Program Schedule-at-a-Glance

(As of October 22, 2021) **Program schedule is preliminary and subject to change*.

****Please note speakers will be participating either in-person or virtual during the conference. Those participating with a virtual presentation will be noted in the schedule below.***

All times represent US Central Time (CT)

Wednesday, November 3, 2021

8:30 am – 5:00 pm
Education Course Program – **"Introduction to Electric Vehicles"**
(Separate registration required)

6:00 pm – 7:30 pm
Meet-in-Greet | Grand Hyatt San Antonio River Walk Hotel

Thursday, November 4, 2021

7:30 am – 8:30 am
Registration and Continental Breakfast

8:30 am – 8:45 am
Welcome and Introductions | Program Chair: Dr. William Anderson, Afton Chemical Corporation

Session #1: Laying the Groundwork
Moderator: Dr. William Anderson, Afton Chemical Corporation

8:45 am – 9:45 am

Keynote Address

Electric Vehicle Tribology and Rolling Element Bearing Challenges
Dr. Ryan Evans, The Timken Company

The development and mainstream adoption of electric vehicles presents an exciting landscape for tribological system and component optimization. While the bearings used in internal combustion engine vehicles have known effective designs, the initial bearing selections in new electric vehicle platforms present opportunities for improvement. An introduction to rolling element bearings will be given, followed by a survey of high-level electric vehicle key trends and technology drivers. Two electric vehicle bearing application spaces are discussed in detail, including wheel end bearings and electric axle bearings. Tribological challenges and recommended solutions in each area are offered, along with descriptions of key technology development capabilities needed to accelerate innovation such as high-speed bearing testing and advanced lubricant rheology experimental apparatus.

Dr. Ryan Evans is the director of research and development at The Timken Company, currently responsible for leading teams that identify and develop new product, materials, and manufacturing technologies to meet customer needs. He joined Timken in 2002 as a researcher in the field of advanced materials and made significant contributions in the areas of thin film coatings (Timken "Wear-Resistant Bearing" premium product option), lubrication, advanced materials characterization, and tribology within the R&D division. He has authored over 40 refereed technical publications and has 14 patents in these fields. He has held several management positions in R&D, including the role of manager of Engineering Fundamentals and Physical Testing. During that time, he had responsibility for Timken's bearing and gear fundamentals, tribology, advanced modeling and simulation, and bearing product performance testing.

Evans transitioned to the Manufacturing Continuous Improvement group as a program manager within Timken's Operations division in 2015, followed by assignments in Supply Chain Management for Aftermarket and Aerospace business segments before returning to R&D in his current role in 2018. He holds a bachelor's of science degree from The University of Akron and master's of science and Ph.D. degrees from Case Western Reserve University, all in chemical engineering. Evans joined the STLE Board of Directors in 2015, and in 2019 he became a member of the Executive Committee, serving one-year terms as treasurer and secretary. Currently, he is serving a one-year term as 2021-2022 STLE Vice President and has won several STLE publishing awards. In addition to STLE, he is a member of ASM International and ASME.

9:45 am – 10:15 am
Compatibility Study of E-Fluids with Copper and Insulation Materials ***[Virtual Presentation]***
Rosemary Ran, Shell (Shanghai) Technology Company, Ltd.

With the consensus on reducing greenhouse gas emissions, a typical manifestation of the automotive market is the rapid growth in the number of electric and hybrid electric vehicles. The development of new energy models and the overall acceleration of the electrification of new cars are not only the way forward of the times, but also of extraordinary strategic significance to China. Unlike the drive structure of conventional fuel vehicles, in hybrid vehicles (HEVs and PHEV), more OEMs combine hardware such as motors, gearboxes, clutches and some control units, with motors set up in transmissions and immersed in transmission lubricants to improve the cooling efficiency of motors. Therefore, the direct contact between the E-motor and transmission lubricants poses many challenges to the compatibility of lubricants and motors and puts forward strict requirements for the oil resistance of motor insulation materials.

For the integrated electric drive system, there is no unified standard specification at home and abroad. The standards used by each lubricant company in the market also vary. In December 2019, the China Electrical Industry Association (CELA), launched "Technical Requirements for Insulation Structure of Drive Motors in New Energy Vehicles." The specification is for the requirements of insulation material hardware, but also clearly proposed that for oil-cooled motors, insulation components and insulation structures should also meet the requirements of oil resistance. In this presentation, we conducted fluid compatibility tests at different temperatures, with various E-motor insulation materials to explore the correlation between different chemical additive technology and motor insulation materials. The results show that there are big differences in compatibility between different insulation materials and oil formulations. At the same time, this presentation also shows the possibility of attenuation or decomposition of additives by different water content in oil, thus affecting the insulation of motors.

The unique transmission structure design of electric and hybrid vehicles from different OEMs presents many challenges for lubricants. However, lubricants can be tailored to demonstrate outstanding insulation compatibility and excellent high temperature corrosion resistance in the above tests, in line with the special design requirements of EVs and hybrid vehicle transmission systems.

Rosemary Ran is Team Leader of Shell (Shanghai) Technology Ltd. for Transmission Fluids and Heavy-Duty Diesel Engine Oils (HDDEO). She holds a master's degree in material science from East China University of Science and Technology. Rosemary has more than 25 years of experience working in lubricants, and expertise in lubricant formulation for both HDDEO and transmission oils. Rosemary is a member of the China Transmission Standard Committee and has considerable engagement with local OEMs. She leads a Shell team to support business needs of China and the AP region via delivering R&D programs in both HDDEO and Transmission (e- fluid) Technologies.

10:15 am – 10:45 am
Improving Gear and Thermal Efficiency of Electric Vehicle Transmission Fluids with the Use of New Group V Base Stocks
Dr. Gareth Moody, Croda Europe Ltd.

The formulating process to produce dedicated transmission fluids for electric vehicles has been an ongoing and continuous process, with a focus on several key parameters such as material compatibility of copper and elastomers and having a controlled level of electrical conductivity. There has been a recent drive to maximize the thermal properties of these fluids and lower traction to improve gear efficiency.

Here, new Group V base fluids will be shown to have exceptionally low levels of traction and high levels of thermal conductivity and are fully compatible with key materials and Group I-IV base oils. These new fluids can be mixed with other base oils to enhance their properties and improve vehicle efficiency in both systems where the transmission is used for motor cooling and systems where it is not and can significantly boost by reducing energy consumption.

Dr. Gareth Moody is a research and technology specialist with Croda Europe Ltd. He has been with Croda for nine years in the Lubricants Department and specializes in automotive applications such as engine oil and transmission base oil and additives. He obtained a PhD in antioxidants for engine oils from the University of York, UK.

10:45 am – 11:00 am
Break

Session #2: EV Driveline Fluids
Moderator: Dr. Peter Lee, Southwest Research Institute

11:00 am – 11:30 am
Profiling Electric Drivetrain Fluid Characteristics – Presented by SAE International
Greg Miiller, Savant Group

With the advent of electrified vehicles, the need for specialized fluids has evolved. Many laboratories, OEMs, and lubricant/additive suppliers have been experimenting with various types of tests to simulate the application as the EV development process takes place. Some current applications utilized in the industry do not properly mimic the process. The characteristics and applications require scrutinization for proper results. SAE's Fuels and Lubricants TC 3 Driveline and Chassis Lubrication Committee is creating an information report to assist those concerned with

lubricants used in drivetrain components powered by electrified vehicles. This knowledgeable team of industry professionals are evaluating various industry applications. The information is planned to clarify the terms and tests related to the properties of lubricants used in electric drivetrains.

Greg Miiller is a Michigan native and a family man with a passion for the outdoors. His career began as a U.S. Marine serving with the 3rd Marine Air Wing repairing radar systems. Since that time, he has performed on an international level in the petrochemical industry for the past 26 years. His professional degrees in electronics and business, along with a Master's in business/operational leadership, have bolstered his career as a Design Engineer, Director of Technology and Executive Vice President of New Business and Engineering for the Savant Group of Michigan (which is a combination of four technical companies). Over the years, he has been awarded 14 patents for designs on testing equipment and authored many technical papers.

Greg has been with ASTM for 25 years serving as an officer with nine groups between Subcommittee's 7, 9 and CS96. On the international front, he has served as an officer with multiple associations including the Coordinating European Counsel (CEC), Energy Institute (EI) of England and Society of Automotive Engineers (SAE). Awards he has received from these groups include the awards of appreciation (twice), excellence (twice) and oratory merit (twice).

Having experience in manufacturing processes, design implementation, quality assurance development and lean engineering, he has been able to help drive the various companies to reduce the cost of goods sold and improved profitability. He enjoys helping people discover their strengths and developing them for matching job roles.

11:30 am – 12:00 pm
Base Oil Benchmarking for Gear Oils in Electric Vehicle Drivetrains ***[Virtual Presentation]***
Dr. Steffen Gläenzer, Clariant

The penetration of electric vehicle technology is a major global trend resulting from regulations intended to improve vehicle fuel efficiency and to reduce emission of greenhouse gases. OEMs, suppliers and researchers are looking for base oils that meet new e-fluid needs, which happen to be different than for lubricants used in internal combustion engine vehicles. So far, few systematic studies benchmark crucial properties of e-fluid base oils. This talk will compare base oil properties of polyalphaolefins and various new polyalkylene glycol solutions covering the following topics: (1.) cooling performance evaluating thermal conductivity and heat transfer properties, (2.) energy efficiency evaluating friction on a ball-on-disc tribometer, (3.) electrical properties evaluating electric conductivities, (4.) sustainability assessing ecotox profile and biodegradability, as well as (5.) thermal and thermal-oxidative stability. One major finding is that depending on the type, polyalkylene glycols offer the possibility to adjust and fine tune these properties within a comparably wide range.

Dr. Steffen Gläenzer is the Global Application Development Manager of Lubricants at Clariant, located at the Clariant Innovation Center in Frankfurt, Germany. He is currently responsible for leading a team that develops new products to meet customer needs in metalworking, industrial lubricants, and automotive fluids. Selected publications deal with PAGs (polyalkylene glycols) for industrial gear oils, compressor oils, greases, food-grade applications, and environmentally friendly lubricants. One of his recent focus fields is the development of new base oils for electric vehicle lubrication and cooling. He joined Clariant in 2013 as a member of the Clariant International Graduate Program, which included positions in the area of Personal Care, Masterbatches for Polymers, and Industrial Lubricants. Dr. Glaenzer holds an undergraduate degree in chemistry from the University of Heidelberg, a Ph.D. degree in chemistry from the University of Rostock, and an MBA from the University of Cardiff. He has published 8 peer-reviewed articles and two patents.

12:00 pm – 1:00 pm
Lunch

Session #3: Lubrication for EVs 1: Base Oils
Moderator: Dr. Neil Canter, Chemical Solutions

1:00 pm – 1:30 pm
Base Oils Useful for E-Mobility
Dr. Ken Hope, Chevron Phillips Chemical Company

As the world is shifting transportation technology toward electric vehicles, many issues are raised concerning lubricants and thermal management fluids. The properties of common base oils have been well known for many years but as we look to EV applications, there are additional considerations in terms of compatibility as well as electrical and thermal properties. This presentation will focus on the physical properties that become important in these emerging applications and how base oils differ for these applications. There is a great deal to learn with this challenge but there is also a good deal to learn from the past from similar applications.

Ken Hope is global PAO technical services manager for Chevron Phillips Chemical Company in The Woodlands, Texas. Hope has 30 years of experience in the lubricant industry. His research interests have been primarily focused in the area of polyalphaolefins (PAOs) and the use of synthetic lubricants. Prior to becoming global PAO technical services manager for Chevron Phillips Chemical, he was a research fellow and team leader for NAO and PAO research and technology responsible for product development, process improvement and technical service for NAO and PAO product lines. For several years, he worked in the analytical group at Chevron Corp. doing NMR research on catalysts and structure/property relationships on various materials. Before joining Chevron Corp., he was the director of NMR research in the chemistry department at the University of Houston.

Hope is past chair of the STLE Houston Section and participated as a Lubrication School instructor for the STLE Houston, Chicago and Oklahoma Sections. For more than 15 years, he instructed the synthetics module of the Basic Lubrication course at STLE's annual meeting. He also holds STLE's Certified Lubrication Specialist™ designation. A former chair of STLE's Editorial & Publications Committee, Hope has served on the editorial board of the Journal of Lubrication Science and as a TLT Technical Editor. He also has served as a member of the API Base Oil Interchange/Viscosity Grade Read Across Task Force as well as ASTM and SAE. He has presented more than 70 technical papers at STLE, NLGI, UNITI, ELGI, ACS, AICHE and SAE meetings and holds 21 U.S. patents.

Hope served on the STLE Board of Directors from 2006 to 2017, and in 2018, he became a member of the Executive Committee, serving one-year terms as treasurer, secretary and vice president. He was elected 2021-2022 STLE President for a one-year term this past May.

1:30 pm – 2:00 pm
Extending Drive Range and Enhancing Thermal Management in EVs using Next-Generation PAOs
Dr. Babak Lotfi, ExxonMobil

Many automotive manufacturers have been adopting the integrated drive-unit design. In this approach, a single fluid is being used for cooling the electric-motor and electrical components, in addition to lubricating the gears, bearings and possibly clutches in the drive-unit. This can pose new challenges to the fluid development. In this work, heat transfer and cooling properties of synthetic base stocks, including next-gen PAO, have been studied compared to next best alternatives in an e-motor system. Testing suggests superior performance of synthetic base stocks, which

results in lower system operating temperatures. Novel PAOs also demonstrate improved energy efficiency, which enables extended driving range.

Dr. Babak Lotfi has a Ph.D. in tribology and has been practicing tribology and lubricants for over 10 years. He has authored/co-authored several research publications, held multiple patents, and presented at various international electric vehicle and tribology conferences. Babak is an STLE member and currently is an associate editor for STLE's Tribology Transactions journal. Since 2017, he has worked for ExxonMobil (EM), and prior to that he worked for Schaeffler. Currently, he is a Global Application Development at EM, working on tribology fundamentals and advancing EV fluids using synthetic fluids.

2:00 pm – 2:30 pm
A Lifecycle Analysis for the Efficiency and Emission of EVs in Comparison to IC Engines
Dr. Ali Erdemir, Texas A&M University

Electric vehicles (EVs) are considered as the new paradigm for future transportation needs due to their higher efficiency and much lower emissions than traditional internal combustion engine vehicles (ICEVs). While energy losses due to rolling friction, aerodynamics, and braking are inherent in EVs as well, thermal and frictional energy losses are greatly minimized in EVs, making them hugely popular for saving energy and protecting the environment. In this presentation, we provide a side-by-side comparison of the energy consumption in ICEVs vs. EVs. The energy efficiency for the ICEV case is about 21% while in the case of EVs, it could be much higher (i.e., 77%). The friction-related losses, excluding braking and rolling friction, are ~16% for an ICEV and only ~6% for an EV. In this presentation, we also evaluate the energy efficiency and the greenness of current ICEV vs. EV scenarios considering lifecycle analyses, including not only tank-to-wheel, which is mostly related to driving the vehicles, but also the well-to-tank which can include manufacturing, maintenance, and recycling stages, thus providing an overall picture that compares the true efficiency and greenness of both cases. Lastly, we survey some of the emerging technologies that can help further enhance efficiency and environmental impact of future EVs.

Dr. Ali Erdemir is a Professor and Halliburton Chair in the Departments of Mechanical Engineering and Materials Science and Engineering at Texas A&M University in College Station, Texas. In recognition of his research accomplishments, Dr. Erdemir has received numerous coveted awards (including STLE's International Award, ASME's Mayo D. Hersey Award, six R&D 100 Awards, two STLE Al Sonntag Awards and the STLE Edmond E. Bisson Award) and such honors as being elected to the U.S. National Academy of Engineering, President of the International Tribology Council (ITC), as well as Past STLE President (2016-2017). He is also a Fellow of AAAS, ASME, STLE, AVS, and ASM International. He has authored/co-authored more than 300 research articles, co-edited four books, and holds 31 U.S. patents. His current research focuses on bridging scientific principles with engineering innovations towards the development of novel materials, coatings, and lubricants for improved efficiency and durability in a broad range of cross-cutting applications including internal combustion and electric vehicles.

2:30 pm – 3:00 pm
Will Electric Vehicles Break the Grid? *[Virtual Presentation]*
Dr. Amro Farid, Dartmouth/MIT

Electrified modes of transportation: vehicles, buses and trains fundamentally couple the transportation system with the electric power grid. This coupling presents new challenges in the operation of each system, which would not have existed if each was operated independently. This presentation will thoroughly investigate these challenges and discuss how well-equipped the grid is today to manage them. To support its points, this presentation draws on simulation results from the first ever full-scale electric vehicle integration study, which was recently conducted for a taxi-fleet use case in Abu Dhabi. To conclude, the presentation advocates for an enhanced Intelligent Transportation

Energy System (ITES) which includes an integrated approach to transportation and energy management. At its core, the ITES requires a new transportation electrification assessment methodology that draws upon traffic simulation, power grid dynamics, and Big Data-Driven use case modeling. Such an ITES would come to include coupled operations management decisions, including vehicle dispatching, charging queue management, coordinated charging, and vehicle-to-grid ancillary services. The study suggests that the future of electrified transportation necessitates closed collaboration between transportation system and electric grid operators.

Dr. Amro Farid is associate professor of Engineering Research Affiliate in the department of mechanical engineering at Dartmouth/MIT. As a faculty member at Dartmouth, he leads the Laboratory for Intelligent Integrated Networks of Engineering Systems (LINES) and has made active contributions to the MIT-Masdar Institute Collaborative Initiative, the MIT Future of the Electricity Grid Study, and the IEEE Vision for Smart Grid Controls.

Farid received his bachelor's and master's degrees in mechanical engineering from MIT, and a Ph.D. in engineering from the University of Cambridge. He is a senior member of IEEE, where he chairs several committees, and a member of ASME's Dynamics Systems & Control Division. He has also co-authored three books.

3:00 pm – 3:15 pm
Break

Session #4: Lubrication for EVs 2: Additives and Finished Fluids

Moderator: Dr. Ken Hope, Chevron Phillips Chemical Company

3:15 pm – 3:45 pm
New E-Mobility Test Developments and Electric Drivetrain Fluid Technology
Dr. Yungwan Kwak, Afton Chemical Corporation

Electrification is a key technology for improving vehicle efficiency and reducing emissions of greenhouse gas and other pollutants. In many hybrid and electric vehicle (HEV and EV) hardware designs, drivetrain fluids are in contact with the integrated electric motor (eMotor). Not surprisingly, the performance requirements for lubricants in these applications are different than those for conventional automatic transmission fluids (ATFs). In particular, they require enhanced electrical and thermal properties, compatibility with conventional and new materials, including a broad range of metallic and non-metallic components. Additionally, gear and pump protection must be maintained, while better performance under high rotational speed is needed. Finally, frictional performance requisite with any shifting devices in the transmission must be dialed into the fluid. Hence, the lubricant industry is challenged with developing various new tests to ensure a robust fluid performance under real-world operating conditions.

This presentation comprises two aspects: electric drivetrain fluid (ETF) development and E-Mobility test method development. First, the performance of newly developed ETF will be described in depth. Second, in the test development section, we will discuss HEV fluid aging, power electronics cooling, and material compatibility, including copper corrosion under a diverse range of operating conditions. Furthermore, applied copper corrosion methods like low voltage connector and circuit board tests under electrified conditions, as well as magnet wire coating, insulation paper, and lacquer compatibility tests will be discussed. Finally, we will touch on the eMotor cooling simulation to expound on the benefits of direct oil cooling versus indirect coolant cooling. Although additional study is needed to correlate with the real-world data, these new test methods are valuable tools to help ensure robust and efficient ETF development to meet evolving hardware demands.

Dr. Yungwan Kwak has an extensive background in polymer science and engineering, having conducted undergraduate, graduate, and postdoctoral studies in South Korea, Japan, and the U.S., respectively. He started his industrial career with a global pigment company in the U.S., where he held global R&D scientist and operations manager positions. Yungwan is currently employed by Afton Chemical, where he leads their E-Mobility technology and polymethacrylate viscosity modifier development efforts. Dr. Kwak has published over 40 peer-reviewed papers and holds multiple U.S. and international granted patents.

3:45 pm – 4:15 pm
Heat Transfer Performance of Fluids for Electrified Vehicles
Dr. Andrew Richenderfer, The Lubrizol Corporation

One major function of driveline lubricants is the ability to remove heat from the powertrain and maintain nominal operating temperatures. In conventional ICE vehicles, this lubricant property is not a key differentiating feature and not included in transmission or axle specifications. However, in electric or hybrid vehicles reducing the operating temperature of the electric motor increases the motor durability, efficiency, and vehicle driving range. In architectures where the motor is cooled by the lubricant, selection of lubricants with specific thermal properties could represent a practical route to optimizing performance. However, selecting a fluid with the correct characteristics is not straightforward. Though the lubricant's thermal properties are unrelated to each other, often in practice they are partially confounded, making it difficult to understand if their individual contributions to heat transfer are of practical significance.

In this presentation, we review the thermal properties of lubricants that influence heat transfer and how they vary with temperature. We describe how these are combined to calculate various 'Figures of Merit' that are used to assess relative cooling capability. Constants used in the Figure of Merit calculation vary with flow regime and this may also change with temperature. We will also describe our development of a heat transfer test rig, which provides real heat transfer measurements under various flow regimes. The rig also quantifies the energy expended to enable each lubricant's cooling capability. This allows us to balance the thermal characteristics of the lubricant against the energy required to accomplish this cooling to maximize electric motor efficiency and vehicle range.

As a research engineer in the Strategic Research Group at Lubrizol, **Andy Richenderfer** supports thermal management strategic projects focusing on test design and development for fluid heat transfer performance and safety. Andy joined Lubrizol in 2020 and prior to that was a thermal-hydraulic engineer at Knolls Atomic Power Laboratory. Andy has Ph.D. in nuclear science and engineering from the Massachusetts Institute of Technology.

4:15 pm – 4:45 pm
Ultra-Low Viscosity E-Fluids Enabling a Sustainable Future *[Virtual Presentation]*
Dr. Hitesh Thaker, Infineum USA L.P.

The automotive industry trends toward improved fuel efficiency and CO_2 emission reduction have resulted in automotive manufacturers incorporating greater levels of electrification, utilizing lower viscosity driveline fluids, and developing more compact, higher voltage designs. As a result, direct oil cooling will play a critical role in thermal management, especially at lower viscosity. Ultra-low viscosity fluids will also need to meet other key requirements like high volume resistivity and material compatibility while maintaining gear and bearing durability. Careful formulation design, including bespoke antiwear and extreme pressure additives, is essential to deliver a balanced e-fluid performance, especially in a low viscosity environment.

Hitesh D. Thaker graduated from the University of Massachusetts in 2012 with a Ph.D. in polymer science and engineering. He has a strong background in polymer chemistry, characterization and organic synthesis. He started his career in the lubricant industry by joining Infineum USA L.P. in October 2012. For the first five years, Hitesh worked as a technologist in the Viscosity Modifiers (VM) Group at Infineum. His research work involved fundamental understanding of the VM impact on lubricating oil in both bench and engine environment. In 2017, Hitesh switched gears and joined the Power Transmission Fluids Group. He is currently the project leader of the e-fluid technology and focused on developing new e-fluids to meet the new and challenging requirements of next generation electric drivetrains.

4:45 pm – 5:15 pm
Challenges and Opportunities for Industrial Lubricants as the Automotive Industry Moves to Electric Vehicles
Dr. Neil Canter, Chemical Solutions

The automotive industry has requirements for other lubricants besides those used in the powertrain. Industrial lubricants that include metalworking fluids, hydraulic fluids, slideway lubricants and diecast fluids are required to manufacture automobiles. This talk will examine how demand for industrial lubricants will change during the transition from internal combustion-powered automobiles to battery-powered electric vehicles. The manufacturing processes for both automobile types will be examined, and the types of industrial lubricants used will be discussed. A comparison will be made about differences in how both automobile types are produced and what effect that will have on the demand for industrial lubricants. Changes in the demand for industrial lubricants by 2040 will be discussed, with an emphasis placed on which specific types will see the greatest impact. New opportunities for industrial lubricants in the manufacture of electric vehicles will also be covered.

Neil Canter received his Ph.D. in Chemistry from the University of Michigan in 1983 and his BS in Chemistry from Brown University in 1978. He has been working in the lubricant industry for over 35 years. Canter runs his own consulting company called Chemical Solutions. He specializes in commercial development, marketing, product development and regulatory support for the lubricant industry. Canter is a member of American Chemical Society, Society of Automotive Engineers (SAE) and the Society of Tribologists and Lubrication Engineers (STLE). He is a Contributing Editor responsible for writing the monthly Tech Beat column in STLE's TLT magazine. Canter is also a member of STLE's Metalworking Fluid Education & Training Committee, the STLE Education Committee and the Program Chair for the Philadelphia Section of the STLE. He recently assumed the position of STLE Advisor – Technical Programs and Services. Besides providing technical and commercial support for STLE. He is also the host of the new STLE podcast series, "Perfecting Motion: Tribology and the Quest for Sustainability."

6:30 pm – 8:00 pm
Networking Reception

Biga on the Banks
203 South Mary's at Market
San Antonio, TX
www.biga.com

Friday, November 5, 2021

7:30 am – 8:30 am
Continental Breakfast

Session #5: Lubricant Testing for EVs

Moderator: Dr. Babak Lotfi, ExxonMobil

8:30 am – 9:00 am
Characterization of E-Fluids from Laboratory Analysis to the Test Bench *[Virtual Presentation]*
Dr. Gunther Müller and Rico Pelz, APL

Lubrication of electric drives requires special fluids that differ from conventional ones, which have to meet specific requirements. Since industry standards, as they exist for conventional lubricants have been lacking up to now, APL has adapted and further developed known methods and test setups for the characterization of fluids for electric mobility applications.

Gunther Müller graduated with a diploma degree in chemistry from the University of Mainz, Germany and earned his Ph.D. at the same university in 1992 in the field of polymer science. Gunther started his career in the chemical industry employed at Evonik, Degussa, PolymerLatex and Bayer. Since 2012, he has worked at APL in Germany as head of the oils and fuels laboratory (accredited to DIN ISO 17025). In this position, he has served in different working groups of DIN, CEC, FVV for the development of new analytical test procedures and is responsible for close cooperation with OEMs regarding in-house testing for oil specifications.

Rico Pelz graduated with a master's of science degree in 2018 from the University of Applied Science in Karlsruhe in the field of electrical engineering, with focus on sensor systems technology. He conducted his bachelor's thesis at APL before he went on to do his master's degree in Melbourne. Since 2018, he has been responsible for the e-fluid team at APL, including the development of new tests in that field, as well as adapting and improving already existing tests in the field of e-mobility.

9:00 am – 9:30 am
E-Mobility Fluid Testing for Heavy Truck Transmissions *[Virtual Presentation]*
Dr. Mattias Forslund, Scania

This investigation evaluates the influence of different transmission fluids on the material compatibility from a thermal and corrosion perspective related to eMachines and transmission for electric motors intended for Heavy Vehicle propulsion systems. Results show that different fluids have a significant impact of the compatibility and, thus, the overall system performance.

Mattias Forslund is development engineer of materials for eMobility at Scania CV AB, Sweden, where he specializes in electrical insulation systems (eMobility, electric machine, power electronics, and batteries). He also was a former project leader in PHM (prognostics and health management) for electronics. Prior to joining Scania, Forslund was an inspection engineer for Nynas AB. He received his Ph.D. in chemistry/corrosion science from Royal Institute of Technology (KTH), Sweden, and master's of science degree in material chemistry from Uppsala University, Sweden.

9:30 am – 10:00 am
Innovative Design of Lubricants Test Rig for E-Grease and E-Fluid *[Virtual Presentation]*
Dr. Deepak H. Veeregowda, Ducom Instruments

A new generation of component test rigs relevant to battery powered electric vehicles (EVs) have become essential for the lubricants industry that is investing heavily in the EV marketplace. In this presentation, we will describe our efforts in designing and manufacturing an electric lubricants test rig known with a two-stage lubricated bearings that can be tested at a speed up to 30,000 rpm and at load up to 15 kN. Bearings can be lubricated with grease or oils; lubricants can be heated up to 150 ^{o}C using our two-stage heat exchanger. Rotordynamics and cooling system design are key techniques to reduce the test rigs downtime and improve safety of the operator. We will elaborate on these techniques during the presentation. Each bearing station is embedded with smart sensors that captures the vibration, noise, bearing friction and temperature of the lubricated system. The sensor system is MOOHA enabled that completely automates the process of data collection, cloud storage, analytics, and reporting, collectively they provide insight to e-grease or e-fluid performance (i.e., antiwear, thermal conductivity, friction, and fatigue resistance). We will share a case study that describes the performance of few electrical lubricants widely used in electric motor and electric wheel hubs of battery powered EVs. The electric lubricants test rig is the first in the market that is aimed at creating relevant lubricants test beds for better performance of EVs and empower the idea of reducing carbon emission through electrification.

Deepak Veeregowda has 10 years of experience in tribology, design of precision instruments and innovation. He received his Ph.D. in 2012. Since then, he works as Global Head of Marketing at Ducom Instruments (Netherlands). He has published more than 20 peer-reviewed articles and received multiple research grants in Netherlands.

10:00 am – 10:15 am
Break

10:15 am – 10:45 am
Dielectric and Electrochemical Properties of Lubricants for Electric Drivetrains and their Influence on the Lubricant-Stator Interface
Michael Miller, Southwest Research Institute

New requirements in lubricants for electric and hybrid vehicle drivetrains are emerging with performance characteristics that are neither well defined nor completely understood in this context of application. Notably, the electrical properties of the lubricants themselves, such as complex dielectric permittivity (or electrical conductivity),

dielectric breakdown, the temperature dependence of dielectric permittivity, and electrochemical activity, can have important influences on the interfacial and bulk material stability of dielectric coatings and the underlying copper wire that constitute the stator elements of the electric motor. To add to the complexity of the application, we must develop a holistic understanding of such electrical characteristics alongside the fluidic and tribological performance of the lubricant. This talk will address the fundamental principles governing the complex dielectric permittivity (and complex conductivity) properties of dielectric fluids (lubricants) and wire coatings, the structure-property relationships of these properties, and the methods used to study their influence on the lubricant-stator interface to assess lubricant-stator compatibility and prognostics of service lifetime.

Dr. Michael Miller is an Institute Scientist at Southwest Research Institute (SwRI). He received his Ph.D. in physical chemistry from the University of Texas at San Antonio and has over 36 years of experience as a physical and synthetic chemist, specializing in computational chemistry/materials, surface science, solid-state chemistry, as well as molecular spectroscopy. The main thrust of his work has been on the development of first-principles theoretical models and experimental methods aimed at predicting or determining physical and chemical pathways for the formation or disposition of materials. In the field of theoretical solid-state chemistry, he employs *ab initio* and semi-empirical computational methods as a means of designing new nano-structured motifs and predicting their thermal, electrical, mechanical, and spectroscopic properties under various conditions. He has expertise in the development of scalable plasma-based processes for the synthesis of coatings and chemical intermediates.

10:45 am – 11:15 am
Efficiency Performance of Lubricants for Electric Vehicle Powertrains
Prof. Dr.-Ing. Karsten Stahl, FZG

Based on their special challenges, the specific requirements for the lubrication of electric vehicle (EV) powertrains are highlighted. Suitable test procedures to measure the efficiency performance of lubricants under typical operating conditions of EV powertrains are presented, such as the hyper-high-speed electric vehicle drivetrain test rig (speed4E), the FZG EV gearbox efficiency test rig and the FZG gear efficiency test rig with an outlook to high-speed upgrade. Exemplary results from these test rigs with various lubricants will be presented, with focus on water-containing polyalkylene glycol (PAGW). The potential but also the challenges of PAGW in EV powertrains will also be discussed.

Prof. Dr.-Ing. Karsten Stahl is director of the Gear Research Centre (FZG) and full professor at the Technical University Munich. In the focus of his research are experimental, simulative and analytical investigations of endurance, tribology, NVH, materials and fatigue life analysis of gears and transmission elements, with the target to develop methods and tools for reliable determination of fatigue life, efficiency, and vibration characteristics.

Prof. Stahl is the author of more than 200 scientific publications, board member of several scientific associations, convener of DIN and ISO working groups, editor of several scientific journals and president of the VDI International Conference on Gears.

11:15 am – 11:30 am
Break

Session #6: Panel Discussion – EV Hardware Trends: Stakeholder Perspectives
Moderator: Dr. Dairene Uy, Shell Global Solutions US Inc.

11:30 am – 1:00 pm
Panel Discussion – EV Hardware Trends: Stakeholder Perspectives

Panelists:
Dr. Hong Liang, Texas A&M University | **Needs in Fundamental Understanding of Electric Vehicles**

During this presentation, we'll summarize our current knowledge of lubricants and discuss fundamental questions to be answered looking ahead to the future of electric vehicles (EVs).

Dr. Hong Liang is Oscar S. Wyatt Jr. Professor of J. Mike Walker '66 Department of Mechanical Engineering at Texas A&M University. Liang's tribological research lies in both fundamental and application aspects. Her research group designs advanced tribo-materials and structures and makes them through nanomanufacturing. Liang investigates surface properties and interfacial interactions of those materials in tribological applications, including chemical-mechanical polishing. Her group has published intensively in the tribology community. Her services to the tribology community include being an associate editor of STLE's peer-reviewed journal, Tribology Transactions, editor of Tribology International, regional editor (North America) of Surface Topography: Metrology and Properties, associate editor of Friction and several other journals.

In 2018-2019, Liang was the assistant director of research partnerships at the Advanced Manufacturing National Program Office of the National Institute of Standards and Technology (NIST), where she served as a 2018-2019 ASME Foundation Swanson Fellow. She received her doctorate and master's degrees in materials science and engineering from Stevens Institute of Technology. She has been an active member of STLE since 1989, including serving on the STLE Board Directors (2007-2013). Currently, she is a member of STLE's Executive Committee. She has also served as chair of the STLE Annual Meeting Program Committee (AMPC), Awards Committee and Fellows Committee.

Troy Muransky, American Axle & Manufacturing | **Challenges of Hardware and Fluid Design for Electric Drive Units *[Virtual Presentation]***

In this talk, we'll discuss comparing an electric drive unit (EDU) to a traditional axle and will cover these topics: (1.) Required Gear/Bearing Durability for unit with 10x more cycle count and 3-4x higher RPM, (2.) High Demand to Cooling and Lubrication with Higher Sustained Temperatures, (3.) Fluid Additive Compatibility with a High Surface Area of Exposed Cooper, and (4.) Vent Expulsion Prevention and Continuous Lubrication Based on Foaming/Aeration.

Troy Muransky is a senior materials engineer for American Axle & Manufacturing, with primary responsibility for all driveline lubricants used within AAM applications.
He received a bachelor's of science degree in chemistry from the University of Michigan and chemical engineering from Wayne State University, respectively.

Troy has over 15 years of experience in the automotive industry in various roles including materials engineering, process engineering, environmental engineering, analytical chemistry, and laboratory management. His technical expertise is focused on driveline lubricating fluids, corrosion resistance coatings, and surface treatments, with most of his professional career being centered on research, development, testing, and launch of organic materials used in automotive applications. He currently serves as a senior member of the Lubricant Review Institute (LRI) Review Committee and is an active member of the SAE Fuels and Lubricants TC 3 Driveline and Chassis Lubrication Committee since 2010.

Joe Noles, Infineum USA L.P. | **Fluids for Electrified Vehicles – Past, Present, and Future**

Joe Noles is global technology advisor for Infineum USA L.P. After obtaining a Ph.D. in chemical engineering from Cornell University, Noles joined Exxon Chemical and held various technology and marketing roles, including crankcase oil formulator and ATF market manager. When Exxon Chemical and Shell Chemical formed Infineum in 1999, Noles served as technical service manager for speciality additives, which included ATF, gear oil, 2T, and railroad oils and in 2004 returned to ATF as the global technology advisor for transmission fluids, responsible for developing factory fill ATF, DCTF, CVTF, and e-Fluids.

Dr. Farrukh Qureshi, The Lubrizol Corporation | **Fluid Implications for Electric Vehicle Drivetrain**

The transition from internal combustion engine (ICE)-powered vehicles to electric motor-powered vehicles is fundamentally changing lubricant requirements. There is the obvious elimination of the ICE. The drivetrain, which is responsible for transmitting power from the source to the wheels, is starkly different. In some ways, the drivetrain has become mechanically simpler. On the other hand, lubrication of bearings and gears in e-vehicles is more challenging due to the high rotational speeds of the motor output shaft. Current capability of gear/lubricant testing is limited to a few thousand revolutions per minute, suitable for conventional vehicles. Improved test capability for mechanical components is needed for evaluation and further development of lubricant/mechanical systems. Lubricants are used to reduce friction, increase bearing and gear life, and dissipate heat to manage the operating temperature. In addition to the needs of material compatibility, copper corrosion protection and thermal management, improving component-level efficiency and durability of mechanical systems will be discussed. Some data detailing the impact of viscosity on temperature rise, power loss, and bearing skidding at high speed will be shared.

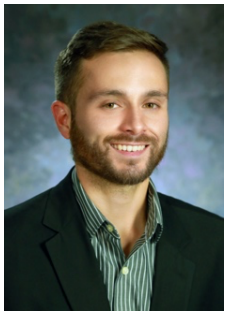
Dr. Farrukh Qureshi is a Technical Fellow in Strategic Research in R&D at The Lubrizol Corporation. His current areas of research include electric vehicle driveline tribology, fuel economy, additive-surface interactions, elastohydrodynamic lubrication and high-pressure rheology. Farrukh earned his Ph.D. in mechanical engineering from Georgia Institute of Technology. He joined Lubrizol's Corporate Research and Development in 1998 and has been providing global tribology leadership for the Lubrizol Additives. Currently, he serves on STLE's Board of Directors and is an STLE Fellow. He has also been involved in various STLE technical committees and served as chair of STLE's Annual Meeting Program Committee in 2015. Farrukh has authored and co-authored more than 40 publications and serves on editorial boards of IMECHE Journal of Engineering Tribology and Tribology–Materials, Surfaces and Interfaces. He has also been active in the ASME Tribology Division where he has held various leadership positions.

Thomas Wellmann, FEV | **Topic: TBA**

Thomas Wellmann has been at FEV for more than 20 years in different roles. Thomas started his career in NVH (noise, vibration, harshness), where he was engaged in multiple projects for powertrain and driveling NVH, including conventional and electrified powertrains. Activities include detailed studies such as driveline torsional analysis and isolation, engine start/stop investigations, hybrid system strategy analysis, with focus on fuel economy and driveline NVH, as well as integration of electric drive units. With focus on transmissions and drivelines, his responsibilities grew to oversee all vehicle and component testing in this area, including projects on driveline efficiency, durability, and vehicle fuel economy for conventional, hybrid electric and fully electrified powertrains. He has published several publications on the topics of driveline electrification of propulsions systems.

Ian Smith, Southwest Research Institute | **Technology Trends in Battery Pack Thermal Management**

While electric vehicles are significantly more efficient than conventional internal combustion powered vehicles, thermal management of the battery pack is critical for the vehicles to meet customer performance and life expectations. This presentation/discussion will cover the current and future trends of battery pack thermal management systems including immersed (dielectric) coolants, novel control strategies and unique materials to balance heat transfer and safety during thermal runaway.



Ian Smith is the manager of the Electrified Powertrain Section at Southwest Research Institute (SwRI). He leads a team of engineers and technicians responsible for research and development and testing of lithium-ion battery cells, modules, and packs, electric motors and inverters, and fuel cells. His work at SwRI has recently focused on evaluating dielectric coolants for lithium-ion batteries and lubricants for electric motors to improve performance, durability and safety. Additionally, Smith is the program manager for the Electrified Vehicle and Energy Storage Evaluation (EVESE) Consortium at SwRI. This program focuses on evaluating the current state-of-the art electrified vehicle technologies and conducts research related to improving these technologies.

1:00 pm – 3:00 pm
Wrap Up and Tour of SwRI facility