: An Investigation into the Tribological Performance of Wear Resistant PVD Coatings Atop Various Tool Steels Used in Injection Moulding Applications

Roshan Lal, University of Birmingham, Wolverhampton, United Kingdom

Wear is a recurring issue in injection moulding applications where abrasive formulations, high temperature and high pressures are employed. Multiple wear mechanisms can damage a single tooling part during production, so protective coatings are often applied by Physical Vapor Deposition (PVD). A variety of coatings (TiAlN, AlCrN, Diamond-Like-Carbon (DLC), CrN etc.), coated atop two tool steel grades have undergone rigorous laboratory testing to evaluate their tribological performance. Nanoindentation, macro-scratch testing, interferometry, atomic force microscopy and a bespoke particle-entraining tribometer at elevated temperatures are among the plethora of techniques implemented to reveal the optimal substrate-coating combination. Wear resistance is shown as a function of both the coating and substrate properties.

2:00 pm – 2:30 pm

3833738: Friction and Wear Characteristics of Pitch & Poly-acrylonitrile-Based Carbon-Carbon Composites in Air and Nitrogen Environment Under Aircraft Taxi Conditions

Akshat Sharma, Farshid Sadeghi, Purdue University, West Lafayette, IN

In this investigation, a disc brake test rig was designed and developed to evaluate the friction and wear characteristics of pitch and poly-acrylonitrile based carbon-carbon composites in air and nitrogen environment. Friction results from drag tests were validated with existing literature. Additionally, controlled tests at specific temperatures and energy flux were performed using an external thermal chamber (temperatures up to 5500C) to quantify the wear coefficients. It was found that temperature of the disc, humidity of surrounding environment, supplied energy flux as well as the type of composite play a critical role in determining whether disc brakes operate in normal wear or dusting wear regime. Furthermore, optical and scanning electron microscopy were conducted to analyze wear mechanisms. Matrix and interface cracking along with fiber breakage were observed from tests in air environment, whereas in nitrogen environment, particulate and layered debris played a prominent role.

2:30 pm – 3:00 pm

3833918: Wear Characteristics of ZDDP Tribofilm

Armand Tamouafo Fome, Leibniz University Hannover, Hanover, Germany

Zinc dialkyldithiophosphates (ZDDPs) are the most commonly used additives in engine lubricants when it comes to minimizing wear. This is achieved by forming a protective tribofilm on the surface of the raceway. Thus, the effectiveness of ZDDP depends on the balance between tribofilm formation and wear rate. In this study, a simple test procedure was set up to investigate the formation and wear of a zddp tribofilm. The focus of this study was on the transition from mild to severe wear. To this end, wear tests were conducted on a two-disc machine. Starting from a mild wear condition with ideal conditions for the formation of a ZDDP tribofilm, the test parameters were gradually changed until the severe wear state was reached. In this condition, the tribofilm formation rate could not keep up with the wear rate. Consequently, the substrate wear was observed.

3:00 pm – 3:30 pm – Break

Early Career and Student Research Posters

Early Career research posters

3893542: Effect of Rail Steel Microstructure to the Deformation Layer at the Rail/Wheel Interface

Yue Yang, Roger Lewis, James Ayabina, Kazim Yildirimli, The University of Sheffield, Sheffield, United Kingdom; Gerald Trummer, Klaus Six, Virtual Vehicle Research GmbH, Graz, Austria

In order to improve modelling of wheel and rail materials a better understanding of wear and rolling contact fatigue mechanisms is required. These are both initiated in the deformed layers that are created at the contact surfaces of wheels and rails where the microstructures are heavily affected by the loading cycles applied by the passage of wheels along the rail. The microstructures were compared along with hardness and strain values. A high-pressure torsion (HPT) technique has been developed to create this deformed layer under controlled conditions in the laboratory. In this work tests were carried under different conditions of twist on the HPT machine and the created deformed layers compared to deformed layers in full-scale wheel rail tests and data from the literature taken from rail extracted from the field. The deformed layer so it is critical that the properties reflect those of actual wheel or rail accurately.

3801745: Abrasive Wear – Analysis in the Set Shaft/Bearing of the Mining Industry

Zirlene Santos, Victor Do Carmo, Federal University Ouro Preto, Ouro Preto, Minas Gerais, Brazil

The research has a goal analysis of how abrasive wear causes failure in the set shaft/bearing of the idlers of load in the industry mining-metallurgical. The methodology has been qualitative using experimental and descriptive research. Also, used experimental research. In this sense, two load idlers were compared, the first with the problem by the locking of the inner ball bearing and the second one not yet hit by the jamming. These cuts were done in the casing to perform the failure analysis and determine what causes of fail of the set shaft/bearing. The results of the research demonstrate that the polyethylene retainer and rubber seal of Idlers were worn out for cause ore. For this reason, was allow input ore in the set shaft/bearing. The shaft/bearing also was worn out for causing the lubricate was be contaminated. The polyethylene retainer and rubber seal don't have resistance effective for abrasive wear caused for ore. It needs to change these component's material.

3908214: Eco-Friendly and Antiwear Ionic Liquids Additives in Marine Turbomachinery Lubricants

Wenbo Wang, Tom Geeza, Huimin Luo, Louise Stevenson, Teresa Mathews, Jun Qu, Oak Ridge National Laboratory, Oak Ridge, TN

Tidal energy, capable of generating clean and sustainable electricity through turbomachinery, is a promising source of the renewable energy portfolio. The conventional lubricants used in marine turbomachinery are toxic and exhibit low biodegradability, potentially resulting in a serious threat to marine ecosystems in the case of a leak or spill. Therefore, it is crucial to develop an environmentally acceptable lubricants (EALs) with high performance in wear protection. Recently, eco-friendly, high-lubricity ionic liquids (ILs) have been successfully invented at Oak Ridge National Laboratory and being further developed for tidal turbine gearbox lubrication. Compared with the commercial baselines, the 'not toxic' and 'readily biodegradable' IL-additized lubricants performed more effectively in mitigating the friction, rolling contact fatigue and wear loss. The wear modes and ILs' surface protection mechanisms were discussed with the assistance of surface and tribofilm characterization.

3892602: The Sound of Tribology – Music and Sound from the Monitoring of Tribological Components

David Brady, University of Leeds, Leeds, West Yorkshire, United Kingdom; Rob Dwyer-Joyce, University of Sheffield, Sheffield, South Yorkshire, United Kingdom

Presenting the results of research in tribology creatively can inspire people and make the subject more engaging and accessible. Music has the power to sooth, excite, and inspire. It is one of the basic forms of human sensory engagement. What better way to present the results of tribological experiments than in the form of music. I have used in situ audio recordings and sensor data from both hip replacement simulators and ultrasonic monitoring of piston rings and ball bearings to form an innovative and creative expression of the sounds associated with the research. Measured signals from real tribological experiments have been collected, converted into an audible frequency range and manipulated and effected to create music. The intention is to create audibly pleasant and stimulating sounds. This outreach project shows the data recorded in these research areas in a creative context, giving a different perspective with the intent to inspire and provoke new interest in the tribology field.

3831414: Molecular Dynamics Investigation of the Nanoscopic Friction on Monolayer MoS_2 in the Presence of Water

Igor Stankovic, Miljan Daši , Institute of Physics Belgrade, Zemun, Belgrade, Serbia

In the current work, molecular dynamics (MD) simulations are employed to study the nanoscopic friction on monolayer MoS_2 in the presence of water. The simulation setup mimics atomic force microscope (AFM) experiments by using an amorphous probe made of SiO_2, a monolayer MoS_2 plate, and water molecules in between to simulate conditions due to air humidity. Two systems are compared, with a probe fully immersed in water and surrounded by water, and a water capillary around the probe. In the latter case, the stick-slip friction behavior is pronounced and increases with the normal load. This study demonstrates that water content in the nanoscopic tribosystem of the MoS_2 surface-SiO_2 probe significantly impacts the probe's lateral and longitudinal movements, and therefore, its stick-slip behavior.

3805447: Research on the Deviation of the Temperature Field of the Brake Disc Between the Experimental Test and the Simulation Calculation

Junying Yang, Fei Gao, Dalian Jiaotong University, Dalian, China

Based on the TM-I reduced scale railway vehicle braking test bench, under the conditions of the initial speed of 80, 120, 160, 200 km/h and pressure of 0.5, 0.7, and 0.9MPa, the corresponding temperature field of the brake disc is obtained by using the methods of braking test and simulation calculation, respectively. The results show that the peak temperature and average temperature of the disc obtained by the test are higher than the values calculated by the simulation. The reason for this deviation is that local contact results in a concentration of heat that increases the temperature above the calculated value. The instantaneous peak temperature of the experimental test can reflect the random change characteristics of the actual contact surface. For the simulation calculation, ideal uniform contact conditions are assumed, and the instantaneous peak temperature obtained by the calculation can avoid the influence of the fluctuation factor of the contact surface.

3802614: Influence of Black Oxide Coating on Micropitting and ZDDP Tribofilm Formation

Mao Ueda, Shell Lubricants Japan K.K., Kanagawa, Japan; Hugh Spikes, Amir Kadiric, Imperial College London, London, United Kingdom

Application of black oxide (BO) coating to steel rubbing surfaces has been suggested as a potential approach to alleviate micropitting. This article confirms that BO coatings can prevent micropitting and identifies the predominant mechanism by which this occurs. Micropitting tests were carried out using zinc dialkyldithiophosphate (ZDDP) solutions in a ball-on-disc tribometer. Micropitting was preferentially generated on the smooth balls and this was completely prevented by applying a BO coating to the rougher discs, regardless of whether the balls were coated or not. In contrast, when the rough discs were not BO-coated, micropitting was consistently generated on both BO-coated and uncoated balls. BO coating has about one-quarter the hardness of the steel used and was found to be very rapidly removed from the surface asperity peaks at the onset of rubbing, despite the presence of ZDDP.

Student posters

3929505: Understanding the Friction and Wear Mechanisms of Additively Manufactured Nanocrystalline Al-Mg Components Deposited Using High-Pressure Cold Spray Technique

Amanendra Kushwaha, Manoranjan Misra, Pradeep Menezes, University of Nevada Reno, Reno, NV

In the present work, cryomilling process followed by cold spray deposition was used to manufacture nanocrystalline (NC) Mg-doped Al parts. X-ray diffraction was used to determine the changes in crystallite size and hardness was measured using a Vickers microhardness tester. A pin-on-flat tribometer setup was used to carry out friction and wear tests. The transfer layer was studied using a scanning electron microscope (SEM). The XRD analysis showed that the crystallite size decreased with an increase in the cryomilling time. The Vickers hardness tests showed an increase in hardness with a decrease in the crystallite size. The results also showed that the coefficient of friction and the wear rate decreased with the increase in hardness. In comparison to pure Al, the Mg-doped Al material displayed superior tribological and mechanical properties. The underlying mechanisms for the reduction in crystallite size and its effect on hardness, friction, and wear performance will be discussed.

3919408: Spectroscopic Evaluation of the Surface Chemical Processes Occurring in MoS_2 upon Aging

Nicolas Molina Vergara, Robert Chrostowski, University of Texas at Austin, Austin, TX; John Curry, Michael Dugger, Sandia National Laboratories, Albuquerque, NM; Tomas Babuska, Sandia National Labs, Albuquerque, NM; Filippo Mangolini, The University of Texas at Austin, Austin, TX

Molybdenum disulfide (MoS2) has been used as solid lubricant in aerospace applications because of its low friction response in inert environments. However, exposure to atmospheric conditions and periods of inactivity can cause MoS_2 to "age" into a high friction state. This poses a significant challenge in the reliable use of MoS_2. Despite the volume of the published literature, our understanding of the surface phenomena taking place during aging of MoS_2 is still elusive. Here, we performed XPS and ToF-SIMS analyses to identify the surface chemical changes occurring in MoS_2 upon aging in variable environments.

This work was funded by the Laboratory Directed Research and Development program at Sandia National Lab., a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the US DOE's National Nuclear Security Administration under contract DE-NA0003525.

3908363: Evaluation of Contact Stiffness at the Rough Interface of a Hard-Coated Aluminum with Different Thicknesses

Md Habibur Rahman, University of Illinois Urbana-Champaign, Urbana, IL

Engineering surfaces are rough at the microscale level and consist of multiple asperities. Most of the work done so far on the contact mechanics of a rough surface is mainly focused on the elastic regime. This study discusses the interfacial contact stiffness and contact load distribution in a rough aluminum surface, without and with a hard coating, consisting of many homogenous asperities considering the plasticity. The average asperity radius is varied to observe the behavior of the contact stiffness with increasing normal stress. The contact load-interference relation is investigated for elastic, elastic-plastic, and fully plastic regimes. A mean contact pressure in terms of interference is found to measure the hardness of the material with changing coating thickness. This work can be used to study the plastic deformation in a material, theoretically, at the microscale level, and design an optimum coating thickness to prevent premature yielding in the substrate material.

3905275: Graphene as a Conductivity Modifier in ZDDP Tribofilms for Use in 3D Tribo-Nanoprinting

Simon Duston, Krzysztof Kubiak, Ardian Morina, University of Leeds, Leeds, United Kingdom; Yuechang Wang, Harbin Institute of Technology, Shenzen, China; Rachel Oliver, University of Cambridge, Cambridge, United Kingdom

3D Tribo-Nanoprinting [1,2] uses AFM to additively manufacture 3D structures on the nanoscale using tribofilm formation. For this to be used as a viable manufacturing technique, the tribofilms must exhibit functional properties, such as conductivity. In this work ZDDP tribofilms have been generated, on a tribometer, using a method that allows for graphene nanoplatelets to be dispersed within the volume of the formed films. These films were generated to contain a range of concentrations of graphene and had thicknesses of approximately 150 nm. Conductive and Lateral Force AFM were used to measure the effect of the graphene on the conductivity and friction properties of the tribofilms. It was found that the otherwise electrically insulating ZDDP tribofilms were able to sustain currents through their thicknesses.

Applications for this novel method of additive manufacturing range from biosensors and electronics, to surface patterning and data storage.

Early Career and Student Posters

3908311: Exploring the Dust Tolerance Capability of Al-6061 alloy Fabricated via Directed Energy Deposition Process

Pial Das, Nicholas Dyrstad-Cincotta, Emil Umerov, Sougata Roy, University of North Dakota, Grand Forks, ND; Matthew Mazurkivich, Sara Rengifo, William Scott, NASA, Huntsville, AL

Erosion by high-speed abrasive particles is a major form of material degradation in numerous systems including spacecraft, especially during a landing on an extraterrestrial body. For those spacecraft's part manufacturing material, directed energy deposited (DED) produced Al-6061 has several advantages over traditionally made alloy, i.e., microstructural uniformity, superior mechanical properties, and enhanced wear performance. On the other hand, reinforcement like hBN/TiC gives even higher strength, wear resistance, and density to the Al matrix over conventional Al6061 alloy. While the strength of the material has been finely studied, the erosion performance of those materials has not been extensively explored. In our recent work, we studied the erosion performance of DED produced specimen, simulating the partially lunar environment, searching for optimum reinforcement percentage against lunar dust simulant particle (Lunar Mare Simulant) under varied temperatures (25C~125C) levels.

3907092: Dry Sliding Wear of Metal-oxide Filled PTFE Composites

Jackson Swets, Joseph Berbach, Harman Khare, Gonzaga University, Spokane, WA

The addition of nanoscale alpha-alumina to polytetrafluoroethylene (PTFE) reduces wear of PTFE by nearly four orders of magnitude under dry sliding on steel. Ultra-low wear of alumina-PTFE composites is enabled by growth of robust tribofilms on both the composite pin and steel surface. Tribofilms are developed in part through friction and shear stress as a result of sliding with the availability of ambient humidity. PTFE composites reinforced with certain other metal oxide nanoparticles result in wear rates comparable to alumina, while others result in significantly higher wear for reasons that remain unclear. Brass counter-surfaces are similarly known to result in higher wear, irrespective of filler choice, including alumina. In the current work, morphological and chemical analyses of worn interfaces are used to determine factors – particularly related to chemical interactions in the interphase region and on the counterface that help promote low wear of metal-oxide PTFE composites.

3907889: Effect of W and Mo Alloying Elements on Additively Manufactured Co-Cr Alloy for Prosthodontic Applications

Sudip Saha, Uday Venkat Kiran Kommineni, Xin Zhang, Xiaodong Hou, Sougata Roy, University of North Dakota, Grand Forks, ND; Manikanta Grandhi, Zhichao Liu, West Virginia University, Morgantown, WV

This study examines the impact of W and Mo on the tribological, and corrosion behavior of Co-Cr alloy produced by Directed Energy Deposition. Primary materials study includes powder morphology, alloy microstructure, microhardness analysis and preparation of artificial saliva. Tribological tests were conducted in dry and lubricated conditions using alumina balls as counterpart and both alloys displayed a combination of adhesive and abrasive wear as primary wear mode. CoCrW alloy exhibited increased friction and wear volume with lower hardness compared to CoCrMo. Oxidation behavior and saliva-induced tribo-film formation were analyzed for both alloys. In lubricated tests brittle behavior of alumina balls were observed, while material transfer from flat to ball was captured during dry contact conditions. Corrosion behavior of the alloys was assessed with open circuit potential and potentiodynamic polarization tests.

3907366: Unleashing the Potential of MXene/MoS_2 Nanocomposites for Superlubricity on Rough Steel Surfaces

Ali Zayaan Macknojia, Aditya Ayyagiri, Diana Berman, University of North Texas, Denton, TX

This study presents the demonstration of the macroscale superlubricity state achieved by spray-coating solution-processed multilayer Ti3C2Tx-MoS_2 blends onto rough 52100-grade steel surfaces. The blends exhibited exceptional tribological performance that has not been reported previously for individual pristine materials, MoS_2 and Ti3C2Tx, under high pressure and sliding speed conditions. The study investigated the processing, structure, and property correlation to gain a deeper understanding of the underlying phenomena. Raman spectroscopy, scanning electron microscopy, and transmission electron microscopy results revealed the formation of an in-situ robust tribolayer responsible for the outstanding performance observed at high contact pressures and sliding speeds. This study has broad implications for the development of solid lubricants that can operate under extreme conditions, likely inspiring further research and development in this field.

3908362: Determining the Elastic Modulus and Permeability of High Molecular Weight Poly(Vinyl Alcohol) (PVA) Hydrogels

Nabila Ali, University of Illinois at Urbana-Champaign, Urbana, IL

Hydrogels are semi-solid materials with three-dimensional network structures that can hold a large quantity of water. Physically crosslinked poly(vinyl alcohol) (PVA) hydrogels prepared with repeated freeze-thawing technique have been investigated widely due to their tunable properties and easy synthesis process. While increasing crosslinks improve the overall mechanical properties, the interrelationship between the elastic modulus and permeability with changing composition is still not fully understood. In this poster we have studied the elastic modulus and permeability of high molecular weight PVA hydrogels with compositions ranging from 4 wt.% to 11 wt.%. We have observed that with increasing concentration of PVA, their elastic modulus increases but the permeability decreases. Since these properties affect contact pressure and lubrication, this study can be useful for sliding applications and also for designing biomedical devices in future.

3908360: Development and Performance Evaluation of Novel Surface Polishing Technique for Additively Manufactured Components

Uday Venkat Kiran Kommineni, Sougata Roy, University of North Dakota, Grand Forks, ND; Brady Kimbrel, Marshall Space Flight Center, NASA, Huntsville, AL

A novel and sustainable Dry Electro-MechanoChemical (DEMC) surface finishing technique was devised, which uses dry electrolyte media to improve the surface quality of additively manufactured nitrogen strengthened austenitic stainless steel. Austenitic stainless-steel samples were fabricated using a laser powder direct energy deposition system, following optimization of process parameters. The effect of DEMC electrolyte composition on material removal rate, surface morphology, and surface roughness was studied. Amplitude (Ra, Rrms, skewness, and kurtosis), spatial, and hybrid surface roughness parameters were investigated using white light interferometry technique. The enhancement in surface roughness after polishing validates the capability of DEMC to improve the surface finish of additive-manufactured parts. This research also highlights challenges with DEMC polishing of DED components such as surface pitting and need for precise parameter control to avoid microstructure changes.

3908272: Utilizing the Surface Roughness Parameters of Rods and Friction in Hydraulic Rod Seals to Study Stick Slip

Sean Kwasny, Fluid Power Institute, Milwaukee School of Engineering, Milwaukee, WI

Stick-slip friction in hydraulic actuators can negatively impact machine controllability and operator safety. It is affected by seal type, fluid properties, and the surface roughness characteristics of the rod. While previous studies have investigated the effect of oil composition and seal type, the impact of rod topology has received less attention. This study examines the effect of sliding speeds, pressure, viscosity, and surface roughness characteristics on the reciprocating seal friction. The experimental investigation was conducted using a servo-controlled electric linear hydraulic actuator. The presence of stick-slip was confirmed through fast Fourier transform analysis of force vibrations. Differences in stick-slip behavior were observed for these parameters which were then used to developed model to study stick-slip friction. The study provides a basis for reducing or eliminating stick-slip vibration, thereby improving the control and safety of hydraulic machinery.

3908320: Investigating the Influence of Novel Chemical Modification Process on Enhancing the Tribological Behavior of High Oleic Soybean Oil

Piash Bhowmik, Clement Tang, Sougata Roy, University of North Dakota, Grand Forks, ND; Brajendra Sharma, Majher Sarker, USDA/ARS/NEA/ERRC, Wyndmoor, PA

Soybean oil is currently being studied as lubricating oil in various industries due to its renewability and biodegradability. In this research, High oleic soybean oil's (HOSO) tribological performance was enhanced through a novel chemical modification process that converted unsaturated fatty acids to saturated ones. Gas chromatography-mass spectrometry and nuclear magnetic resonance spectrometry were used to characterize soybean oils. The physicochemical properties of HOSO, chemically modified HOSO, and high oleic sunflower oil were measured. The tribological behavior of the oils was investigated using a ball-on-flat type reciprocating tribometer at room temperature and 100°C. The select chemical modification process increased wear resistance by 17% at room temperature and 8% at 100°C operating temperature. Major differences in wear mechanisms were further analyzed using white light interferometry, scanning electron microscopy, and energy-dispersive X-ray spectroscopy techniques.

3908309: Effects of $Ti_3C_2T_z$ MXene Nanoparticle on Fluidic Properties & Tribological Performance

Kailash Arole, Micah Green, Hong Liang, Texas A&M University, College Station, TX

In this work, we evaluate the performance of $Ti_3C_2T_z$ as an additive to enhance the heat transfer, rheological properties, and tribological performance of silicone and Polyalphaolefin (PAO) oils. Experimental results showed that adding $Ti_3C_2T_z$ improved thermal conductivity by 16% and 23% in silicone and PAO oils, respectively. The rheological data revealed that adding Ti_3C_2Tz nanosheets reduced the viscosity by 52.3% and 24.3% in silicone and PAO oil, respectively. This non-Einstein viscosity reduction can be attributed to the disruption of hydrophobic interactions of base oil molecules due to the addition of hydrophilic $Ti_3C_2T_z$ nano-sheets, which could disrupt local bonding networks of base oil. The addition of $Ti_3C_2T_z$ reduced the friction by 23% and 65 % in silicone and PAO oils, respectively. The improved properties and reduced fluidic drag in viscosity and friction lead to potential applications in (electrical) vehicles that will be helpful in attaining improved fuel economy.

3908248: Depth-dependent Adhesion of Gradient-stiff Hydrogel, Measured Using AFM Nano-indentation

Md Mahmudul Hasan, Alison Dunn, University of Illinois at Urbana-Champaign, Urbana, IL

Gradient-stiffness, common entity in biological livings, and hydrogels, plays a pivotal role in their physiological and tribological performance. Earlier, we reported that gradient-stiff surface, where stiffness gradually increases into depth, controls the overall contact mechanics. The varying polymer chain density in such surface changes their adhesive interaction, which needs a methodical investigation. Here, we investigated the evolving adhesion into the depth of polyacrylamide hydrogel, molding against different materials, using AFM. Results showed that mold material can tune gradient layer properties on identically-composed hydrogels, i.e., glass-molded hydrogel has thinner gradient layer,~ 150nm, compared to that of Polyoxymethylene-molded hydrogel,~ 450nm.The adhesion at shallow depth was significantly higher with having different probe-sample separation mechanism compared to deep depth. These results allow clear understanding of depth-dependent adhesion in a gradient-stiff surface.

Early Career and Student Posters

3908150: Hydrogel Permeability as a Function of Elastic Modulus for Improving Mechanical and Surface Properties

Nusrat Chowdhury, University of Illinois at Urbana-Champaign, Urbana, IL

Hydrogels are composite materials with high content of water of 90-95% that provides tremendously low friction to the surface. Even though these gels hold high water content, their mechanical strength and structural properties make them feasible for biomedical applications. In our current effort, we have tested 7-11% pAAm hydrogel for their permeability values through a permeability tester and the elastic modulus with micro-indentation. The permeability values for these compositions range from 2 ×10-16 - 2×10-17 m2 and the modulus ranges from 20-80 kPa. The elastic modulus follows an increasing trend with a decrease in the permeability of the hydrogel. As there is an inverse relationship between the modulus of elasticity and permeability, we can have a quantitative idea of permeability value from the modulus of the hydrogels. The higher the strength of the material, the harder it will be to squeeze out fluid from the gels because of the denser polymer content and mesh size.

3907912: Evaluating the Effect of Erucic Acid Content on Tribological Performance and Thermal Oxidation Behavior of Plant-Based Lubricants

Rawan Al Sulaimi, Diana Berman, University of North Texas, Denton, TX

This study compared six plant-based lubricants (Jojoba, Castor, Canola, Rapeseed, Pennycress, and Lesquerella) with PAO4 oil to evaluate their potential as environmentally friendly alternatives to synthetic oils. The results showed that high erucic acid content oils exhibited better lubrication properties and oxidation resistance under high temperature and shear regimes. To further investigate this, the effect of erucic acid on tribological behavior and thermal oxidation was studied by comparing oils with similar structures but different erucic acid contents. The study found that higher erucic acid oils reduced friction and wear on steel surfaces under loads up to 20N and temperatures up to 200C. The study proposes a new approach to enhance the performance of biolubricants by manipulating their molecular structure.

3907519: Tribological Study of a Protic Ionic Liquid as an Additive in Base Oils Under Electrified Conditions

Seungjoo Lee, Ali Erdemir, Pushkar Deshpande, Texas A&M University, College Station, TX; Leonardo Farfan-Cabrera, Tecnologico de Monterrey, Monterrey, Mexico; Patricia Iglesias, Rochester Institute of Technology, Rochester, NY

E-mobility is considered imperative for a sustainable transportation for future. However, not much is known about the adverse effects associated with undesirable passing of electrical current within the moving parts of electric vehicle (EV) drivetrains. Ionic Liquids (ILs) are well-known for their unique physical and chemical properties which might make them potential candidates for use in EV lubricants. Here, we present tribological studies of various base oils (including PAOs and Mineral base oils as well as a lubricant derived from plastic wastes) with and without a protic IL additive under electrified conditions. Results of extensive tribological tests confirmed the existence of unique tribochemistry greatly impacting friction and wear. Base on the results of tribological and analytical studies, we propose a phenomenological model that explains the underlying mechanism for the generation of a highly protective tribofilm under some of the electrified test conditions.

3907498: Mitigating Wear in Knife Mill for Biomass Preprocessing by Applying Wear Resistant Blade Materials

Tomas Grejtak, Jun Qu, Oak Ridge National Laboratory, Oak Ridge, TN; Jeffrey Lacey, Miranda Kuns, Damon Hartley, David Thompson, Idaho National Laboratory, Idaho Falls, ID; George Fenske, Oyelayo Ajayi, Argonne National Laboratory, Lemont, IL; Peter Blau, Blau Tribology Consulting, Enka, NC

Critical components of biomass preprocessing equipment are susceptible to excessive wear due to inorganic components of feedstock. Through comprehensive characterization and in-depth analysis, we demonstrate that knife milling performance for preprocessing forest residue can be significantly improved by using specialized wear-resistant blade material. Experimental testing on a knife mill revealed that the operational life of milling knives can be improved by 8X and 3X with applying tungsten carbide and iron borided blades, respectively, in comparison to the commonly used tool steel blades. Additionally, the advanced blade material not only enhances the durability of knives but also increases the milling throughput and improves the operational cost of knife milling.

3907873: A Comparative Analysis in Tribo-Mechanical Behavior of Cold Rolled and Additively Manufactured Nickel Titanium Alloy

Hyunsuk Choi, Sougata Roy, University of North Dakota, Grand Forks, ND; Yashwanth Bandari, FasTech LLC, Danville, VA

NiTi is known for its two unique properties: shape memory and superelasticity. NiTi alloys with superelastic behavior are recently being studied for load-bearing applications due to their ability to withstand significant elastic strains and enhanced mechanical characteristics compared to shape memory NiTi. This research used ball-on-flat, reciprocating sliding tests to examine the tribo-mechanical behavior of a NiTi alloy fabricated via Laser wire directed energy deposition (LW-DED). The tests were carried out in unlubricated conditions against AISI 52100 balls at temperatures ranging from room temperature to 200°C. Wear tracks were analyzed using the sets of microscopy and white light interferometry to understand the changes in wear mechanisms as a function of testing temperature. These findings are then compared to the behavior of superelastic cold-rolled 55 NiTi alloy to reveal the benefits and challenges of fabricating NiTi alloy using LW-DED additive manufacturing.

3907838: Tribochemistry of Diamond-like Carbon – Interplay Between Hydrogen Content in the Film and Oxidative Gas in the Environment

Seokhoon Jang, Pennsylvania State University, State College, PA; Muztoba Rabbani, Ashlie Martini, University of California Merced, Merced, CA; Andrew Ogrinc, Maxwell Wetherington, Seong Kim, The Pennsylvania State University, University Park, PA

The superlubricity of hydrogenated diamond-like carbon (HDLC) solid lubricant films is highly sensitive to the hydrogen content in the film and the oxidizing gas in the environment. This study investigated the tribochemical origins of the environmental sensitivity of HDLC films with two different hydrogen contents (mildly-HDLC vs. highly-HDLC). A Langmuir-type kinetics analysis revealed that the highly-HDLC film exhibited lower oxidation propensity than the mildly-HDLC film in O_2 and H_2O environments. The molecular origin of such difference was investigated with reactive molecular dynamics simulations; the hydrogen content dependence of oxidation reactivity of HDLC with O_2 and H_2O may be governed by the degree of undercoordinated carbon atoms in the film which decreases as the degree of hydrogenation increases. This finding can guide the design of HDLC that is less sensitive to environmental conditions and exhibits superlubricity across a wider range of practical operating conditions.

3907831: An Investigation of Varnish Formation and Removal in a High-Pressure Piston Pump

Shriya Reddy Kalijaveedu, Fluid Power Institute, Milwaukee School of Engineering, Milwaukee, WI

Prevention and remediation of hydraulic system varnish is important to equipment users because varnish can cause valve malfunction, heat exchanger fouling and shorten fluid life. In this investigation the tendency of fluids to form deposits was evaluated using the JCMAS P 045 High Pressure Pump test. Fluids that had low and high varnish-forming potential were evaluated. A modular plate and frame heat exchanger was used to facilitate inspection and analysis of deposits. Fluids with high-varnish forming tendency were found to deposit oxidation debris on heat exchanger surfaces. Thermal imagine and heat transfer analysis were used to evaluate effect of varnish on heat exchanger performance. A varnish removing additive effectiveness was evaluated. The system was drained and disassembled for inspection. The cleaner was found be effective at removing deposits at both temperatures. These findings provide insights in how to extend the life of hydraulic fluids and equipment.

3811630: Molecular Dynamics Simulation and Machine Learning-assisted Analysis for Nano-confined Lubricants Under Slow Shear Rates Nearly Comparable to Experiments

Ikki Yasuda, Yusei Kobayashi, Katsuhiro Endo, Noriyoshi Arai, Kenji Yasuoka, Keio University, Yokohama, Japan; Kazuhiko Fujiwara, Kuniaki Yajima, National Institute of Technology, Sendai College, Sendai, Japan

Lubricant with the desired frictional properties is important in achieving an energy-saving society. At the interfaces of mechanical components, lubricants are confined under high shear rate and pressure, and behave quite differently from the bulk. To probe the molecular behavior, computational approaches such as non-equilibrium molecular dynamics (NEMD) simulations have been performed. However, the low-shear-velocity regions have rarely been simulated due to the expensive calculation, and the molecular dynamics around shear velocity comparable to the experiment are not clearly understood. In this study, we performed NEMD simulations of extremely confined lubricants, which were analyzed using an unsupervised machine learning approach to detect molecular movements that contribute to shear thinning. We found the magnitude of diffusion corresponded to the viscosity, and the location of slips that varied depending on the spherical and chain lubricants was irrelevant.

3906603: Effect of Chemical Cleaners on Varnish Removal and Elastomeric Seals

Jose Morales, Ashlie Martini, University of California, Merced, Winton, CA; Zhen Zhou, Chevron Global Lubricants, Richmond, CA

Varnish formation from lubricating oils is a challenge because the deposits on metal surfaces could obstruct fluid flow and result in wear or heat transfer issues. Chemical cleaners can remove varnish from the surfaces of lubricated mechanical components. Using a custom test rig, chemical cleaners specifically formulated to remove varnish were evaluated under different conditions. The testing procedure determined the rate of varnish removal and enabled quantitative comparison of cleaner performance. In addition, the potential effect of the cleaners to degrade elastomeric materials was evaluated by characterizing the geometric and mechanical properties of seals in the test rig. The results of this testing contribute to enabling mechanical systems to have a longer lifespan, proper functionality, and better performance.

3907064: Experimental and Finite Element Modeling of Soft Biological Tissues in Contact

Conor Shanley, Northwestern University, Evanston, IL

Development of novel medical devices for treatment of musculoskeletal pain at trigger points necessitates the modelling of contact between relatively rigid structural materials (e.g., acetal polymers) and soft tissues, such as skeletal muscle. The steady-state indentation response of the skeletal muscle structure of the posterior neck was measured with a testing device, and a finite element model (FEM) was built to simulate the response, using a first-order Ogden hyper-elastic solid material model. The error between empirical and FEM-generated displacement-load curves was minimized via a two-stage optimization process comprised of an Optimal Latin Hypercube DoE analysis and a Sequential Quadratic Programming optimization loop. The optimized Ogden model has an initial shear modulus ( ) of 5.16 kPa and a deviatoric exponent ( ) of 11.90. The results are similar to prior studies performed on in vitro tissue samples, but the new model parameters better reflect the in vivo tissue behavior.

3907069: Tribological Performance of Lithium Complex Greases with Pyrylium- and Pyridinium-Based Ionic Liquids

Cinderella Moustafa, Miguel Chacon Teran, Michael Findlater, Ashlie Martini, University of California, Merced, Merced, CA

Ionic Liquids (ILs) have been studied as green lubricants for the last two decades. Literature has shown that adding ILs to lubricating oils can have a positive effect on wear and friction behavior. However, there have been fewer studies about the potential benefit of ILs as additives for grease. In this study, the tribological performance of lithium complex greases with pyrylium- and pyridinium-based ILs were investigated. Four-ball tests according to ASTM D2266 and ball-on-disk tests according to a modified combination of ASTM G99 and ASTM D5907 standards were used to evaluate the friction coefficient and wear behavior of the greases. At least two trials were run for each grease-IL combination and test condition using different 52100 steel samples to ensure the results are robust. The results show that pyrylium- and pyridinium-based ILs can be effectively blended into lithium complex greases as additives and may enhance both wear and friction performance.

3907408: Molecular Dynamics Modeling of Thermal Conductivity of Several Hydrocarbon Base Oils

Jannat Ahmed, Q. Jane Wang, Oluwaseyi Balogun, Northwestern University, Evanston, IL; Ning Ren, Roger England, Frances Lockwood, Valvoline Inc., Lexington, KY

The research is on the determination of the thermal conductivities of several hydrocarbon base oils by means of non-equilibrium molecular dynamics simulation using two force-fields. It aims to explore a simulation-based method for lubricant molecular design and analysis concerning heat transfer in vehicle components. We used two methods to calculate bulk thermal conductivity, both giving consistent results. The predicted conductivities show certain overpredictions as compared with the experimentally measured results, and overprediction factors are defined. The results lead to a formula that describes the effects of carbon chain length and number of branches of liquid hydrocarbons on their thermal conductivity.

Early Career and Student Posters

3901772: Optimization of Digital Image Correlation Techniques for the Assessment of Plantar Loading and Tribology Regimes in Foot Health Applications

Francesca Sairally, Peter Culmer, University of Leeds, Leeds, United Kingdom; Claire Brockett, University of Sheffield, Sheffield, United Kingdom; Heidi Siddle, David Russell, School of Medicine, Leeds, United Kingdom

Diabetic foot ulceration is exacerbated by plantar loading patterns and leads to health complications. Current assessment includes pressure measurement but neglects shear, which contributes to ulcer formation. Our group developed a novel plantar load measurement technique (STAMPS) for clinical application. This combines a plastically deformable insole with Digital Image Correlation (DIC) to characterise in-shoe shear strain. This work reports DIC enhancement through computational methods to improve spatial resolution for assessing tribological interactions. A parametric study of DIC subset parameters was conducted against representative literature plantar strain. Experimental loaded deformation studies validated the outcomes. The results show reducing the DIC subset and strain radius improves the strain output accuracy, with larger settings showing over-smoothing. This technique shows potential for risk assessment in a clinical environment, such as diabetic foot interventions.

3902839: Tribological Behaviors of Textured Surfaces Produced by Laser Powder Bed Fusion

Tobias Martin, Q. Jane Wang, Jian Cao, Northwestern University, Evanston, IL; Stephen Berkebile, US Army DEVCOM Army Research Laboratory, Aberdeen Proving Ground, MD

Surface texture affects the tribological behavior of mechanical components in boundary and mixed lubrication. Currently, many additively manufactured parts undergo expensive and time-consuming post processing to meet surface roughness requirements. If tribologically beneficial surface textures are designed so that the texturing and additive manufacturing processes can be combined, parts thus made can be used in their as-built condition. Consequently, production cost is reduced, and a prolonged life of these parts can be expected. This poster presents a study based on reciprocating tribotests, performed on the top surfaces of materials produced by laser powder bed fusion with the sliding direction parallel, perpendicular, and angled to the laser scanning direction. Friction and wear were recorded and correlated to the position within the wear track and velocity variation for an in-depth understanding of these parameters and their impact on the performance of surface texture patterns.

3901888: Tactile Perception of Vellum Quantified by Friction and Surface Roughness

Samuel Leventini, Brian Martin-Gutierrez, Abhishek Kumar, Ashlie Martini, University of California, Merced, Merced, CA; Asa Mittmann, CSU Chico, Chico, CA; Susan Kim, Illinois State University, Normal, IL

Before digital copies of books and manuscripts, they were written on vellum, or prepared skins of animals. Scientists today have proposed that ancient readers navigated through the papers by touch, or sensory responses from interacting with the medium. Here, we studied the potential correlation between sliding friction, measured roughness, and perceived roughness of vellum samples from different animals and preparation methods. Friction was measured through unilateral reciprocating sliding tests on 14 different samples with a probe mimicking a human finger. Roughness and other characteristics were measured using interferometry. A panel of untrained volunteers was used to gather sensory data for correlation with the other results. Results were then compared against each other to find any correlation or trends. Data demonstrated an inverse relationship between perceived and actual roughness, and coefficient of friction and measured roughness.

3903929: Molecular Structure and Environment Dependence of Shear-Driven Chemical Reactions

Yu-Sheng Li, Seokhoon Jang, Seong Kim, The Pennsylvania State University, State College, PA; Fakhrul Hasan Bhuiyan, Ashlie Martini, University of California, Merced, Merced, CA

This study examined the tribopolymerization of molecules with different internal ring strain energy (cyclohexane, cyclohexene, methylcyclopentane) on stainless steel surfaces in N_2, O_2, and H_2 environments to gain a better understanding of the underlying mechanisms of tribochemistry. The results showed that in N_2 and H_2 environments, cyclohexane had the lowest reactivity among the three precursors tested, with a similar trend observed in reactive molecular dynamics simulations. Additionally, the origin of D- and G- bands in the Raman spectrum of tribofilms could be a result of photochemical degradation of tribofims by high-energy Raman laser. Based on the infrared analysis, tribofilms were organic materials containing oxygenated groups. These findings provide valuable insights into the complex and dynamic interfacial processes involved in tribochemistry, which could have important implications for developing more effective lubricants and surface coatings for industrial applications.

3905567: A Review of the Variation of Physicochemical and Tribological Properties of Biolubricants Depending on its Chemical Structure

Claudia Sanjurjo Muñiz, Eduardo Rodríguez Ordóñez, Antolín Estaeban Hernández Battez, University of Oviedo, Gijón, Asturias, Spain

The increase in crude oil prices, the environmental consequences or the depletion of fossil resources, have increased the necessity of bio-based alternatives. This leads to the search for renewable, biodegradable and eco-friendly raw materials to obtain lubricants that meet these characteristics. This review deals with the state of the art of bio-lubricants along their most common raw materials and molecular structures, as well as the relationship between molecular structures and physicochemical/tribological properties. This research concludes that the production of fatty acid alkyl esters (FAAEs) from vegetable oils as the most promising route to produce a wide range of bio-lubricants through double transesterification reactions. In addition, the need to study its application in the production of microalgae-derived biol-lubricants is revealed, due to its environmental benefits during culture and production processes.

3904795: Metal Oxide Tribofilms: Relating Antiwear Additive Synergy with Mechanical Properties

Daniel Delghandi, Sage Fulco, Pranjal Nautiyal, Parker LaMascus, Kevin Turner, Robert Carpick, University of Pennsylvania, Philadelphia, PA; Robert Wiacek, Pixelligent Technologies, Baltimore, MD

A reduction in gear and engine oil viscosity is a potential solution in the quest for a higher efficiency transportation sector, but lower viscosity oil requires advanced anti-wear additives. Zirconia nanocrystals form tribofilms that inhibit wear and scuffing while behaving cooperatively with commercial antiwear additives, suggesting that the antiwear additives may be integrated in the tribofilm, affecting its properties. This work investigates the mechanical properties of zirconia tribofilms formed with various concentrations of a phosphorus-based additive. Phosphorus integration is determined by spatially resolved compositional characterization, and nanoindentation is used to determine the mechanical properties of the formed tribofilms. We report that phosphorus can be integrated in the tribofilm bulk without influencing the hardness or elastic modulus of the tribofilm.

3905814: Run-In and Superlubricity of Diamond-Like Carbon at Microscale Sliding Contacts

Hind Flaih, Ana Colliton, Eskil Irgens, Lucas Kramarczuk, Griffin Rauber, Jordan Vickers, Brian Borovsky, St. Olaf College, Northfield, MN; Seokhoon Jang, Seong Kim, Pennsylvania State University, State College, PA; Zhenbin Gong, Junyan Zhang, Lanzhou Institute of Chemical Physics, Lanzhou, China

We present an experimental study of the run-in to low friction of diamond-like carbon (DLC) coatings through a process involving tribochemical reactions. We use an indenter probe to load a stainless-steel sphere (100 μm) onto a hydrogenated DLC coating that forms the surface of a quartz crystal microbalance (QCM). By resonating a shear mode of the QCM, we induce sliding friction at the interface with track lengths in the nanometer range and frequencies near 5 MHz. The QCM measures friction while the normal load is fixed at values between 5 μN and 1 mN. These measurements can be sustained even when a secondary lateral motion is superimposed using a piezo stage, with a track length of 20 μm and frequency of 10 Hz. Our results show that adding microscale sliding facilitates the run-in process to ultralow friction values, requiring far fewer cycles and less time than nanoscale sliding alone. We present measurements of the frictional shear stress showing a linear increase with pressure.

3905210: Molecular Dynamics Study of Thermal Degradation of Lubricants for Aerospace Applications

Daniel Miliate, Ashlie Martini, University of California Merced, Merced, CA; Stephen. Didziulis, Andrew Clough, Peter Frantz, The Aerospace Corporation, El Segundo, CA

The extreme conditions of space have created unique challenges in tribology. The development of multiply-alkylated cyclopentane (MAC) lubricants has been instrumental in addressing some of these challenges. However, experimental results have shown that lubricant life depends in part on the materials of the interreacting surfaces. The objective of this study was to use reactive molecular dynamics simulations to understand the degradation mechanisms of the MAC lubricant 1,3,4-tri-(2-octyldodecyl) cyclopentane. The lubricant was modeled in the presence of various metals commonly used in aerospace applications. Simulations were run at elevated temperatures both with and without oxygen to analyze the effect of the metal on oxidation and non-oxidative thermal degradation. The findings here contribute to better understanding MAC lubricant degradation mechanisms and its sensitivity to metals

3899176: Benchtop Tribological Characterization of Electric Motor Greases for Hybrid Bearings

Abhishek Kumar, Jose Vasquez-Reyes, Ashlie Martini, University of California Merced, Merced, CA; Christina Cheung, Thomas Murray, Anoop Kumar, Chevron Corporation, Richmond, CA

Electric motors (EM) can require that greases operate in demanding conditions, such as high temperature, and with non-ferrous materials. Evaluating grease formulations for these conditions therefore requires modifications of standard benchtop tests. This study involved tribological characterization of EM greases using four-ball and ball-on-disk tests with materials and conditions modified to better reflect current and emerging applications, including electric vehicles. The hybrid bearing configuration was mimicked by testing with silicon nitride and 52100 steel tribopairs. The market-available and new grease formulations studied had mineral or synthetic base oil, and polyurea or lithium thickener. The friction traces, wear response, energy dissipation, and estimated film thickness were analyzed to enable comparison of the tribological properties of these greases specifically for EM applications.

3808273: Towards Achieving Long Term Reliability in High-Performance Electroadhesive Clutches for Haptics and Robotics

Changhyun Choi, Aditya Kuchibhotla, Cynthia Hipwell, Texas A&M University, College Station, TX

To change friction force in various applications such as haptics and robotics, electroadhesion has been gaining attention due to its reduced complexity and fast response. Models which combine electric field and contact mechanics have been used to predict initial electrostatic force, such as in a electrostatic chuck, but they do not address dynamic or long term performance in devices which may have relative motion, such as clutches. These devices are more likely to have issues with wear and its longterm impact on friction force. In this work, we analyze the clutching performance between a conductive latex and dielectric substrate using electroadhesion and study its tribological behavior with respect to different operational, material, and geometric parameters. Understanding the failure modes will be used to further improve long-term clutching performance, achieving high electroadhesive shear stress and high wear resistance, which can enable the wider use of electroadhesion.

3832230: Wear-Related Fault Detection of Hydraulic Axial Piston Pump Using Deep Learning Model with Limited Data Samples

Chul-Hee Lee, Oybek Eraliev, Kwang-Hee Lee, Inha University, Incheon, Republic of Korea

Numerous studies of fault detection systems have demonstrated the advantage of DL models over classical machine learning (ML) in terms of feature extraction, feature dimension reduction, and diagnosis performance. Sometimes, a sensor problem during data acquisition renders some of the information potentially inappropriate for further processing, leaving only a small sample of the data available for analysis. To overcome this drawback, a DL model based on a stacked convolutional autoencoder (SCAE) model is developed in this study. This study outlines the creation of a time-frequency visual pattern recognition-based approach for hydraulic axial piston pump fault detection mostly caused by wear damages at the contact interfaces. The results show that, even with a little data sample, the suggested approach can give an outstanding diagnostic performance with over 99.5%. Additionally, when the data is noisy, the suggested model performs better at diagnosis than other DL models.

Early Career and Student Posters

3810966: Superior Macro-Scale Tribological Performance by the Synergetic Effect of Graphene Family Materials 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. 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-based nanomaterials with aqueous glycerol for improved lubrication performance between self-mated steel contacts. The results show that the aqueous glycerol with graphene based nanoadditves show superior dispersion stability and significantly reduced the friction and wear. This striking decrease in the coefficient of friction and wear is due to the synergetic effect of aqeous glycerol and graphene layers. This work demonstrated that graphene 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.

3812585: Modeling and Analysis of Piston-Pin Lubrication for Internal Combustion Engines Considering Deformation and Cavitation

Zhiyuan Shu, Zhen Meng, Tian Tian, Massachusetts Institute of Technology, Cambridge, MA; Rolf-Gerhard Fiedler, MAHLE International GmbH, Stuttgart, Germany; Per Liljeros, Volvo Penta, Gothenburg, Sweden

In an internal combustion engine system, the wrist pin operates under high pressure and temperature and is susceptible to friction and wear but the study on these tribological pairs proves to be difficult. In this work, a piston pin model is developed to simulate the flow field and interaction between the piston pin and the surfaces in contact with it. The influence of pressure and temperature on lubricating oil properties and surface deformation is considered. The simulation results applying the pin model to a diesel engine show that the flow of lubricating oil is easily affected by factors such as piston pin bore profile and lubricating oil supply. The key to reduce friction loss is to transport lubricating oil to high load area in time and to minimize local asperity contact by modifying the shape of pin bore and small end at the edges.

3833902: Analytical Study of Friction Reduction Performance for DLC-involving Contact with Commercial Fully-Formulated Oil

Maria-Isabel De Barros Bouchet, Yue Guan, Fabrice Dassenoy, Ecole Centrale de Lyon, Ecully, France

Diamond-like carbon (DLC) has become attractive in automobile industry thanks to its excellent anti-wear and low friction properties. For example, by tuning the mechanical properties of coatings, tetrahedral amorphous (ta-C) DLC self-mated configuration can reach ultralow friction regime with the presence of ZDDP [1]. Amorphous hydrogenated (a-CH) DLC self-mated configuration can also have CoF around 0.02 with PAO, but CoF increases with the presence of ZDDP additive [2]. However, in most of these works, the selected lubricants are mainly composed of a base oil + one/two additives, conditions far from the industrial application. In this work, the interaction of commercially fully-formulated oil with DLC self-mated and DLC/steel mixed configurations is investigated. The different parameters as sliding velocity, contact pressure are tuned to investigate their impact on tribological behaviour.

3835471: Applied Variational Methods for Modelling Vascular Structures

Abdu Yearwood, University of The West Indies, Georgetown, Guyana

This study applied variational methods within a level-set framework for the modeling of vascular structures. Extracting meaningful information from medical images was demonstrated using a DICOM dataset acquired from the OSIRIX online Library and the St. Joseph Mercy Hospital, Georgetown, Guyana. It was found that although active contouring could be used to reconstruct the surface of a segmented region by explicit definitions the reconstructed surface may not be a true representation of the vessel wall across all 2D images. Consequently, an implicit approach was applied to extract 3D structures, while a Chan-Vese model was used in a 2D context for a global understanding of the segmentation problem. While active contouring can often lead to poor performance, due to pixel leakage artifacts, it may yet prove useful as part of a pipeline to conduct realistic biofluid research.

3836553: Novel Fretting-Corrosion Mechanisms of Friction Stir Processed Steel Manufactured by High Deposition Rate Additive Manufacturing Process

Alessandro Ralls, Pradeep Menezes, University of Nevada, Reno, Reno, NV

Acting as a novel technology, the application of high-pressure deposited (HPD) coatings has attracted to attention of many due to its solid-state deposition-like features. From an industrial perspective, the application of HPD coatings is fundamental to preserving the working lifespans of various machining components. This is especially true in chloride-rich environments that are continuously exposed to oscillatory contacting tangential movements. However, due to the porous nature of HPD coatings, they suffer from rapid material degradation due to severe pitting and premature brittle fracture. In this work, we investigated the influence of FSP on the fretting-corrosion mechanisms of HPD steel. It was found that the effect of FSP enhanced the metallurgical bonding and intrinsic hardness of the HPD coating. As such, their fretting-corrosion performance was also improved, concluding that FSP is a viable method to enhance the surface quality of HPD coatings.

3895186: Investigating the Tensile and Compressive Properties of Diabetic and Non-Diabetic Plantar Skin to Develop Surrogates for Use in Biofidelic Tribological Test Beds

Sarah Crossland, Francesca Sairally, Jen Edwards, Peter Culmer, University of Leeds, Leeds, West Yorkshire, United Kingdom; Claire Brockett, University of Sheffield, Sheffield, United Kingdom

Diabetic foot ulceration (DFU) is a leading cause of non-traumatic lower limb loss with plantar loading, pressure and shear, contributing to formation. Current assessment tools are solely pressure based, further understanding of ulcer formation requires measurement of plantar shear load. Biofidelic testing using surrogates allows investigation of plantar skin and subcutaneous tissue strain responses under varied loading regimes reducing cadaveric tissue reliance. To develop representative surrogates, cadaveric plantar skin studies were conducted including stress-strain response and dynamic mechanical analysis for tensile and compressive properties using replicative frequencies and strains from the feasibility study. Surrogates were manufactured to mimic the cadaveric tissue response, using a silicone tissue with embedded strain limiting layer. The surrogates provide a repeatable method for use in tribological testing of the plantar aspect and detailed measurement of plantar loading.

3900395: Molecular Mechanisms of Tribochemical Reactions: Reactive Molecular Dynamics Simulations of Cyclic Organic Molecules

Fakhrul Hasan Bhuiyan, Ashlie Martini, University of California, Merced, Merced, CA; Yu-Sheng Li, Seong Kim, The Pennsylvania State University, State College, PA

Tribochemical reactions determine the performance of lubricant additives that form friction and wear-reducing tribofilms. However, mechanistic understanding of these reactions is still limited because the mechanochemical response of reactant species is a complex function of many variables. Here, we studied tribochemical reactions of simple cyclic organic molecules to isolate the effect of chemical structure on reaction yield and pathway. Results identified shear stress as the key driver of association reactions under tribological conditions. The trend of reaction yield in simulations was consistent with shear-driven polymerization yield in ball-on-flat sliding experiments. Analyzing the simulated oxidative chemisorption showed the effect of the chemical features of a reactant on its sensitivity to mechanochemical activation. Lastly, the most common association reaction pathways were identified, and a bond-by-bond analysis revealed the role of shear stress in mechanochemical activation.

3895265: A Multiscale Modeling Approach to Study the Plunger-Bore Interface of a Radial Plunger Pump

Henry Soewardiman, David Pickins, Yip-Wah Chung, Q. Jane Wang, Northwestern University, Evanston, IL; Blake Johnson, Nikhil Murthy, Stephen Berkebile, US Army DEVCOM Army Research Laboratory, Aberdeen Proving Ground, MD

Within a high-pressure fuel pump, the plunger-bore interface is critical to ensure the efficient delivery of fuel to the rest of the fuel system. However, scuffing may occur at this interface due to high pressure, high-frequency motion, and poor lubrication. This poster presents a multiscale modeling system of a radial plunger pump to simulate the plunger motion and interaction with the cylinder bore, aiming to characterize the interfacial conditions that lead to severe adhesive wear. System-scale models identify the structural and fluid behavior of the fuel pump, and data from those models are used in a plunger-bore interface model to explore critical contact conditions in detail, particularly regions of asperity contact and the variation in the fuel charge-discharge cycle. The interface model then records the minimum film thickness, friction force variation, and leakage as factors for design optimization.

3931863: Superlubric Phase of Ice

Arnab Neogi, Subramanian SKRS Sankaranarayanan, University of Illinois, Chicago, IL; Anirudha Sumant, Argonne National Laboratory, Lemont, IL

We developed a machine learning potential which captures the interactions between two water molecules. With this force field being able to describe the properties of water, we modelled a tribology set up and discovered a superlubric regime for ice. The structure at the interface, which is formed by applying a specific normal load, temperature and sliding velocity have not been previously discovered and it is a metastable structure. This structure also falls under smart material, as this is not a thermodynamically stable structure on its own but is formed with the application on pressure-temperature-velocity conditions which means that the 2D layer is not depleted over long cycle range as long as the environmental conditions are maintained.

This discovery will lead us in fundamental understanding of the structural modifications that happen due to shearing and sliding on earth due to global atmosphere heating and other phases of ice that exist in other planetery bodies.

3918449: Stopper Contact During Freeze-Thaw Cycling of Prefilled Syringes

Catherine Fidd, Grace Lin, Adam DeLong, Kylie Van Meter, Santiago Lazarte, Florida State University, Tallahassee, FL; Nestor Rodriguez, Becton Dickinson, Franklin Lakes, NJ; Brandon Krick, Florida State University, Tallahassee, FL

Drugs and vaccines in prefilled syringes can be frozen for storage to maintain viability. Thermal-induced density and phase changes can result in stopper movement within the syringe barrel. Loss of contact with the stopper and barrel may occur due to the mismatch of thermal expansion coefficients and low-temperature phase transformations of the materials in the syringe system. The combined effects can result in hysteresis in the temperature-stopper displacement relationship; here, the stopper's final position at room temperature is different from the initial position after freeze-thaw cycles. This project aims to investigate the stopper displacement and contact via a cryostat system that can perform variable cooling/heating ramps from ambient down to -80°C. Realtime in situ optical imaging can track the stopper's movement during the freeze/thaw cycles, obtain CTEs of the syringe and stopper materials, and monitor barrel-stopper contact can be through differential pressure measurements.

Participants Index 2023

Includes technical program authors, Commercial Marketing Forum (CMF) presenters, Early Career Research (ECRP) and Student Poster (SP) authors.

Please note authors with multiple papers listed in technical sessions.

(As of April 25, 2023)

A

Aamer, Saeed, 2B
Abd Aziz, Mohd Syafiq, 6L, 6L
Adabasi, Gokay, 2N
Adams, David, 5E
Adler, Matthias, 7C, 8C
Afanasiev, Pavel, 7A
Afshar Mohajer, Mahyar, 5L
Agocs, Adam, 8I
Ahmed, Jannat, 6D, SP
Ahmed Abdalglil Mustafa, Waleed, 6I
Ahyee, Amakoe K., 5F
Ajayi, Oyelayo, 5D, 5D, 6D, SP
Akiyama, HIrotoshi, 5E
Alauzen, Tanner, 4D
Aldossary, Abdulrahman, 5D
Alemanno, Fabio, 6G, 6G
Alenezi, Abdullah N., 6F
Ali, Nabila, 7F, SP
Allan, Jesse, 2H
Almqvist, Andreas, 1M, 3C, 6F, 6N, 7G
Al Sheikh Omar, Alaaeddin, 3A,5N
Al sulaimi, Rawan, SP
Alumà, Marc, 2C, 3F
Amami, Lassad, 8C
Amanov, Auezhan, 6L
Ambekar, Amar M., 4C
Amerio, Ezio, 7M
Amiri, Ahmad, 4F
Ammam, Ianis, 8F
Ancheta, Joshua, 2N
Anderluh, Robert, 6N
Anders, Elizabeth, 3D
Anderson, William A., 2G, 2I, 8I
Andersson, David, 4N
Angelini, Thomas E., 8F
Anglin, James R., 2G
Aouadi, Samir, 2D, 7A
Arai, Noriyoshi, SP
Arghir, Mihai M., 3C
Argibay, Nicolas, 5D
Arnold, Dirk, 1A
Arole, Kailash, 7A, SP
Aruta, Vincenzo, 2H
Arya, Ujjawal, 2B, SP
Ash, Robert, 3H
Asif, Ayesha, 4F
Atalay, Onur, 2B
Ayabina, James, ECRP
Ayyagiri, Aditya, SP
Azuma, Naoki, 4A, 4A, 6K

B

Baboukani, Behnoosh, S. 3N
Babuska, Tomas, 2D, 3D, 5E, 6K, SP
Bachnacki, Dawid, 5D
Bagov, Ilia, 2O
Bailey, Sophia J., 8F
Bairagi, Satyaranjan, 5F
Bakolas, Vasileios, 2B
Bala, Aparna, 2A, 2O
Baldwin, Thomas, 3G
Balogun, Oluwaseyi, SP
Balzer, Bizan N., 4N
Bandari, Yashwanth, SP
Bansal, Dinesh, 7H
Bantchev, Grigor B., 1G
Baral, Khagendra, 1D
Bartram, Michael, 2C
Basu, Shubhamita, 2H
Bauer, Frank, 7C, 8C
Baumann, Matthias, 8C
Baykara, Mehmet, 2N, 3N
Becker-Dombrowsky, Florian Michael, 1E, 7I
Beckford, Samuel, 4D
Beemsterboer, Richard D., 3F
Behera, Ranjan, 4L
Beheshti, Ali, 5L
Bekisli, Burak, 7C, 8G
Belkacemi, Lisa, 5D
Beltran, Lluís, 3A
Benmansour, Marina, 7A
Bennington, Leeman, 3E
Berbach, Joseph, 3D, SP
Berens, Frank, 6H
Bergant, Zoran, 4G
Bergeron, Bryan, 5A
Berkebile, Stephen, 2D, 2M, 3D, 3I, 5D, 5D, 5D, 5G, 5L, 6D, 6F, 6L, 7A, SP, SP
Berlet, Peter, 7M
Berman, Diana, 2D, 3N, 7A, SP, SP
Berryman, Jacqueline, 6G
Berthel, Bruno, 6N
Berthier, Yves, 5M
Beyerlein, Irene, 5D
Bhamra, Jagjeevan, 5E
Bhattacharjee, Arnab, 5D, 5D
Bhowmik, Piash, 4F, SP
Bhuiyan, Fakhrul Hasan, 5E, 6E, SP, SP
Bhutta, Muhammad U., 6D
Bienefeld, Christoph, 1E
Bijwe, Jayashree, 5N

Binanzer, Lisa, 3G
Bird, Marc, 5E
Björling, Marcus, 3C
Blatter, Ines L., 5D
Blau, Peter J., 3I, SP
Blouin, Antoinette, 8C
Blumenfeld, Michael, 2C
Bodewig, Alexander H., 3B
Bomidi, John, 5E
Bond, Samuel, 2I
Borovsky, Brian P., 5E, SP
Bosch Giner, Juan, 8G
Boudreau, David M., 3A
Boukraa, Salah, 4B
Bou-Saïd, Benyebka, 3C
Bouscharain, Nathalie, 5G
Boyce, Brad, 3D
Brady, David J., ECRP
Bramley, Phoebe, 7F
Brase, Markus, 8C
Braun, Daniel, 5G
Bretonnet, Amelie, 4K
Brideau, Jeremy, 2H
Briggs, Tom, 3F
Brinkmann, Katharina, 6L
Brizuela, Marta, 6L
Brockett, Claire, SP, SP
Brooks, James B., 2K
Brown, Fran, 7F
Brunetiere, Noel, 2M, 7C, 8C
Budinski, Kenneth G., 5G
Budnyk, Serhiy, 6A
Buffiere, Denis, 4K
Bui, Thomas, 3N
Bunchek, Victoria, 2E
Bunting, Lindsey, 5H
Burris, David, 5D, 5D

C

Cairns, Euan, 7A
Calderon Salmeron, Gabriel, 3I
Cañellas, Gerard, 2C, 3A, 3F
Cann, Philippa, 3F
Canon, Francis, 8F
Cao, Guoqing A., 8I
Cao, Jian, 5L, SP
Cao, Renshui, 6B
Cardenas, Arturo, 3G, 3K
Carlton, Hayden, 4D
Carpick, Robert W., 1D, 1N, 3N, 4L, 5E, 6E, SP
Carre, Matt, 7F
Carvalho, Jaime, 8G
Casey, Brian M., 3A
Cassin, Felix, 2N
Castano, Valentina, 8G
Cawich, Pedro, 5I
Celis, Jean-Pierre, 1C
erne, Borut, 4G
Cesmeci, Sevki, 7C
Chacon Teran, Miguel, SP
Chaise, Thibaut, 5F
Charkaluk, Eric, 6N
Chau, Allison L., 8F, 8F
Chen, Min, 1H
Chen, Qian, 7M
Chen, Yan, 7A
Cheung, Christina, 6M, SP
Chisolm, Steven, 8F
Choi, Changhyun, SP
Choi, Hyunsuk, 5L, SP
Chong, Daesung, 7E
Chorier, Jeremy, 5M
Choudhry, Jamal, 6N
Chow, Lesley, 6K
Chowdhury, Md. I., 2D
Chowdhury, Nusrat, 6K, SP
Chretien, Christelle, 2I
Chrostowski, Robert, SP
Chu, Nolan R., 1M
Chun, Hanul, 6M
Chung, Yip-Wah, 2M, 6D, 6F, 6L, 7G, SP
Ciria, Jose Ignacio, 2E
Clarke, Ben, 7F
Clayson, Chris, 5I
Cleveland, Christopher, 2I
Clifford, Elizabeth, 3C
Clough, Andrew J., SP
Coburn, Vincent, 3I
Cole, Stephanie, 3K
Colliton, Ana, 5E, SP
Combarros, Mar, 2C, 3A, 3F
Comfort, Allen S., 7G
Conesa, Cayetano E., 4L, 6F
Conrad, Eamonn, 6I
Cooper, Denise, 7H
Creamer, Michael, 1K, 6C
Crom, Lori, 5A
Cross, Graham L., 3N
Crossland, Sarah, SP
Culmer, Peter, SP, SP
Culverhouse, Trenton, 5D
Curry, John, 2D, 5E, SP

D

Dadouche, Azzedine, 3I, 4B
Dahlke, Emily, 5D
Daley, Tobias, 3E
Dalley, Raymond, 2E
Das, Pial, 5L, SP
Daši , Miljan, ECRP
Dassenoy, Fabrice, 4L, 5E, 6I, 7A, 7A, SP
Dato, Albert, 6G, 6G
Davami, Keivan, 5L
David, Thorsten, 6I
Davis, Scott, 6H
Davison, Sam, 4F
Dazer, Martin, 3G, 3G
De Barros Bouchet, Maria-Isabel, 5E, SP
de Boer, Greg, 1M, 5F
Dechant, Simon, 3B
Delbé, Karl, 6F
Delferro, Massimiliano, 4L
Delgado, Adolfo, 7A
Delghandi, Daniel, SP
DellaCorte, Christopher, 8G
Dellis, Polychronis, 5A
DeLong, Adam, 6K
DelRio, Frank W., 5E
Demas, Nicholaos, 5A
Demel, Volker, 1K
Demott, Connor J., 7F
De Pauw, Stijn, 6G

Participants Index

D

Derdeyn, Marc, 6G
DeSantis, Kevin, 4H
Deshmukh, Sanket, 2O
Deshpande, Aditya, 2N
Deshpande, Pushkar, 2I, 4L, SP
de Vries, Lieuwe, 7I
DeWald, Adrian, 6B
Dianova, Anastasia, 6L
Dickstein, Joshua, 3H
Didziulis, Stephen. V., SP
Dietzel, Dirk, 3N
Diez, Stephan, 5G
Dimaio, Jeff, 4H
Dini, Daniele, 2M, 5E, 7E
Dixon, John T., 6H, 7H, 7M
Dobrowolski, Christopher, 4I
Dodin, Benoit, 6N
Dodos, George S., 7L
Doerr, Nicole, 2O, 5G, 6A, 8I
Doll, Kenneth, 2F
Dorcy, Nicole H., 6F
Dowding, Peter, 4L
Drees, Dirk, 1C, 5G, 7K
Dubreuil, Frédéric, 5E
Duchowski, John K., 3E, 3E
Dufils, Johnny, 5E
Duggal, Bob, 2H
Dugger, Michael, 2D, 2D, 5E, SP
Duncan, Kevin, 2F, 5I
Dunn, Alison C., 6K, 7F, SP
Dusenbury, James S., 7G
Duston, Simon, SP
Dutt, Jayanta K., 4C
Duval, Arnaud, 5F
Dworet, Ross L., 2H
Dwyer-Joyce, Rob, 2A, 2B, 2C, 3I, 3K, 5G, ECRP
Dyrstad-Cincotta, Nicholas, 5L, SP
Dzhafarov, Roman, 5G

E

Edward, Bright A., 1E
Edwards, Camille, 5E
Edwards, Jen, SP
Egberts, Philip, 1N, 2N, 5M
Eggenstein, Matthias, 5A, 7M
Ehara, Taro, 2C, 3F
El Laithy, Mostafa, 4B, 4B
Elsby, Neil, 5A
Elupula, Ravinder, 1K
Emami, Nazanin, 3A
Emeric, Ariadna, 2C, 3A, 3F
Emrich, Stefan, 2B
Endo, Katsuhiro, SP
Engelfried, Maximilian, 8C
Engelman, Kristi, 8I
England, Roger, SP
Eraliev, Oybek, SP
Erck, Robert, 5A
Erdemir, Ali, 2I, 2M, 4L, SP
Erickson, Nolan, 2I
Eriten, Melih, 5F
Eryilmaz, Osman L., 2D
Escarcega Herrera, Kasandra, 5L
Ewen, James, 5E, 7E

F

Fabijonas, Bruce, 4C
Fahl, Joerg, 3I
Fang, Lu, 4L
Farfan-Cabrera, Leonardo, 2I, SP
Farokhzadeh, Kora, 8I
Fathi-Najafi, Mehdi, 6I
Fedor, Gabriela, 2H
Feile, Klara, 8F
Felix-Quiñonez, Armando, 5B
Felmeth, Simon, 7C
Fenske, George, 6D, SP
Fernández González, Alfonso, 6I
Ferrera, Monica, 5G
Fidd, Catherine, 6K, 6K
Fiedler, Rolf-Gerhard, SP
Filin, Alina, 7M
Findlater, Michael, SP
Fischer, Jürgen, 8L
Fischer, Thomas, 7L
Flaih, Hind, 5E, SP
Flank, Sharon, 2C
Fleming, Robert A., 5N
Fletcher, Alexander, 7E
Fotue, Joseph, 2A
Fowell, Mark, 6G
Fox, Michael, 6D
Francisco, Arthur, 2M
Franke, Jörg, 5B
Franklin, Steve, 2N
Frantz, Peter, SP
Frauscher, Marcella, 8I
Frazier, Cole T., 2I, 7G, 8I
French, Tyler, 6K
Fridrici, Vincent, 6N
Frizell, Jacob, 7E
Froelich, Daniel, 7C, 8C
Frohnapfel, Bettina, 3A, 7A
Fujiwara, Kazuhiko, SP
Fukuzawa, Kenji, 4A, 4A, 6K
Fulco, Sage, SP
Furfari, Domenico, 6L

G

Gadegaard, Nikolaj, 5F
Galipaud, Jules, 4L, 5E, 7A
Gallego, Nidia, 7E
Gangopadhyay, Arup, 1I
Gant, Andrew J., 4G
Gao, Fei, ECRP
Gao, Hong, 7M
Gao, Hongyu, 3N
Garabedian, Nikolay, 2O, 6A
Garcia, Inaki, 4L
Garcia-Lecina, Eva, 4L
García Tuero, Alejandro, 1I, 6I
Gault, Baptiste, 5D
Geeza, Tom, ECRP
Gentieu, Timothée, 6B
Georgiou, Emmanouil, 1C, 5G, 7K
Georgiou, George, 7J

Gerlach, Christian, 7K
Ghanbarzadeh, Ali, 4L, 5F
Ghezzi, Ilaria, 5M
Ghosh, Sujan, 4D
Giampaolo, Emanuele, 3C
Gil, Ludovic, 6K
Gillespie, David, 5I, 6I
Giudici, Paolo, 6L
Glaenzer, Steffen, 1G
Glavatskih, Sergei, 3I, 5M, 6C
Golden, Robert, 1K
Goldsby, David, 1D
Gomez, Yesid A., 2E
Gong, Zhenbin, 5E, SP
González Rodríguez, Rubén, 1I
Goss, Josue A., 5N
Gould, Benjamin, 5D
Govedarica, Aleksandra, 5M
Goyal, Arjun, 6H
Graham, Bradley, 6F
Grande, Hans, 4L
Grandhi, Manikanta, SP
Granja Oramas, Maria Victoria, 1O, 7A
Gray, Sharon K., 7C
Gray, William A., 2B
Greaves, Martin, 4H
Greco, Aaron, 5A
Green, Micah, SP
Greiner, Christian, 2O, 5D, 6A
Grejtak, Tomas, 3I, SP
Grillenberger, Hannes, 2B, 2B, 4B
Gross, Kyle, 2H
Grün, Jeremias, 7C
Grunlan, Melissa A., 7F
Guan, Yue, 5E, SP
Guenther, Mark, 5A
Gullapalli, Sravani, 1O
Gumbsch, Peter, 3A, 7A
Guo, Emily, 1D, 8F
Guo, Liang, 7I
Guo, Yanbao, 5D
Gupta, Surojit, 3D, 5D

H

Hackel, Lloyd, 5L
Hackler, Ryan, 4L
Hadler, Amelia, 7J
Hahury, Rachid, 2N
Hall, Bernie, 2E
Hamano, Yosuke, 5E
Hamer, Clive, 3G, 6A, 7M
Hammerstone, Diana, 6K
Hansen, Erik, 3A, 7A
Haque, Faysal M., 3D
Harcrow, Aaron, 7C
Harmain, G A, 3C
Harr, Mark, 1A
Harrison, Judith A., 1N
Hartlen, Kurtis, 2C
Hartley, Damon S., SP
Harvey, Terry, 3B, 4B, 4B
Harwood, William G., 4H
Hasan, Md Mahmudul, 6K, SP
Hasanovic, Adnan, 8I
Hasegawa, Tomoya, 7L
Hassan, Fuad M., 7C
Hauschild, Matt, 4H
Hausmann, Maximilian, 5B
Havelka, Kathleen, 4K
Haynes, James A., 3I
He, Qi, 7F
He, Xin, 7E
Heckman, Nathan, 3D
Hees, Andreas, 6I
Heiden, Michael, 5L
Hein, Ricardo, 4I
Heinl, Adrian, 8C
Heinrich, Julius, 6K
Hellman, Patrick, 7E
Heo, Junwon, 4C
Hepley, Elaine, 1C
Hernández Battez, Antolín Estaeban, 6I, SP
Herrmann, Inga, 1A
Herve, Gregoire, 3F
Hess, Brian, 6C
Higashitani, Yuko, 3C
Higgs III, C. Fred, 1O, 7A
Hindemith, Michael, 6L
Hindér, Gustav, 6F, 7G
Hipwell, Cynthia, SP
Hirayama, Tomoko, 4A, 5N, 6M
Hobbs, Matthew, 1C
Hof, Matthias, 3F
Hogenberk, Femke, 6M
Höger, Olav, 8L
Holgerson, Mikael, 8L
Holmberg, Hans-Christer, 6F, 7G
Holmes, Melvin, 7F
Homayoonfard, Marjan, 4L
Hope, Ken, 1H
Horwich, Greg, 3E
Hou, Xiaodong, SP
Huang, Wenyu, 4L
Huang, Yunsheng, 4B
Hubbard, James, 7A
Hudson, Cole, 1I, 2I
Huffman, Lauren M., 8L
Huitink, David, 4D
Hunt, Zach, 4H
Hutchinson, Phil, 4A
Huybrechts, Ward, 3F

I

Ibrahim, Karim Khaled, 7I
Iglesias, Patricia, SP
Iino, Mari, 2I
Iino, Shinji, 6I
Ingram, Marc, 3G
Irgens, Eskil, 5E, SP
Irving, Matt, 5A
Isaac, Daulton, 6B, 7E
Itoh, Shintaro, 4A, 4A, 6K
Itoigawa, Fumihiro, 6B
Iwase, Shunsuke, 5B, 6B

Participants Index

J

Jackson, Andrew, 6E
Jackson, Mark, 5A
Jackson, Robert L., 1M, 2I, 5F
Jacobs, Tevis, 5F
Jacques, Kelly, 2D
Jalalahmadi, Behrooz, 3B
Jang, Seokhoon, 2D, 5E, 5E, SP, SP, SP
Jasak, Hrvoje, 6N
Jenei, Istvan, 7A
Jeng, Yeau-Ren, 1M
Jernigan, Zachary, 5D
Jha, Ashish, 2A
Jogesh, Kollol, 7A
Johnson, Blake, 6L, SP
Johnson, Jacqueline A., 7C
Jolly, Pascal, 7C
Joly-Pottuz, Lucile, 7A
Jones, Edward, 2F, 7J
Jones, Morgan, 5D
Jones, Roland, 5A
Jonkeren, Mirco, 6L
JoRuetta, Ellington, 4A
Jose, Subin A., 6G
Josyula, Sravan, 6G, 6G
Jules, Galipaud, 7A
Jung, Hyunsung, 4C
Junk, Christopher, 3D

K

Kadiric, Amir, 5A, 5B, 6E, 6G, 7I, 7I, ECRP
Kai, Li, 2A
Kakudo, Hiromitsu, 4B
Kalijaveedu, Shriya Reddy, 6C, SP
Kalin, Mitjan, 1D, 4L, 5N, SP
Kalliorinne, Kalle, 6F, 7G
Kamihata, Tomoki, 8L
Kaperick, Joseph P., 5M
Karasz, Erin, 5L
Karnaukh, Kseniia, 8F
Kasai, Moritsugu, 4C, 5A
Kasar, Ashish K., 6G
Kaur, Jasreen, 6K
Kawabata, Sanemasa, 3C
Keiser, James R., 7E
Kelley, Josephine, 1B
Kerrouche, Rami, 3I, 4B
Kew, Ben J., 7F
Khan, Arman M., 6D
Khan, Thawhid, 3K
Khandelwal, Manish, 1E
Khare, Harman, 3D, 3D, SP
Kiakojouri, Amirmasoud, 6B
Kim, Hoon, 1K, 6C
Kim, Jihan, 4C
Kim, Seong H., 2D, 5E, 5E, 6E, 6E, SP, SP, SP, SP
Kim, Seon Joon, 2N
Kim, Susan M., SP
Kim, Yeseul, 4C
Kimbrel, Brady A., 5L, SP
Kimura, Nobuharu, 7L
King, Paul, 3A
Kirchner, Eckhard A., 5B, 7I
Kirkby, Thomas, 6G
Kirsch, Gabe, 5H
Kirsch, Mathew S., 6B, 7E, 7M
Kitson, Andrew, 6K
Klein, Thomas, 3K
Klinger, Jordan, 6D
Knopp, Andrea L., 1G
Knotts, Nathan, 6C
Knowles, James, 6F
Kobayashi, Yusei, SP
Koch, Oliver, 2B, 2B, 5F
Kodambaka, Suneel, 2N
Kogge, Sandeep, 1E
Kolekar, Anant, 7I
Koly, Farida, 5D
Koly, Farida Ahmed, 5D
Kommineni, Uday Venkat Kiran, SP
Kopitzke, Joerg, 5G
Kopnarski, Michael, 2B
Korres, Spyridon, 4L
Kosarieh, Shahriar, 6I
Kosta, Ivet, 4L
Koutsomichalis, Angelos, 1C
Kozen, Alexander, 2D
Kramarczuk, Lucas, 5E, SP
Kratzer, Dominik, 3G
Krauss, Gordon G., 6G, 6G
Krick, Brandon, 2D, 2D, 3D, 3D, 6K, 6K, 8G
Kriech, Matt, 3H
Kruhoeffer, Wolfram, 4B
Kubiak, Krzysztof, SP
Kuchibhotla, Aditya, SP
Kumar, Abhishek, 6M, SP, SP
Kumar, Anoop, 6M, SP
Kumar, Charchit, 5F
Kumara, Chanaka, 6A, 7E
Kuns, Miranda W., SP
Kunze, Christian, 1A
Kurchan, Alexei, 3A
Kurita, Keisuke, 7L
Kushwaha, Amanendra K., 7G, SP
Kusumoto, Tatsuya, 4C
Kwak, Wonil, 1B, 6B, 6B
Kwak, Yungwan, 2I, 2I
Kwasny, Sean, SP

L

Lacey, Jeffrey A., SP
Lal, Ayush, 7I
Lal, Roshan P., 8M
LaMascus, Parker, SP
Lancaster, Nicholas, 3E
Lance, Michael, 6A
Lancon, Thibault, 2N
Lange, Isabell, 5H
Langston, Justin, 2H
Lanigan, Joseph, 4F
Larson, Steven, 2D
Larsson, Roland, 1M, 6F, 6N, 7G
Latorre, Carlos A., 5E
Lazarte, Santiago, 2D, 6K
Leckner, Johan, 3I, 6M
Le Coeur, Cédric, 5M
Lee, Chul-Hee, SP
Lee, Jeonkook, 1B
Lee, Kwang-Hee, SP
Lee, Leonard R., 7C
Lee, Peter M., 8I, 8I, 8I

Lee, Seungjoo, 2I, 4L, SP
Lee, Wonhyeok, 5F
Lee, Yeongdo, 1B, 6B, 6B
Lee, Yongbok, 1B, 6B, 6B
Lehee, Guilllaume, 6K
Leimhofer, Josef, 2G
Leriche, Cyrian, 7M
Leventini, Samuel, SP
Lewis, Roger, 7F, ECRP
Li, Huijie, 6G, 6G
Li, Jinjin, 4L
Li, Jinxia, 6I
Li, Shenghua, 2A
Li, Suzhi, 3N
Li, Wenxiao, 7F
Li, Yulong, 6A
Li, Yu-Sheng, 5E, 6E, SP, SP
Liamas, Evangelos, 7F
Liang, Hong, 2D, 7A, SP
Liang, Michael W., 8I
Liehr, Philipp, 5B
Ligong, Chen, 2A
Liljeros, Per, SP
Lim, Homin, 4C
Lima, Eduardo G., 4K, 6C
Lin, Fengchang, 6K
Lin, Grace, 6K
Lisy, Tom, 3H
Litters, Thomas, 8L
Liu, Hong, 6D
Liu, Jiayi, 4I
Liu, Shuangbiao, 2M, 6D, 6F
Liu, Ting, 5G
Liu, Zhichao, SP
Lockwood, Frances, SP
Lohner, Thomas, 5A
Loken, Jack, 7G
Londhe, Nikhil, 3B
Long, Rong, 5L
Loos, Jörg, 5B
Lopes, Lais, 1C, 5G, 7K
Lorenz, Steven, 3B
Lorenzo Martin, Maria Cinta, 5D, 5D, 6D
Lucazeau, Siegfried, 5I
Lugt, Piet M., 6H, 6M, 7L, 8L
Luo, Huimin, ECRP
Luo, Jianbin, 4L
Lutz, Marlon, 4K, 6C
Luz, Lucas T., 7J

M

M. Mulvihill, Daniel, 5F
Ma, Philip, 6H, 8I
Macias, Tatianna, 5G
Mack, Timothy, 3E
Mackie, Alan, 7F
Macknojia, Ali Zayaan, SP
Mackwood, Wayne, 2H, 2K
MacLaren, Alexander, 7I
Macron, Etienne, 5E
Maeda, Masayuki, 5B
Maegawa, Satoru, 6B
Magness, Zach, 3K
Mahapatra, Rajendra, 5G
Mahmood, Samsul Arfin, 1D
Mainwaring, Robert, 5A
Makowiec, Mary, 6D
Malaga, Adolfo, 2E
Malburg, Mark, 7K
Maldonado, Emmanuel, 2N
Malinski, Tom, 1H
Malisa, Edward, 1O
Mandrile, Fabrizio, 4B
Mangolini, Filippo, 5E, 6E, SP
Marcel, Bartz, 8F
Marian, Max, 1O, 8F
Marnell, Matt, 8I
Marotta, Lee, 3E
Martin, Alan T., 1D
Martin, Tobias V., 5L, 6D, 7G, SP
Martin-Alarcon, Leonardo, 5M
Martin-Gutierrez, Brian, SP
Martini, Ashlie, 2D, 3N, 5E, 5G, 6C, 6E, 6E, 6M, SP, SP, SP, SP, SP, SP, SP, SP
Marunaka, Hiroshi, 3B
Maruyama, Taisuke, 5B, 6B
Masen, Marc, 3F, 6G, 7F
Massi, Francesco, 5M
Mathews, Teresa, ECRP
Mathias, Thomas J., 1N
Matsubara, Kazushige, 6I
Matsui, Shigeki, 2I
Matsuki, Shingo, 2I
Matsumoto, Yoshihiro, 7L
Matthews, Sarah, 4A
Matzke, Caleb, 3D, 5D
Matzke, Markus, 8L
Mavros, Georgios, 6F
Mayer, Joachim, 4B
Mazeran, Pierre-Emmanuel, 2N
Mazurkivich, Matthew, SP
Mazzu, Angelo, 5F
McClimon, John B., 1D
McClure, Ted G., 3K
McCormick, Robert, 2F
McGhee, Alexander J., 8G
Medjahed, Abdel-Salem, 8C
Meier, Janet M., 3I
Meijer, Robert J., 7L
Meinel, Andreas, 2B, 2B
Meingaßner, Georg Johann, 6D
Melchior, Helmut, 2H
Melia, Michael, 5L
Menezes, Pradeep, 5G, 6G, 7E, 7G, 7G, SP
Meng, Yonggang, 6B
Meng, Zhen, SP
Merk, Daniel, 5B, 5B
Merkle, Lukas, 3G
Meyers, Tiffany, 1G
Michael, Paul, 6C, 7C
Michael, Seemann, 4A, 4H
Miliate, Daniel, SP
Miller, Brendan, 3A
Miller, Charles, 4D, 4D, 5N
Miller, Elizabeth, 6D
Mills, German, 2I
Milton, Ashley, 4K
Minch, Britt, 7J
Minz-Schuett, Annabelle, 3I
Mirring, Patric, 6B
Misra, Manoranjan, 5G, 7G
Mittmann, Asa S., SP
Miyazaki, Mayu, 6L
Modi, Jitesh, 2B

Participants Index

M

Mohamed, Amran, 4A
Mohammadpour, Mahdi, 3I
Mol, Henk, 7I
Molina Vergara, Nicolas A., SP
Mollet, Julie, 5H
Moneke, Kenechukwu, 6E
Moody, Gareth, 5I, 6I
Moore, Peter N., 6I
Morales, Jose A., SP
Morgan, Alexes, 3K
Morina, Ardian, 3A, 4L, 4L, 6F, 6I, SP
Morita, Takehiro, 7F
Morris, Nick, 3A
Morterolle, Sébastien, 6B
Mosher, Donna, 6H
Mosley, Meredith, 6H
Motamen Salehi, Farnaz, 6I
Mourhatch, Ramoun, 3A
Moustafa, Cinderella, SP
Muhlenkamp, Aaron, 3B
Murray, Thomas, 6M, SP
Murthy, Nikhil K., 3I, 5D, 5D, 5D, 6L, SP
Mutyala, Kalyan C., 1I

N

Nadeem, Irfan, 5N, SP
Nagamine, Takuo, 6L
Najar, Farooq A., 3C
Nakae, Rio, 5E
Nakahara, Yasuhito, 6I
Nakamura, Toshitaka, 2I
Nakanishi, Hironobu, 5N
Nakano, Ken, 5B, 6L
Nalam, Prathima C., 1N, 3N
Narita, Keiichi, 6I
Nasah, Junior, 5L
Natrajan, Ganesh, 2A, 2O
Nautiyal, Pranjal, 6E, SP
Navar, Ricardo, 6D
Navaratnam, Ramesh, 2F, 8I
Navarro, Àngel, 2C, 3A, 3F
Nays, Pascale, 8F
Neal, Peter, 2K
Neicamp, Henry, 2E
Nelias, Daniel, 5F, 6B
Neogi, Arnab, SP
Neu, Marcel, 7I
Nicholas, Gary, 2C, 3I
Nicola, Andreas, 3G, 3G
Niedzwiecki, Daniel, 4H
Nijdam, Thijs, 7I
Nivet, Clément, 8F
Noda, Takashi, 7L
Noel, Olivier, 2N
Norris, Paul R., 3G
Notheaux, Guillaume, 2K, 5M
Nozue, Takumi, 4A
Ntioudis, Stavros, 7E

O

O'Keefe, John, 2H
Ochiai, Masayuki, 8C
Ogata, Rui, 7L
Ogbomo, Egheosa, 7E
Ogbonna, Kevin, 8F
Ogrinc, Andrew L., SP
Ogunsola, Oluwaseyi, 1O, 2O
Okamoto, Ryuichi, 5E
Olanipekun, Mabel U., 1E
Oleksiak, Thomas P., 2G
Oliver, Rachel A., SP
Omoregbee, Henry O., 1E
Oo, Wai H., 3N
Ortiz, Alvaro Jose, 6H, 7H
Osara, Jude A., 6M, 7L
OShea, Brendan, 6H
Ozdogan, Mehmet, 2N
Ozkan, Tanil, 7C, 8G

P

Pailler-Mattei, Cyril, 8F
Pandey, Ankit, 3F
Pandey, Raj K., 4C
Panwar, Pawan, 6C
Pap, Bálint, 8C
Papadopoulos, John, 8I
Pape, Florian, 3B, 6E
Paris, Jean-Yves, 6F
Park, Jun-Sang, 5D
Pasaribu, Rihard, 7L
Passman, Frederick J., 2K
Patel, Manish R., 4H, 5G
Pathirannehelage, Bhadrakalya, 3N
Patro, Debdutt, 6G, 6G
Pattnayak, Manas R., 4C
Patzer, Gregor, 1I
Pavan, Sophie, 7A
Peerzada, Safia, 5I
Penaranda, Jonathan, 7C
Penaranda, Jonathan J., 8G
Pendyala, Prashant, 2N
Peretti, Gladys, 5G
Perez, German, 4D
Perkins, Meredith, 6H
Perrin, Gautier, 5M
Perris, Jack, 5F
Pfeifer, Jochen, 7F
Pflaum, Hermann, 6D
Phelan, Colin, 5N
Philibert, Gwenaelle S., 4I
Pickins, David, 6L, SP
Pinardon, Victor, 6B
Pitenis, Angela A., 8F, 8F
Pitkar, Ashutosh, 5N
Piya, Afrina Khan, 3A
Placek, Doug, 6C
Poley, Jack, 2E
Poll, Gerhard, 3B, 6E
Pollock, Gary, 2O
Polycarpou, Andreas, 4F
Pond, Theresa, 2D
Pondicherry, Kartik, 6K
Ponnekanti, Nagendramma, 3F
Potnis, Harish, 4K
Powrie, Honor, 6B
Pratt, Clifford, 3H
Prost, Josef, 2O
Pyun, Young-Sik, 6L

Q

Qi, Hao, 7L
Qi, Jiahui, 5D
Qiao, Na, 6F
Qiao, Zhangyu, 6N
Qu, Cangyu, 5E
Qu, Jun, 3I, 6A, 7E, ECRP, SP
Qureshi, Farrukh, 3I

R

Rabbani, Muztoba, 2D, SP
Raeymaekers, Bart, 2O
Rahman, Md Habibur, SP
Rahman, Md Hafizur, 5G, 7G
Rajala, Scott, 5I
Ralls, Alessandro M., 7E, SP
Rau, Julia, 5D
Rauber, Griffin, 5E, SP
Ray, Anjan, 3F
Read de Alaniz, Javier, 8F
Reddyhoff, Tom, 6G, 6L, 6L
Rehbein, Wilhelm, 3K, 5H
Reihmann, Matthias, 1K
Reinholdsson, Fredrik, 8L
Ren, Hang, 5N
Ren, Ning, SP
Rengifo, Sara, SP
Renner, Peter, 2D, 5L
Rezaee, Sara, 2A, 2O
Rice, Adam, 6H
Rincon, Christopher, 5N
Ristic, Andjelka, 8I
Rivera Rellán, Noelia, 1I, 6I
Roberts, Matthew, 5H
Rödel, Philipp, 2B, 4B
Rodelas, Jeffrey, 5L
Rodgers, Marianne, 2C
Rodriguez, Mark, 2D
Rodriguez, Nestor, 6K
Rodríguez Ordóñez, Eduardo, 1I, SP
Rodzwic, Richard, 4C
Rohbogner, Christoph J., 7L
Rosenkranz, Andreas, 8F
Rothammer, Benedict, 8F
Rovere, Michael, 5M
Roy, Sougata, 4F, 5L, 5L, 5L, 8F, SP, SP, SP, SP, SP
Ruggiero, Shawn, 3D, 5D
Russell, David, SP
Russell, Thomas C., 1B
Ryan, Helen T., 3G
Ryu, Keun, 3C, 4C

S

Sadeghi, Farshid, 1B, 2B, 2B, 3B, 3B, 6B, 8M, SP
Sadow, Aaron, 4L
Saha, Sudip, 8F, SP
Sairally, Francesca J., SP, SP
Sajid, Syed Ashir, 3K
Sakai, Kazumi, 7L, 8L
Sakhamuri, Maruti Sai Dhiraj, 3B
Sanchez, Carlos, 4I, 8I
Sanchez, Daniel A., 3N
Sánchez, Juan, 8G
Sanchez Garrido, Daniel E., 7G
Sandberg, Joakim, 6F, 7G
Sandro, Wartzack, 8F
Sanjurjo Muñiz, Claudia, SP
Sankaranarayanan, Subramanian SKRS, SP
Santana, Hugo, 8G
Sarkar, Anwesha, 7F, 7F
Sarker, Majher, 4F, SP
Sasaki, Shinya, 6L
Sattari Baboukani, Behnoosh, 1N
Sawae, Yoshinori, 7F
Sawyer, W. Gregory, 2M
Saxena, Rishu, 2O
Schall, J. David D., 1N
Scharf, Thomas, 2D
Scherger, Jacob, 4A
Schimmel, Thomas, 2H, 4A
Schirmeisen, Andre, 3N
Schlichting, Marie-Louise, 6G
Schneider, Ameneh, 4K
Schneider, Johannes, 3A, 6A, 7A
Schnetzer, Philipp E., 3G
Schomburg, Cory, 3E
Schroeder, Sven, 4L
Schulze, Kyle, 1D, 8F
Schupp, Jonathan, 2C
Schwedt, Alexander, 4B
Scott, John, 2F
Scott, William, SP
Secker, Jack, 7J
Segal, Briana, 5G
Seidl, Viktoria, 6A
Semelsberger, Troy, 6D
Sepoetro, Denis, 6C
Shafiee, Abbas, 6B
Shakhvorostov, Dmitriy, 6I
Shanley, Conor, SP
Sharma, Akshat, 8M
Sharma, Brajendra K., 2F, 4F, SP
Sheehan, Jennifer, 4N
Shetty, Pramod, 7L
Shiller, Paul, 4I
Shimizu, Yasunori, 5A
Shirani, Asghar, 2D
Shirvani, Khosro, 6N
Shive, Travis, 4B
Shore, Joseph F., 7I
Shu, Ju, 4L
Shu, Zhiyuan, SP
Shyam, Amit, 3I
Shyti, Rexhina, 8F
Siddle, Heidi, SP
Sidebottom, Mark A., 3D, 3D
Sikdar, Soumya, 7G
Singh, Atul P., 3F
Singh, Kushagra, 3B
Siniawski, Matthew, 6G, 6G
Six, Klaus, ECRP
Slatter, Tom, 3A, 7F
Smaili Iderkou, Noura, 8L
Smeeth, Matthew, 3G, 6A, 7M
Smith, Greg, 7H
Smith, Jesse, 2D
Smith, Joshua J., 6G
Smithhisler, Olivia, 2D
Smolders, Lotje, 3F
Soewardiman, Henry, 6F, 6L, SP

Participants Index

S

Soltannia, Babak, 5M
Song, Wei, 4L
Song, Yuxi, 4A
Sorg, Adrian, 3G
Sowa, Mark, 2D
Speed Jr., Lake, 8I
Spence, Trevor, 8I
Spenceley, Oliver, 2A
Spikes, Hugh A., 5A, 6A, 6A, 6E, 7I, ECRP
Sprogies, Nicolai, 5A
Stahl, Karsten, 3G, 5A, 6D
Staniewski, George, 2E
Stankovic, Igor, 2N, ECRP
Stapels, Michael, 2K, 7J
Staudinger, Paul, 6K
Stephenson, Gemma, 2F
Sterling, Amanda, 1D
Stevenson, Louise, ECRP
Stibbs, William, 6I
Stow, Carl, 5A
Strandwitz, Nicholas, 2D
Strathmann, Timothy, 2F
Strobl, Patrick, 6D
Strube, Sabrina, 4A, 4H
Sudmeyer, Holger, 3H
Sulejmanovic, Dino, 7E
Sun, Lin, 5N
Suzuki, Hiroyuki, 3I
Swets, Jackson E., 3D, SP
Syed, Dillawar, 1O
Szlufarska, Izabela, 1D

T

Tada, Akira, 2I
Tadokoro, Chiharu, 6L
Taghizadeh, Saeid, 2A
Taha, Jaime, 7A
Tajedini, Mohsen, 2D
Takada, Satoshi, 4B
Takano, Kouichi, 6I
Takekawa, Daisuke, 6I
Takenaka, Mikihito, 4C
Tamouafo Fome, Armand, 8M
Tanaka, Koichi, 2N
Tanaka, Yudai, 5E
Tang, Clement, 4F, SP
Tang, Jing S., 7C, 7C
Tang, Steven, 1H
Tao, Yida, 2H
Tatsumi, Hiroyuki, 5I, 6I
Tatzgern, Fabio, 5G
Taylor, Chris, 7J
Taylor, Christopher, 3K
Tekath, Lea, 7J
Thielen, Stefan, 5F
Thomlison, Johnnie, 7J
Thompson, David N., SP
Thompson, Travis, 2F
Thrush, Steven J., 7G
Tian, Tian, SP
Tian, Zaihao, 5B
Tobie, Thomas, 3G
Tolbert, John, 6K
Tomar, Pankaj, 7K, 7K
Tomlinson, Katherine, 3A, 7F
Tonazzi, Davide, 5M
Toohey, Michael, 5H
Torimoto, Koshiro, 5E
Toro Betancur, Alejandro, 8G
Tourvielle, Jean-Noel, 6I
Trifkovic, Milana, 5M
Tripathi, Saugat, 5N
Tripathy, Manisha, 5L
Trummer, Gerald, ECRP
Tsujii, Yoshinobu, 6L
Turner, C.H., 7E
Turner, Kevin, SP
Twining, Steven J., 3E
Tysoe, Wilfred, 5N, 6E

U

Uche, Grac,e 2O
Uday Venkat Kiran, Kommineni, 5L, 8F, SP
Ueda, Mao, 6E, ECRP
Uhryn, Jackson, 5M
Ullah, Sifat, 3D
Umerov, Emil, SP
Uribe Saenz De Camara, David, 5B
Uruena, Juan Manuel, 8F

V

Vacher, Beatrice, 7A
Vaitkunaite, Gerda, 3A, 7A
Valencia, John, 8G
Van Den Ende, Dirk, 6M
Vanden Poel, Geert, 8I
Van Der Donck, Tom, 1C
Van Fossan, Zachary, 5E
Van Hoecke, Hendrik, 6G
Van Meter, Kylie E., 2D, 3D, 6K, 8G
Vardon, Derek, 2F
Varenberg, Michael, 6N
Vargiolu, Roberto, 8F, 8F
Vasquez-Reyes, Jose, 6M, SP
Veeregowda, Deepak, 6G, 6G
Velarde, Luis, 3N
Velasquez, Andrew C., 8I
Velez, Stefanie, 3H
Vélez, Miguel, 8G
Veliu, Altin, 2O
Venderbosch, Rudy, 7M
Viat, Ariane, 1G
Vickers, Jordan, 5E, SP
Vierneusel, Bernd V., 3B, 4B
Viesca Rodríguez, José Luis, 1I, 6I
Vilaseca, Montserrat, 3A
Ville, Fabrice, 5G
Visweswaran, Ramaratnam, 2A, 2O
Vives, Jordi, 3A
Vladescu, Sorin-Cristian, 6L
Voelkel, Katharina, 6D
Voevodin, Andrey, 2D, 7A
Voice, Derek, 6I
Vorlaufer, Georg, 2O, 6A

W

Walck, Scott D., 2D, 5D
Wall, Peter, 1M
Walsh, Michael, 2D
Wang, Bin, 5D
Wang, Deguo, 5D
Wang, Dongze, 5F
Wang, Ling, 4B, 4B, 5B, 6B
Wang, Miao, 5N
Wang, Q. Jane, 1M, 2M, 5L, 6D, 6F, 6L, 7G, SP, SP, SP
Wang, Shuncai, 5B
Wang, Wen, 3N
Wang, Wenbo, 7E, ECRP
Wang, Yiyu, 4L
Wang, Yuechang, SP
Wang, Yufei, 5N
Wangenheim, Matthias, 6L, 6L, 8C
Ward, Claire, 6C
Warren, Bethan, 5I
Warshney, Mayank, 6K
Washizu, Hitoshi, 5E, 7L
Watson, Johann L., 6I
Weber, Bart, 2N
Webster, Martin, 4L
Wee, Minsoo, 4C
Wei, James Jianjun, 2K
Wei, Ronghua, 5N
Weinzapfel, Nick, 3B
Wellmann, Thomas, 4I
Wenzel, Andrei, 3E
Werner, Michel, 2B
Wetherington, Maxwell T., SP
Wiacek, Robert, 6E, SP
Wieber, Stephan, 6I, 7A
Wilbs, Christian, 7C, 8C
Wilches Peña, Luis V., 8G
Williams, Daniel, 4I
Williams, John, 1A
Wilson, Alyson, 6H
Windebank, Keith, 3E
Wingertszahn, Patrick, 5F
Wise, Harry, 7G
Wohlfahrt, Sabine, 4H
Wong, Janet, 4A, 6A, 6G
Wong, Patrick Pat-lam, 1B
Wong, Teresa, 6B
Wood, Robert, 3B, 5B
Woodfall, Mike, 5H
Wopelka, Thomas, 8I
Woydt, Mathias, 1I
Wu, Jerry J., 2F
Wurzbach, Richard, 2E

X

Xia, Yidong, 6D
Xu, Chaochen, 1N, 2N
Xu, Hanping, 7C, 7C
Xu, Yang, 5F

Y

Yahiaoui, Malik, 6F
Yajima, Kuniaki, SP
Yamada, Shuhei, 7L
Yamamoto, Kenji, 6I
Yamashita, Naoki, 4A, 5N, 6M
Yan, Jieming, 6E
Yanagisawa, Honami, 7L
Yang, Junying, ECRP
Yang, Kongsheng J., 8I
Yang, Liuquan, 3A
Yang, Quanpeng, 6C
Yang, Xingwei, 5L
Yang, Yue, ECRP
Yarlott, Marc W., 3E
Yasuda, Ikki, SP
Yasuoka, Kenji, SP
Ye, Zhijiang, 1N, 2M, 2N, 5N
Yearwood, Abdu, SP
Yida, Tao, 2A
Yildirimli, Kazim, ECRP
Yoder, Andrew R., 4K
Yokomizo, Masato, 5I
Yoon, Eui-Sung, 2N
Yu, John J., 5B
Yuan, Li, 3N
Yuryevich, Terekhov A., 7C

Z

Zabawski, Evan, 2E, 2E, 3E
Zahouani, Hassan, 8F, 8F
Zaiat, Anatoly, 7I
Zhang, Chao, 2M
Zhang, Hedong, 4A, 4A, 6K
Zhang, Jie, 2A, 6A, 6A, 6L
Zhang, Junyan, 5E, SP
Zhang, Ran, 5N
Zhang, Wenyang, 5I
Zhang, Xin, SP
Zhang, Zefu, 6C
Zhang, Zheng, 5D
Zhao, Haibo, 1H
Zhao, Yixing Philip, 2K
Zhong, Karl, 3K
Zhou, Zhen, SP
Ziobro, Jesse, 3K
Zorko, Damijan, 4G
Zou, Min, 4D, 4D, 5L, 5N
Zurcher, Théo, 6N

stle
LONG BEACH
May 21-25, 2023

Annual Meeting Committees and Councils

2022-2023 STLE Board of Directors

Ryan D. Evans (President)
The Timken Company,
North Canton, OH

Hong Liang (Vice President)
Texas A&M University,
College Station, TX

Jack McKenna (Secretary)
Sea-Land Chemical Company,
Westlake, OH

Kevin Delaney (Treasurer)
Vanderbilt Chemicals, LLC,
Norwalk, CT

Steffen Bots, CLS, OMA (Incoming Treasurer)
LUBESERV, Brannenburg, Germany

Ken Hope, FSTLE, CLS (Immediate Past President & Presidential Council Chair)
Chevron Phillips Chemical Company,
The Woodlands, TX

Edward P. Salek, CAE (Executive Director)
STLE Headquarters
Park Ridge, IL

William Anderson, FSTLE
Afton Chemical Corporation,
Richmond, VA

Nicolas Argibay
Ames Laboratory – U.S. Department of Energy, Ames, IA

Vasu Bala
(incoming), Tiarco LLC, Dalton, GA

John Bomidi
Baker Hughes, The Woodlands, TX

Aaron Greco
Argonne National Laboratory,
Lemont, IL

Hannes Grillenberger
Schaeffler Technologies AG & Co. KG,
Herzogenaurach, Germany

Elaine Hepley CLS, OMA
(incoming), POLARIS Laboratories,
Indianapolis, IN

Karen Harrington, CMFS (retiring),
Fuchs Lubricants Company, Harvey, IL

Brian M. Holtkamp
Nye Lubricants, Inc., Libertyville, IL

Peter Lee FSTLE
Southwest Research Institute,
San Antonio, TX

Khalid Malik, CLS, OMA
Ontario Power Generation,
Pickering, Ontario, Canada

Mandi McElwain
Univar Solutions, Philadelphia,PA

Kuldeep Mistry
Chevron Products Company
(a division of Chevron U.S.A. Inc.),
Richmond, CA

Ramoun Mourhatch
Chevron Oronite LLC, Richmond, CA

Jason Papacek, CLS, OMA
Calumet Specialty Products Partners,
L.P., Indianapolis, IN

Angela Pitenis
University of California, Santa Barbara,
Santa Barbara, CA

Farrukh Qureshi
The Lubrizol Corporation, Wickliffe, OH

Douglas Sackett, CLS
TotalEnergies, Monticello, FL

Raj Shah FSTLE
Koehler Instrument Company, Inc.,
Holtsville, NY

David Turner, CLS, (retiring),
CITGO Petroleum Corporation,
Houston, TX

Dairene Uy, (incoming),
Shell Global Solutions (US) Inc.,
Houston, TX

2022-2023 STLE Annual Meeting Committees and Industry Councils

Annual Meeting Program Committee

Gareth Fish, CLS (Chair)
The Lubrizol Corporation, Wickliffe, OH

Ashlie Martini, FSTLE (Vice Chair)
University of California, Merced, Merced, CA

Azzedine Dadouche (Secretary)
National Research Council Canada, Ottawa, Ontario, Canada

Jun Qu, FSTLE
Oak Ridge National Laboratory, Oak Ridge, TN

Alison C. Dunn
University of Illinois at Urbana-Champaign, Urbana, IL

Hannes Grillenberger
Schaeffler Technologies AG & Co. KG Herzogenaurach, Germany

Gordon Krauss
Harvey Mudd College, Claremont, CA

Annual Meeting Education Course Committee

Babak Lofti (Chair)
ExxonMobil Technology & Engineering Company, Annandale, NJ

Vasu Bala
Tiarco LLC, Dalton, GA

Nathan Knotts
Chevron, Richmond, CA

Lawrence Ludwig, CLS, CMFS, OMA
Schaeffer Manufacturing Company St. Louis, MO

Jennifer Lunn, CMFS
Reminderville, OH

Farrukh Qureshi
The Lubrizol Corporation, Wickliffe, OH

Carlos Sanchez
Southwest Research Institute San Antonio, TX

Kevin Saunderson, CMFS
BP Lubricants USA, Inc., Dousman, WI

Brajendra Sharma
USDA, Wyndmoor, PA

Weixue Tian
ExxonMobil Research & Engineering Company, Annandale, NJ

Yvette Trzcinski, CLS
HF Sinclair, Waukesha, WI

Awards Committee

John Bomidi (Chair)
Baker Hughes, The Woodlands, TX

Kuldeep Mistry (Vice Chair)
Chevron Products Company (a division of Chevron U.S.A. Inc.) Richmond, CA

Nicholaos (Nick) Demas
Argonne National Laboratory, Lemont, IL

Carlos Sanchez
Southwest Research Institute, San Antonio, TX

Qian (Beth) Zou
Oakland University, Rochester, MI

Angela Pitenis
University of California, Santa Barbara Santa Barbara, CA

Diversity, Equity, and Inclusion Committee

Elaine Hepley, CLS, OMA (Chair)
POLARIS Laboratories, Indianapolis, IN

Nicolas Argibay
Ames Laboratory – U.S. Department of Energy, Ames, IA

Steffen Bots, CLS, OMA
LUBESERV, Brannenburg, Germany

Aaron Greco
Argonne National Laboratory, Lemont, IL

Peter Lee, FSTLE
Southwest Research Institute, San Antonio, TX

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

Khalid Malik, CLS, OMA
Ontario Power Generation, Pickering, Ontario, Canada

Angela Pitenis
University of California, Santa Barbara Santa Barbara, CA

Education Committee

Richard G. Butler, CMFS (Chair)
New Age Chemical, Algonquin, IL

Babak Lotfi (Course Chair)
ExxonMobil Technology & Engineering Company, Annandale, NJ

Patrick Brutto, CMFS
Faith-Full MWF Consulting, Bloomingdale, IL

Neil Canter, FSTLE, CMFS
Chemical Solutions, Willow Grove, PA

Greg Croce, CLS
Chevron Products Company, Concord, CA

Lawrence G. Ludwig, Jr., CLS, CMFS, OMA
Schaeffler Manufacturing Company, St. Louis, MO

Jennifer Lunn, CMFS
Reminderville, OH

Mihir K. Patel, CLS
Chevron Oronite, LLC, Richmond, CA

Exhibitor Advisory Committee

John Rastoka
Acme-Hardesty Company, Blue Bell, PA

John Russo
Advanced Chemical Concepts, Inc., Kentwood, MI

Alyson Wilson
Afton Chemical Corporation, Richmond, VA

Steven Tang
Colonial Chemical, South Pittsburg, TN

Vincent Colantuoni
Koehler Instrument Company, Inc., Holtsville, NY

Raj Shah, FSTLE
Koehler Instrument Company, Inc., Holtsville, NY

Chris Napoleon
Napoleon Engineering Services, Olean, NY

Tara Delong
Napoleon Engineering Services, Olean, NY

Andrew Hutchinson
PCS-Instruments, London, United Kingdom

Rob Harpum
Pilot Chemical Company, West Chester, OH

Amanda Swasey
The Lubrizol Corporation, Wickliffe, OH

Fellows Committee

Gary Doll, FSTLE (Chair)
The University of Akron, Akron, OH

Jeffrey Streator, FSTLE (Vice Chair)
Prairie View A&M University, Prairie View, TX

Raj Shah, FSTLE
Koehler Instrument Company, Inc. Holtsville, NY

Min Zou, FSTLE
University of Arkansas, Fayetteville, AR

Frederick J. Passman, FSTLE, CMFS
BCA, Inc., Princeton, NJ

2022-2023 STLE Annual Meeting Committees and Industry Councils

Jun Qu, FSTLE
Oak Ridge National Laboratory,
Oak Ridge, TN

Joichi (Joe) Sugimura, FSTLE
Kyushu University, Fukuoka, Japan

Technical Committees: AI and Machine Learning Special Session

Wilfred (Eddy) Tysoe (Co-Chair)
University of Wisconsin-Milwaukee,
Milwaukee, WI

Prathima C. Nalam (Co-Chair)
SUNY University at Buffalo, Buffalo, NY

Biotribology Technical Committee

Brandon Krick (Chair)
Florida State University, Tallahassee, FL

Angela Pitenis (Vice Chair)
University of California, Santa Barbara
Santa Barbara, CA

Marc Masen (PSC)
Imperial College London, London,
United Kingdom

Condition Monitoring/Predictive Maintenance Technical Committee

Daniel Walsh (Chair)
Ametek Spectro Scientific,
Chelmsford, MA

Alfredo Garcia (Co-Chair)
Luval SA, San Bernardo, Chile

Kemberlee Snelling, CLS (PSC)
Trico Corporation, Davison, MI

Greg Horwich (Co-PSC)
Gastops, Dartmouth, Nova Scotia, Canada

Contact Mechanics Technical Committee

Rohit Voothaluru (Chair)
The Timken Company, North Canton, OH

Morgan R. Jones (Vice Chair)
University of California, Santa Barbara
Santa Barbara, CA

Kyle D. Schulze (Secretary)
Auburn University, Auburn, AL

Robert Jackson (PSC)
Auburn University, Auburn, AL

Iyabo Lawal (Vice PSC)
Rice University, Austin, TX

Michael Varenberg (Vice PSC)
John Crane, Inc., Morton Grove, IL

Ali Beheshti (Member-at-Large)
George Mason University, Fairfax, VA

Ideation Event: Discussion Roundtables

Hannes Grillenberger (Chair)
Schaeffler Technologies AG & Co. KG
Herzogenaurach, Germany

Electric Vehicles/Engine & Drivetrain Technical Committee

Peter Lee, FSTLE (Chair)
Southwest Research Institute
San Antonio, TX

William Anderson, FSTLE (Vice Chair)
Afton Chemical Corporation,
Richmond, VA

Harpal Singh (Secretary)
Eastvale, CA

Carlos Sanchez (PSC)
Southwest Research Institute
San Antonio, TX

Hyeok Hahn (Vice PSC)
Chevron Lubricants, Richmond, CA

Environmentally Friendly Fluids Technical Committee

Brajendra K. Sharma (Chair)
USDA-ARS ERRC, Wyndmoor, PA

Daniel B. Garbark (Vice Chair)
Battelle, Columbus, OH

Helen L. Ngo (Secretary)
USDA-ARS ERRC, Wyndmoor, PA

Selim M. Erhan (Co-PSC)
Process Oils, Inc., Trout Valley, IL

John Fang (Co-PSC)
Chevron Products Company, Richmond, CA

Fluid Film Bearings Technical Committee

Bruce Fabijonas (Chair)
Kingsbury Inc., Philadelphia, PA

Balint Pap (Vice Chair & Secretary)
Safran Transmission Systems, Colombes,
France

Cori Watson-Kassa (PSC)
GE Aerospace, Charlottesville, VA

Gears and Gear Lubrication Technical Committee

Pinzhi Liu (Chair)

ExxonMobil Technology & Engineering
Company, Annandale, NJ

Nikhil Murthy (Vice Chair)
US Army Research Laboratory
Aberdeen Proving Ground, MD

Chengjiao Yu (PSC)
Hebei University of Technology
Tianjin, China

Grease Technical Committee

H. Scott Crawford (Chair)
Primrose Oil Company, Dallas, TX

Salil Bapat (Vice Chair)
Purdue University, West Lafayette, IN

Wei Dai (PSC)
The Timken Company, North Canton, OH

Lubrication Fundamentals Technical Committee

Nicole Doerr (Chair)
AC2T research GmbH, Wiener Neustadt,
Austria

Chanaka Kumara (Vice Chair)
Oak Ridge National Laboratory,
Oak Ridge, TN

Brendan Miller (PSC)
Chevron Oronite Company, LLC,
Richmond, CA

Xin He (Vice PSC)
Oak Ridge National Laboratory,
Oak Ridge, TN

Materials Tribology Technical Committee

John F. Curry (Chair)
Sandia National Laboratories, Albuquerque, NM

Mark A. Sidebottom (Vice Chair)
Miami University, Oxford, OH

Mary Makowiec (PSC for Materials Tribology)
Pratt & Whitney, East Hartford, CT

Nikhil Murthy (PSC for Tribochemistry – Materials & Nanotribology Joint Session)
US Army Research Laboratory, Aberdeen Proving Grounds, MD

Kylie VanMeter (PSC for Tribology of Biomaterials – Materials & Biotribology Joint Session)
Florida State University, Tallahassee, FL

Metalworking Technical Committee

Bridget Dubbert (Chair)
Engineered Lubricants Company, Maryland Heights, MO

Nicole Clarkson (Co-PSC)
Barentz North America, LLC, Lisle, IL

Stephanie Cole (Co-PSC)
Münzing North America, Mount Holly, NC

Mining Tribology Special Session

John Bomidi (Chair)
Baker Hughes, The Woodlands, TX

Eliah Everhard (PSC)
Baker Hughes, The Woodlands, TX

Nanotribology Technical Committee

Prathima C. Nalam (Chair)
SUNY University at Buffalo, Buffalo, NY

Nikolay Garabedian (Vice Chair)
Karlsruhe Institute of Technology, Karlsruhe, Germany

Mehmet Z. Baykara (PSC)
University of California, Merced, Merced, CA

Arnab Bhattacharjee (Vice PSC)
University of Delaware, Newark, DE

Arzu Colak (Vice PSC)
Clarkson University, Potsdam, NY

Behnoosh Sattari Baboukani (PSC for Tribochemistry)
University of California, Berkeley, Berkeley, CA

Nonferrous Industry Council

Andrea Lynn Knopp (Chair)
Constellium, Ravenswood, W.VA

Grigor B. Bantchev (Secretary)
USDA/ARS/NCAUR, Peoria, IL

Bill Poynor (Treasurer/PSC)
Kaiser Aluminum, Spokane Valley, WA

Rolling Element Bearings Technical Committee

Daniel Merk (Vice Chair)
Schaeffler Technologies Schweinfurt, Bavaria, Germany

Bryan Allison (Vice Chair)
SKF Aeroengine, Clymer, NY

Daulton Isaac (Secretary)
Air Force Research Laboratory Wright Patterson Air Force Base, OH

Kushagra Singh (PSC)
Purdue University, West Lafayette, IN

Alexander Fletcher (Vice PSC)
Air Force Research Laboratory Wright Patterson Air Force Base, OH

Seals Technical Committee

Jing Shen Tang (Chair)
Ultool, LLC, Duluth, GA

Jing Yang (Vice Chair & PSC)
Apple, Round Rock, TX

Surface Engineering Technical Committee

Auezhan Amanov (Chair)
Sun Moon University, Sunmoon-ro, Asan, South Korea

Sougata Roy (Vice Chair)
University of South Dakota, Grand Folks, ND

Kora Farokhzadeh (Secretary)
DSM, San Jose, CA

Ali Beheshti (PSC)
George Mason University, Fairfax, VA

Sustainable Power Generation Technical Committee

Matthew Hobbs (Chair)
EPT, Calgary, Alberta, Canada

Elaine Hepley, CLS, OMA (PSC)
POLARIS Laboratories, Indianapolis, IN

Synthetic Lubricants and Hydraulics Technical Committee

Lauren Huffman (Chair)
The Dow Chemical Company, Midland, MI

Paul Norris (Vice Chair & Secretary)
Afton Chemical Ltd., Bracknell, Berkshire, United Kingdom

Ryan Fenton (PSC)
BASF Corporation, Tarrytown, NY

Patti Cusatis (Vice PSC)
BASF Corporation, Tarrytown, NY

Tribotesting Technical Committee

Oluwaseyi Ogunsola (Chair)
Shell Global Solutions (US) Inc., Houston, TX

Jun Xiao (Vice Chair)
Rtec Instruments, Inc., San Jose, CA

Adedoyin Abe (PSC)
University of Arkansas, Fayetteville, AR

Ashish Kumar Kasar (Vice PSC)
University of Nevado, Reno, Reno, NV

Wear Technical Committee

Mathieu Renouf (Chair)
Université De Montpellier, Montpellier, France

Yan Zhou (Vice Chair)
Quaker Houghton, Oak Ridge, TN

Ali Beheshti (Secretary)
George Mason University, Fairfax, VA

Bulent Chavdar (PSC)
Eaton Corporation, Southfield, MI

Bulent Chavdar (Vice PSC)
Eaton Corporation, Southfield, MI

John Bomidi (Vice PSC)
Baker Hughes, The Woodlands, TX

Wind Turbine Tribology Technical Committee

Manish R. Patel (Chair)
ExxonMobil Chemical Company, Spring, TX

David Pack (Vice Chair)
Bisley International, LLC, Fulshear, TX

Ramesh Navaratnam (PSC)
Patech Fine Chemicals, Dublin, OH

Student and Early Career Posters

Robert Erck (Chair)
Argonne National Laboratory, Lemont, IL

2023 STLE Annual Meeting

Advertisers index

Events like STLE's 2023 Annual Meeting & Exhibition would not be possible without the generous support of advertisers and sponsors. STLE would like to extend its thanks to the companies listed below whose advertising support contributed substantially to the production of this Program Guide. Almost all of these organizations are here in Long Beach with a booth in the trade show.

Acme-Hardesty Company **41**

Advanced Chemical Concepts ..... **OBC**

Afton Chemical Corporation ..... **IFC**

Applied Rigaku Technologies Inc **71**

Azelis L&MF US **79**

Bruker **61**

Cannon Instrument Company **93**

CRC Press **137**

Dover Chemical Corporation ..... **IBC**

Dow **87**

Eastman **23**

Elé Corporation **83**

Emery Oleochemicals **75**

Ergon, Inc. **31**

Tuesday Tab – Back
ExxonMobil Chemical

Sunday/Monday Tab – Front
Evonik

Falex Corporation **45**

INEOS Oligomers **37**

Italmatch Chemicals **125**

J.A.M. Distributing Company **53**

Kao Chemical **117**

King Industries Inc. **51**

LANXESS Corporation **49**

Münzing **133**

Nouryon **55**

Sunday/Monday Tab – Back
Ravago Chemicals North America

Tuesday Tab – Front
Richful Lube Additive Co., Ltd.

Savant Labs **111**

Sea-Land Chemical Company **154**

SEQENS **39**

SONGWON Management AG **143**

Wednesday Tab – Front
2023 STLE Annual Meeting Exhibitor Appreciation Hours

Thursday Tab – Back
2024 STLE Annual Meeting Call for Presentations

Wednesday Tab – Back
STLE Mobile App: Annual Meeting

Thursday Tab – Front
2023 STLE Tribology Frontiers Conference &
Tribology & Lubrication for E-Mobility Conference

STLE Certification **63**

STLE Learning Management System **167**

STLE Membership **13**

STLE Podcast: Perfecting Motion® – Tribology &
The Quest for Sustainability **91**

The Lubrizol Corporation **59**

TriboNet **107**

ULProspector **159**

Vanderbilt Chemicals, LLC **161**

VBASE Oil Company **99**

Zschimmer & Schwarz **129**

notes

notes

notes

notes

Visit Us at Booth #327

HANDLE EXTREME PRESSURE

METALWORKING - POWERTRAIN - FUEL ADDITIVES

All Major Forms

Sulfurized
Phosphorus
Chlorinated
Synthetic

Alternative Additives Portfolio

Emulsion
AW/AO
Corrosion Inhibition
Wetting
Base Alkalinity
Dispersant/Detergent

WITH BEAUTIFUL RESULTS

DOVER Chemical Corporation
A Subsidiary of ICC Industries Inc.

Learn more about the standard and custom solutions available from Dover Chemical.
www.doverchem.com/metalworking-fluid-additives

330-343-7711 • 800-321-8805 • Fax: 330-364-9626
Customer Service: 800-753-6837 • customerservice@doverchem.com

THE KEY TO KNOWLEDGE IS NOT KNOWING THE ANSWER, IT'S KNOWING WHERE TO FIND THE ANSWER!

ACC

Advanced Chemical Concepts, Inc.

ACC can cover all of your Lubricity Additive Needs from Synthetic Fluids to High and Low-Oil Semi Synthetic Fluids to Soluble Oils.

VISIT ACC'S BOOTH #227

4675 Talon Court SE Kentwood, MI 49512

P: 216.221.3952 | F: 216.221.4291

www.advancedchemicalconcepts.com