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TTRF

6th TTRF-TAIHO International Symposium on Automotive Tribology 2023

1. Date : Thursday, Apr 13, 2023 10:30-17:15(JST)
2. Venue: Intl. Conf. Room, 3F, Bldg.3, Nagoya Congress Center, Nagoya, Aichi Prefecture
3. Theme: Future Prospects of Tribological Materials Surviving a Once-in-a-Century Period of Profound Transformation - Part 2 Surface Treatment
4. Program:

< Opening >	Moderator Toru Desaki	
10:30-10:40	Opening Address	Tetsushi Suzuki (Taiho Kogyo Co., Ltd.)
< Honorary Lecture >	Chair Kenneth G. Holmberg (TTRF Director)	
10:40-11:30	Honorary Lecture 1: Development of Future Powertrains for Commercial Vehicles	Naoya Ishikawa (Isuzu Advanced Engineering Center, Ltd.)
11:30-12:20	Honorary Lecture 2: New Development of Functional Surface Finishing Technologies for Next Generation Automobiles	Shochiku Kure (Nagoya Institute of Technology)
	「Declinature」 Honorary Lecture 3: Process Routes for Mass Produced Carbon Nanotube Based Metal Matrix Composites	Ivica Kolarić (Fraunhofer IPA, Stuttgart Germany)
12:20-13:30	<Lunch> Cafeteria “Cascade”	
< Session 1 > Low Friction	Chair Makoto Kano (KANO Consulting Office)	
13:30-14:00	Lecture 1: Friction Reducing Methods of DLC Films in Oil-less Conditions	Yuuki Tokuta (Tokyo Metropolitan Industrial Technology Research Institute)
14:00-14:30	Lecture 2: Development of DLC Reinforced Metal Matrix Coatings for Low Friction Sliding Components	Shahira Liza binti Kamis (Universiti Teknologi Malaysia)
14:30-15:00	Lecture 3: Material Design for Control of Tribo-film Structure Formed from Friction Modifiers	Ryo Koike (Toyota Motor East Japan, Inc.)
15:00-15:10	General Discussion	
15:10-15:30	<Break>	
< Session 2 > Improve Durability and Reliability	Chair Hiroyuki Kousaka (Gifu University)	
15:30-16:00	Lecture 4: Advanced Durability Surface Treatment Materials of Sliding Bearing for High Performance Diesel Engine	Hayato Kodama (Taiho Kogyo Co., Ltd.)
16:00-16:30	Lecture 5: Development of High-strength and Anticorrosive Aluminum Alloys and Improvement of Fatigue Property	Ai Serizawa (Shibaura Institute of Technology)
16:30-17:00	Lecture 6: Improvement of Fatigue Strength by Mechanical Surface Treatment Using Sustainable Peening Method	Hitoshi Soyama (Tohoku University)
17:00-17:10	General Discussion	
< Closing >	Moderator Toru Desaki	
17:10-17:15	Closing Address	Koichi Sugihara Organizing Committee Chair (Taiho Kogyo Co., Ltd.)

5. Reception: 18:00-19:30(JST) Cafeteria “Cascade” B1F, Nagoya Congress Center

6. Abstract

< Honorary Lecture >

Honorary Lecture 1	Development of Future Powertrains for Commercial Vehicles	Naoya Ishikawa (Isuzu Advanced Engineering Center, Ltd.)

Reducing CO_2 emissions to prevent global warming is one of the most important issues and the electrification of automobiles is being promoted worldwide to achieve carbon neutrality. However, considering that most of the current electric power is made from fossil fuels, then not only electrifying vehicles will not lead to CO_2 reduction. To decarbonize all vehicles, it is necessary to develop social infrastructure first, and it is expected to take a lot of time. Therefore, internal combustion engines must continue to reduce CO_2 emissions by using fuel derived from renewable energy and improving thermal efficiency until completing the electrification of vehicles.

Commercial vehicles are working vehicles that support people's lives and logistics and are indispensable for the lives of people around the world. Therefore, it is necessary to satisfy customer requirements such as operating cost, durability reliability and cruising range. Carbon neutrality of commercial vehicle must be promoted while considering LCA (Life Cycle Assessment) and TCO (Total Cost of Ownership).

In this presentation, introducing the challenges faced by commercial vehicles and Isuzu Motors' efforts to become carbon neutral and reporting future powertrain technology development, such as fuel efficiency improvement technology, exhaust emission reduction technology and initiatives for carbon neutral fuels.

Honorary Lecture 2	New Development of Functional Surface Finishing Technologies for Next Generation Automobiles	Shochiku Kure (Nagoya Institute of Technology)

Surface finishing technology of materials plays an essential role in ensuring the safety and performance in automotive industry. Recently, the automotive lightweighting strategy is becoming the major growth trend in order to save and improve energy consumption accompanied by the revolutionary transition from internal combustion engine (ICE) to hybrid electric (HEV) and all electric (AEV) vehicles. Accordingly, the target materials of surface treatment transfer gradually from conventional casting irons and steels to various light metals like aluminum, magnesium, and titanium alloys. Especially, to meet the car revolution from ICEVs to AEVs, new surface technologies are needed for newly emerging automotive parts such as electrical charging connector/plugs, relative materials for lithium-ion batteries, etc.

This lecture will first review the trends of conventional surface treatments for enhancing wear and corrosion resistance, and then introduce several novel approaches on functional surface finishing technologies of various non-ferrous materials, e.g., to fabricate Al_2O_3/MoS_2(-Sn, Ni) composite coatings on aluminum alloys with enhanced lubricity/wear resistance for engine/transmission parts, Ag(Sn)-Graphene composite coatings on copper alloys with high conductivity and wear resistance for electrical terminals/connectors, TiO_2-TiN(-Sn, MoO_x) composite films on titanium with large capacity and high safety for anode materials of lithium-ion batteries, towards promising applications for next-generation automobiles.

Honorary Lecture 3	Process Routes for Mass Produced Carbon Nanotube Based Metal Matrix Composites	Ivica Kolarić (Fraunhofer IPA, Stuttgart Germany)

Since their discovery, carbon nanotubes have been attributed with a number of positive properties. In particular, the combination of properties makes carbon nanotubes interesting as an additive. CNTs can improve not only the mechanical properties of the matrix, but also the electrical and tribological properties. This makes the use of CNTs particularly interesting for bearings and connectors.
However, when processing CNTs in metals, the problem of DI dispersion is much greater than in polymers, for example.
In this presentation, two new process routes will be presented that can enable the incorporation of CNTs in metals in an industrially suitable framework. One of these is surface functionalisation and the other is a patented fluidised bed process.

< Session 1 > Low Friction

Lecture 1	Friction Reducing Methods of DLC Films in Oil-less Conditions	Yuuki Tokuta (Tokyo Metropolitan Industrial Technology Research Institute)

In recent years, oil-less technologies have been attracted much attention in academic and industrial fields because of increasing awareness of environmental destruction. In this problem, diamond-like carbon (DLC) films are one of the key technologies to accomplish the development of oil-less sliding parts. A DLC films have amorphous structure which is composed of sp^2 and sp^3 hybridized orbital carbon (and hydrogen), and this unique structure bring high mechanical hardness, high wear resistance and low friction. On the other hand, friction reduction mechanism for DLC films have been explained in two types of friction phenomena. One of mechanism is graphitization of DLC wear particle generated by friction which induce lower sharing resistance at the sliding interface. The other mechanism is hydrogen termination of DLC films structure which induce low surface energy, and it reduce friction resistance between DLC films surface and opposite material surface. In our previous studies, we focused on improvement technique to reduce friction of DLC films based on these two mechanisms. In this presentation, we introduce friction reducing methods of DLC films in oil-less conditions, such as pre-heat treatment, surface profile optimization, and chlorine-doping.

Lecture 2	Development of DLC Reinforced Metal Matrix Coatings for Low Friction Sliding Components	Shahira Liza binti Kamis (Universiti Teknologi Malaysia)

In recent years, advanced coating materials and structures with good self-lubrication properties for bearing system have aroused great interest. The implementation of the self-lubricated coating in bearing systems is expected to aid in significant reduction of environmental pollution caused by the extensive use of oil lubricants as well as beneficial for inaccessible bearings on all types of equipment which work in remote places. Diamond-like carbon (DLC) are considered one of the best solid lubricants and have a high wear resistance capability. In this project, the continuous supply of solid lubricant to the contact surface during sliding are achieved by disperse Diamond-like carbon (DLC) flakes into the matrix of one of the sliding components. We developed self-lubricating DLC/Cu and DLC/Ni coatings to decrease wear rate and friction of sliding component in the absence of an external lubricant. The effectiveness of formulated solid lubricant additive in the metal coating can supports the strong request by industry today for machines that use less energy for the same output and have components that last longer in service.

Lecture 3	Material Design for Control of Tribo-film Structure Formed from Friction Modifiers	Ryo Koike (Toyota Motor East Japan, Inc.)

As the viscosity of engine oil becomes lower, it concerns increasing friction at boundary lubrication for mechanical parts of automobiles. So, it is required for friction modifier in lubricants to contribute to low friction under widely sliding conditions. It is known that MoDTC, the most widely used as friction modifier, is not effective under low temperature conditions. Furthermore, it is found that some combination of materials affects friction properties. Although various materials including hard coatings are used in automobiles, so we need to consider how dose the material combination match for these additives.

In this study, we tried to clarify the tribo-film structure on hard coatings, and appeared that the crystal structure of hard coatings affects to the tribo-film structure including molybdenum sulfide. And it is the key for forming tribo-film to transfer the metal from the counterpart materials. In particular, if the crystal lattice size of hard coatings is just half that of Fe oxide transferred from counterpart, the tribo-film is stable. These results indicate the possibility what we can control the friction properties by the materials combination. I'll talk about the process forming tribo-film in running-in with friction modifier, and one of the examples of material development with this knowledge. Moreover, I will introduce the process and future development of these research through industry-academia co-creation.

< Session 2 > Improve Durability and Reliability

Lecture 4	Advanced Durability Surface Treatment Materials of Sliding Bearing for High Performance Diesel Engine	Hayato Kodama (Taiho Kogyo Co., Ltd.)

In recent years, environmental requirement against exhaust gas becomes severe. In order to satisfy latest regulation, increase internal pressure of diesel engine cylinder is expected. Accordingly new surface treatment materials durable at like that high pressure and corresponded to Lead-free environmental requirement, becomes require. New metal plating and resin coating were developed to satisfy those new requirements.

Bismuth plating is typical traditional type metal plating have been using. Which have good tribological performance but fatigue wear performance wasn't enough since it was soft metal and mechanical strength wasn't enough for high stress bearing used for high environmental performance diesel engine. Newly developed metal plating composed Bismuth to alloy by Antimony expected to increase strength and as the result fatigue performance was improved. On the other hand, wear performance of typical resin coating wasn't enough for above application to avoid excess wear which gave metal lining appeared. Newly developed resin coating have improved wear performance achieved by optimizing composition. It includes high strength base resin available to increase resin ratio and newly selected hard type additive. As the result, newly developed resin coating succeeded to satisfy wear performance. This time we introduce those newly developed materials.

Lecture 5	Development of High-strength and Anticorrosive Aluminum Alloys and Improvement of Fatigue Property	Ai Serizawa (Shibaura Institute of Technology)

Al alloys, the most commonly used lightweight structural metals, are expected to be applied to a broader range of components, such as transportation equipment. This paper describes a novel control method of corrosion protection for Al alloys using steam, i.e., the steam coating process. In the process, hydroxide crystals are densely formed on the Al alloy surface, exhibiting an increase in corrosion resistance because hydroxide crystals behave as an anticorrosive film. At the same time, precipitation hardening can be achieved by utilizing the thermal energy of the steam, resulting in increasing the strength of the alloy. Examples of the multi-functionalization of Al alloys by the steam coating process were considered. The potentiodynamic polarization curves revealed that the corrosion current density of the film-coated substrates significantly decreased, and that the pitting corrosion was completely suppressed. The appearance of surface of the film-coated specimen exhibited no damage at all, even after saltwater immersion. Also, the fatigue test was conducted to understand the role of hydroxide film in fatigue life. The main findings of the research were that the hydroxide film exhibited excellent adhesion and suppressed the occurrence of fatigue cracks during the plane bending fatigue test. The fatigue life was increased when the hydroxide film was prepared by the steam coating process with appropriate conditions.

Lecture 6	Improvement of Fatigue Strength by Mechanical Surface Treatment Using Sustainable Peening Method	Hitoshi Soyama (Tohoku University)

In order to improve fuel efficiency and electric power, low friction, durability and reliability, as well as environmental considerations are required. One of effective methods for these purposes is mechanical surface treatment to improve fatigue strength. In the presentation, sustainable mechanical surface treatment using cavitation impact, i.e., “cavitation peening” is introduced in view point of fundamental and the practical applications. Shot peening is one of the effective mechanical surface treatment to improve fatigue strength and reliability. The impact of shot produces work hardening and introduces compressive residual stress. However, the use of shot produces dust that is not only harmful to workers but also presents the danger of dust explosion. In addition, the broken shot eventually becomes industrial waste. Another disadvantage of shot peening is that the impact of shot causes an increase in surface roughness, which reduces the fatigue strength. At cavitation peening, shots are not required. The great advantage of cavitation peening is that the treated surface is very smooth compared with that after shot peening. The improvements of fatigue properties of gears and rollers by cavitation peening were demonstrated.