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TTRF

7th TTRF-TAIHO International Symposium on Automotive Tribology 2024

1. Date : Wednesday, Apr 17, 2024 10:45-17:05(JST)
2. Venue: Intl. Conf. Room, 3F, Bldg.3, Nagoya Congress Center, Nagoya, Aichi Prefecture
3. Theme: Prospects for Powertrain "Lubricants" Facing Carbon Neutrality
4. Program:

< Opening >	Moderator Toru Desaki	
10:45-10:55	Opening Address	Toshio Niimi Organizing Committee Chair (Taiho Kogyo Co., Ltd.)
< Honorary Lecture >	Chair Kenneth G. Holmberg (TTRF Director)	
10:55-11:45	Honorary Lecture: Materials and Lubrication Challenges for a Sustainable Electric Vehicle Mobility: Recent Progress and Future Prospects	Ali Erdemir (Texas A&M University)
11:45-13:00	<Lunch> Cafeteria “Cascade”	
< Session 1 > Research and Development of Lubricants Part1	Chair Yasuhiro Murakami (Murakami’s Office of Tribology Technologies)	
13:00-13:30	Lecture 1: Development of Novel Film Forming Additive Contributing to Improving Efficiency of Electric Vehicles	Toshitaka Nakamura (ENEOS Corporation)
13:30-14:00	Lecture 2: Mechanism of Low Friction of Fullerene-Added Oil Under Boundary/Mixed Lubrication	Tomomi Honda (University of Fukui)
14:00-14:30	Lecture 3: Lubrication of Electric Powertrain: A Method to Predict Friction in the Mixed and Boundary Regimes	Ian Sherrington (University of Central Lancashire)
14:30-14:45	General Discussion	
14:45-15:15	<Break>	
< Session 2 > Research and Development of Lubricants Part2	Chair Tomoko Hirayama (Kyoto University)	
15:15-15:45	Lecture 4: Development of Transaxle Lubricating Oil for Electrified Vehicles	Daisuke Tokozakura (Toyota Motor Corporation)
15:45-16:15	Lecture 5: Improvement of Performances of Lubricants Applied to Transaxles in Electric Vehicles	Hiroyuki Tatsumi (Idemitsu Kosan Co.,Ltd.)
16:15-16:45	Lecture 6: Development of Ionic Liquids (ILs) as Lubricant Additives and Control of Lubricating Properties of ILs	Shouhei Kawada (Kansai University)
16:45-17:00	General Discussion	
< Closing >	Moderator Toru Desaki	
17:00-17:05	Closing Address	Tomohiro Kano (Taiho Kogyo Co., Ltd.)

5. Abstract

Honorary Lecture	Materials and Lubrication Challenges for a Sustainable Electric Vehicle Mobility: Recent Progress and Future Prospects	Ali Erdemir (Texas A&M University)

Electric vehicle mobility (or E-mobility) has lately been expanding rapidly and is now regarded as the new paradigm for a sustainable transportation future [1]. When realized fully, this form of mobility is expected to have a huge positive impact on our energy security, environmental cleanliness, and economic prosperity for generations to come. Accordingly, in recent years, global efforts to switch from internal combustion-engine-powered traditional vehicles (ICEVs) to electric-powered vehicles (EVs) have intensified across the world and the production volume has already reached over 10 million units in 2022 and potentially over 60 million by 2040. To meet such growing demands, many emerging EV and existing automotive companies have rapidly increased their EV production capacities. So far, EVs appear to function well from a reliability point of view thanks to the rapid transition of critical knowledge bases gained from conventional ICEVs to EVs; however, in the long run, the further enhancement of the performance, efficiency, and reliability of the battery packs, electric motors, and drivetrain components of EVs will be imperative for such vehicles to become more mainstream and sustainable. From the knowledge bases accumulated so far, it appears that the materials and lubrication issues in EV transmissions and gearboxes differ significantly from those of the traditional ICEVs, and hence not only the materials but also the fluids used for lubrication and thermal management will have to be further enhanced. In particular, there seems to be an urgent need for the development of a new breed of lubricants that can provide not only superior lubricity, higher resistance to wear, corrosion, and contact fatigue but also desirable thermal and electrical properties for a safe, smooth, and long-lasting operation. Due to the much harsher operating conditions (including, higher torques, speeds, and temperatures) of EVs, traditional lubricants are falling short of meeting the reliability and thermal management requirements of high-performance EVs. These lubricants are also required to have proper electrical properties and excellent compatibility with drivetrain materials across the rapidly changing operational and environmental conditions that may also include very low and high operating temperatures. Some of the specific challenges are identified as further optimization of fluid viscosity and the customization of existing additive packages for the much higher torque, load, speed, and temperature requirements of contact interfaces where uncontrollable current/voltage fluctuations and frequent electrical discharges may also occur. It looks that in this new paradigm of the E-Mobility era, thermal, electrical, and tribological issues are all very closely intertwined and hence the future materials and lubrication solutions for EV applications must keep in mind not only the tribological but also the thermal and electrical realities if possible in a combinatorial manner. Moving forward, a scenario like "one fluid does all and for the life of an EV" seems to be the collective goal of EV and lubricant companies alike. In this presentation, some of these challenges impacting friction, wear, and lubrication of moving mechanical components in EVs will be reviewed first. Emphasis will be placed on the impact of fluid type (including water-based, low viscosity multi-purpose base stocks, etc.) that can help increase efficiency, thermal and oxidative stability, material compatibility, and wear performance. New trends in functional additives, tribological materials, and coating/surface treatment technologies that can potentially provide much higher resistance to wear, fatigue, and oxidation (even under thermally and electrically challenging conditions) are discussed next. Finally, some of the emerging technologies that can further enhance the efficiency, durability, and environmental compatibility of future EVs will be presented.

[1] K. Holmberg and A. Erdemir, The impact of tribology on energy use and CO2 emission globally and in combustion engine and electric cars, Tribology International, 135 (2019) 389-396.

< Session 1 > Research and Development of Lubricants Part1

Lecture 1	Development of Novel Film Forming Additive Contributing to Improving Efficiency of Electric Vehicles	Toshitaka Nakamura (ENEOS Corporation)

Lubricants have impact on efficiency of e-Axles, drivetrain system of electric vehicles (EV). It is considered that lowering lubricant viscosity is effective to improve efficiency in mild operating conditions under hydrodynamic lubrication, while it tends to show rather negative effect in severe conditions under mixed lubrication due to intensive contact between sliding surfaces. Therefore, it is essential to prevent friction losses under severe conditions in order to achieve further improvement of efficiency. In this study, we developed a novel friction modifier (FM) suitable for EV fluids, which effectively reduces the friction of reduction gears, especially under severe condition. The effect of the additive was investigated using a Mini Traction Machine (MTM) and an e-Axle gearbox, and friction reduction under the mixed lubrication condition and improved efficiency at the gearbox were observed as estimated. In order to investigate the working mechanism of the FM, we measured oil film thickness . As the result, it indicates that the FM has effect to increase the oil film thickness significantly.

Lecture 2	Mechanism of Low Friction of Fullerene-Added Oil Under Boundary/Mixed Lubrication	Tomomi Honda (University of Fukui)

ZnDTP is used in lubricating oils as an antioxidant to inhibit oxidation. The use of ZnDTP has been avoided due to its high environmental impact, and new multifunctional additives are required. Thus, fullerenes are attracting attention as a new multifunctional additive. In the case that such fullerene-added oils are used in actual equipment, it is important to elucidate the mechanism by which fullerenes inhibit the autoxidation reaction of lubricating oil such as the amount of reaction per molecule, changes associated with the reaction, and evaluation of the reactants. In this study, we evaluated the friction and wear properties of the fullerene reactants after their antioxidant function to elucidate the antioxidant mechanism of fullerenes. As a result, it was clarified that the fullerene reactants contribute to low friction and wear. To confirm the existence state of fullerene in a solvent like the state in oil, we performed observations using FE-SEM. From the observation, it was found that a layered aggregate was formed. This study indicates that fullerenes have potential as multifunctional additives because, in addition to their antioxidant properties, the reactants of fullerenes after the antioxidant function also contribute to low friction and wear.

Lecture 3	Lubrication of Electric Powertrain: A Method to Predict Friction in the Mixed and Boundary Regimes	Ian Sherrington (University of Central Lancashire)

This presentation will outline the main characteristics required of fluids used for the lubrication and cooling of electric vehicle (EV) powertrain and list some of the conventional test methods currently available for evaluating the main characteristics of EV fluids. However, the main focus of the presentation will be placed on discussing the challenges related to lubrication modelling in the mixed and boundary regimes of a contact. A simple technique, developed at the Jost Institute for Tribotechnology under TTRF funding, which has been applied to modelling friction for base oils and lubricants such as friction modifiers or anti-wear additives will be described. The method involves normalizing measured friction coefficients and plotting these values against the well-established Lambda Ratio (lubricating film thickness divided by combined root means square surface roughness). In this instance it is found that friction coefficient data for different lubricants fall on a "Master Curve" which can be used to make reliable estimates of friction in the boundary and mixed regimes.

< Session 2 > Research and Development of Lubricants Part2

Lecture 4	Development of Transaxle Lubricating Oil for Electrified Vehicles	Daisuke Tokozakura (Toyota Motor Corporation)

The automotive industry is accelerating the development of electrified vehicles to help reduce CO2 emissions and prevent global warming. Improvement of fuel efficiency of electrified vehicles will be an important technical initiative. Reducing transaxle loss is an effective method of improving the efficiency of all electrified vehicles. One effective method of accomplishing this goal is to reduce the viscosity of transaxle lubricating oil. However, it is generally known that lowering viscosity can cause durability issues such as wear and seizure because the thickness of the lubricating oil film on metal sliding surfaces is insufficient. To counter the negative impact of lowering viscosity, a new additive formulation for lubricating oil specifically for electrified vehicles has been designed in anticipation of the wider adoption of such vehicles in the future. As a result, a new transaxle fluid has been completed that ensures unit durability while reducing viscosity by 50 % compared to conventional fluids. With this new lubricating oil, the fuel efficiency of HEVs can be increased by 1.0 % or more under test cycle driving conditions, and the cooling performance of the motor, which is an important element of electrified vehicle transaxles, can be improved.

Lecture 5	Improvement of Performances of Lubricants Applied to Transaxles in Electric Vehicles	Hiroyuki Tatsumi (Idemitsu Kosan Co., Ltd.)

In order to reduce carbon dioxide emissions, electric vehicles equipped with transaxles for electric vehicle (E AXELs) are expected to become more popular. Lubricants for E AXLE require a variety of performance. In particular, in terms of the protection of the unit and the increase in efficiency, the most important of these performances is the cooling of the motor and the protection of the gears and bearings. In this study, these characteristics were examined in detail.

For the cooling performance of the motor, we designed and evaluated the original testing machine. As a result, it was found that it is important to reduce the kinematic viscosity and increase the heat transfer coefficient in order to improve the cooling of the motor. In addition, after evaluation with a gear and bearing tester, it was found that the contact surface could be controlled by using appropriate phosphorus additives and improved the protection of gears and bearings. As a result of this study, we found that by properly selecting base oils and anti-wear agents, it is possible to design lubricants for E AXEL with excellent motor cooling and gear and bearing protection.

Lecture 6	Development of Ionic Liquids (ILs) as Lubricant Additives and Control of Lubricating Properties of ILs	Shouhei Kawada (Kansai University)

Ionic liquids are expected to be new lubricants due to their great physical properties. Lubricating performances of ionic liquids are known to exhibit low frication a low wear under certain conditions in lab-level experiments. However, ionic liquids have not been able to get out of the feasibility study stage because many lubrication systems have reached such high levels that only marginal performance gains can be achieved. Therefore, a novel use of ionic liquids is required. This presentation in symposium will talk the application of ionic liquids as lubricant additives and application to friction manipulation system. In friction manipulation systems, this research focuses on the electric double-layer structure of ionic liquids and is oriented toward stabilizing the friction coefficient in the boundary lubrication region.