CONFERENCES

POLYTRIB 2018, 24TH–25TH SEPTEMBER, PORTOROSE

The TINT Laboratory and the Slovenian society for Tribology organised the 3rd consecutive international conference PolyTrib 2018. The main topic was polymer tribology, with emphasis on relevant industrial topics such as polymer gears and innovative novel fields such as polymer bio-tribology. The conference attracted about 70 participants from 11 different countries, namely from 5 different research institutes, from 13 different universities and from 20 different companies from EU, USA and Japan. The conference consisted of 27 presentations, including 4 invited lectures, given by Prof. Dr. Valentin Popov (Technical University of Berlin, Germany), Dr. Aljaž Pogačnik (KissSoft, Switzerland), Prof. dr. Roland Larsson (Luleå University of Technology, Sweden) and Prof. dr. Yoshinori Sawae (Kyushu University, Japan). As a part of the conference the International workshop on Polymer Tribology supported by STINT, Sweden-Japan 150 Anniversary Grants, was also organized. The conference was more than positively received and had great attendance, which sets high hopes for the next edition of **PolyTrib 2020**.

LubMAT 2018

Sixth Congress in Lubrication, Tribology and Condition Monitoring LUBMAT 2018 took place in June in San Sebastian, Spain. More than 100 presentations brought together the leading experts in the field of tribology. Prof. Kalin attended the event with the lecture entitled “Influence of the additives and their chemistry on the oil wetting behaviour on steel at room and elevated temperature”.

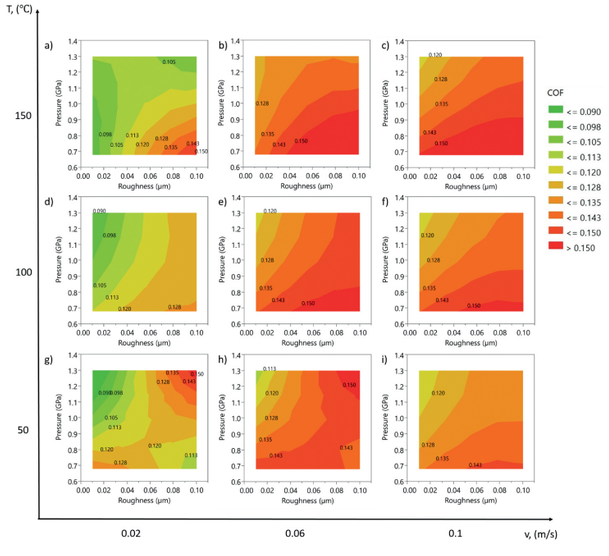
University *of Ljubljana*
Faculty *of Mechanical Engineering*

Tribology and interface nanotechnology

PhD DISSERTATIONS

DR. KOSTA SIMONOVIĆ: MODEL FOR THE FRICTION PREDICTION OF THE DIAMOND LIKE CARBON COATINGS (DLC) IN THE BOUNDARY LUBRICATION CONDITIONS

This Ph.D. thesis studies individual and synergistic contributions of the Anti-Wear (Zinc dialkyldithiophosphate, ZDDP), Friction-Modifier (Glycerol isostearate, GIS) and Automotive additive package to the friction of the steel and DLC contacts across a broad range of boundary-lubrication contact conditions. A design-of-experiments was used to enable broad-range experimental matrix and Elastic-net regression technique was used to develop friction models and friction maps depending on the most relevant contact parameters, namely pressure, roughness, speed, and temperature. Moreover, obtained models are based on the experimental parameters and their interactions whose statistical significance has been undoubtedly proven. The major conclusion is that statistically identified interactions of the experimental parameters show which of the parameters interfere and compete in their influence on the coefficient of friction, hence, which of the investigated parameters must be simultaneously considered if proper conclusions are to be made. What is more, it is shown that single parameter investigations of the boundary lubrication regime do not reveal true properties of the contact/lubricant combination in the whole range of the boundary lubrication regime.



KONTAKT

Laboratory for Tribology
and Interface Nanotechnology

University of Ljubljana
Faculty of Mechanical Engineering

Bogišićeva 8
1000 Ljubljana, Slovenia

tel.: +386 1 4771 460
fax: +386 1 4771 469

info@tint.fs.uni-lj.si
www.tint.fs.uni-lj.si

Tint

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Laboratory for Tribology and Interface Nanotechnology

NEW METHOD DEVELOPED FOR DETERMINING WEAR CHARACTERISTICS OF SUSPENSIONS AND FLUIDS CONTAINING SOLID PARTICLES

Wear characteristics of fluids containing solid particles is strongly dependent on operating conditions and the properties of wear particles. In industrial use, where particles are being mixed together in containers, there are mainly two wear mechanisms present, abrasion and erosion. In TINT, we have developed a new method for determining wear characteristics of various suspensions. Based on the obtained results and past experiences we can successfully simulate the influence of different working conditions, as well as properties of particles and surfaces on wear in real applications. The method is particularly useful for monitoring the wear of containers, mixers and other parts used in the process industry, where various suspensions with aggressive solid particles are used.

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TRIBOS+ : JOINT EUROPEAN MASTER IN TRIBOLOGY AND CONTACTS RECEIVED 4-YEAR FUNDING OF 3.5 M €

Within the framework of the prestigious Erasmus Mundus Joint Master Degree programme, the Faculty of Mechanical Engineering received a four-year funding of EUR 3.5 million for the implementation of the Joint European Master's Degree in Tribology of surfaces and interfaces – TRIBOS+, which represents an upgrade of the existing 5-year TRIBOS programme.

The TRIBOS programme is jointly implemented by four well recognized European universities (University of Ljubljana, University of Leeds, University of Coimbra, University of Luleå), and is coordinated by Prof. dr. Mitjan Kalin from the Faculty of Mechanical Engineering UL. Upon completion of the 2-year programme of the 2nd degree, the TRIBOS Consortium of the partner universities awards the students a true Joint Master Degree Certificate, which is also a great rarity among all European Joint programmes.

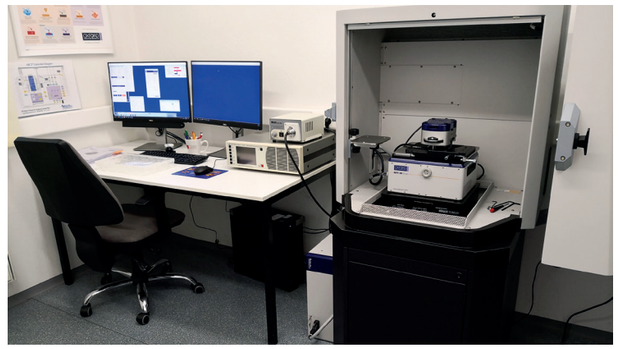
The main objective of the TRIBOS+ study is to offer an advanced education programme in the field of tribology, surfaces and lubrication and related applications in engineering. The curriculum is designed to give graduates all the necessary skills and competences for an adequate understanding of the field of tribology, lubricants and surfaces, and also educates them in the direction of practical application of the acquired knowledge in solving real engineering problems both independently and in a research group.

More than 60 students from 28 different countries have enrolled in previous TRIBOS programme. The demand for their competences is high in both industry and academic European institutions, as the employability of TRIBOS students is 100 percent.

NEW EQUIPMENT

ATOMIC FORCE MICROSCOPE FOR QUANTITATIVE ANALYSIS OF MECHANICAL AND TRIBOLOGICAL PROPERTIES OF SURFACES AND BOUNDARY FILMS

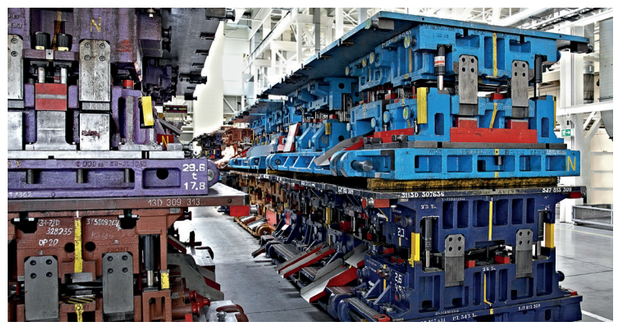
We have recently purchased a new atomic force microscope (AFM) MFP 3D Origin, Asylum Research, Oxford Instruments. One of the main advantages of the new AFM is quantitative evaluation of the mechanical and tribological properties of surfaces and boundary films, such as for instance elasticity, damping, stiffness, friction, energy dissipation, etc. These properties of the boundary films are essential for newer tribological studies and allow for the new development of green lubrication technologies that use new additives and form films that are usually weaker, therefore quantitative comparison between them is crucial.



CURRENT RESEARCHES

NANO-ENGINEERED GREEN LUBRICATION TECHNOLOGY FOR SUSTAINABLE HIGH-PERFORMANCE STAMPING

In collaboration with Hidria we have received the applicative project, which is about designing novel, green, high-performance, boundary-film contacts for stamping. These contacts satisfy technological and increasingly stringent legislative requirements after reducing the environmental impact. This is a critical requirement for stamping and other heavy-loaded lubricated mechanical components because existing European and national regulations has already placed severe restrictions on the use of many of the most effective lubricant additives and so are affecting the performance of some modern machinery.



RESEARCHES IN LABORATORY FOR FLUID POWER AND CONTROLS

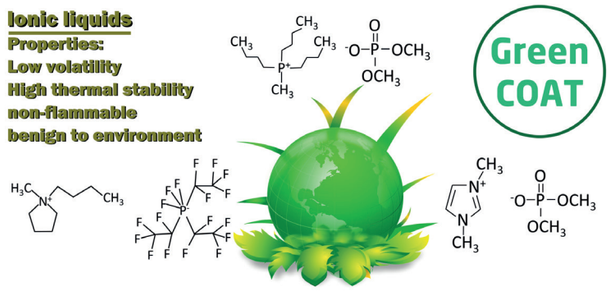
In Laboratory for fluid power and controls they have studied the tribological properties of (water-lubricated) contacts with stainless steel AISI 440 and DLC-coating for an orbital hydraulic motor application. A purpose of this investigation was to identify the most appropriate material pair and the parameters which ensure the best tribological conditions. Model tribological tests "Ball on disc" tests and measurements were performed with the advanced equipment for friction and wear determination. The lowest coefficient of friction was observed in the contact stainless steel/DLC in water and it was lower than the coefficient of friction in the contact stainless steel/stainless steel in oil. Furthermore, wear in the contact stainless steel/DLC was very low and it was immeasurable. On the other hand, the wear volume loss in the contact stainless steel/stainless steel in oil and in the contact stainless steel/DLC in water was hardly measurable. A combination of DLC and stainless steel was recognised as a very promising solution for better tribological behaviour in water hydraulic and represents a potential material pair which may be used in the water orbital hydraulic motor. The results of the research work were published in the SCI journal Tribology International.

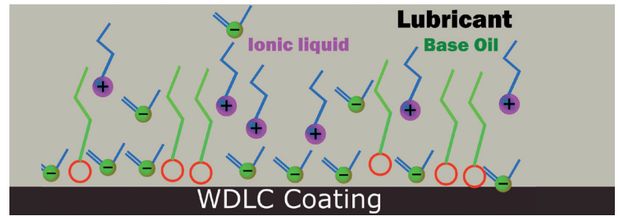
BILATERAL PROJECT WITH QINGDAO UNIVERSITY OF TECHNOLOGY, CHINA

This year we started bilateral project with Qingdao University of Technology from People's Republic of China that will establishing collaboration between two research groups dealing with the same topic – i.e. effect of solid-liquid interactions and phenomena on lubrication, but each group in their specific field. The main goal of the proposed project is to develop a useful model that will enhance tailoring film thickness and friction in oil lubricated macro-engineering contacts by solid-liquid interactions. In this way we will achieve the optimal lubricating film thickness that will be thick enough to prevent wear, but will at the same time provide low friction. Namely, we have already shown that only tailored interactions on surface-lubricant interface can reduce friction up to almost 50 %.

IONIC LIQUIDS AS POTENTIAL ADDITIVES FOR ULTRA LOW FRICTION ON W-DOPED DLC SURFACE UNDER BOUNDARY LUBRICATION CONDITIONS

GreenCOAT project, which is funded under the European M-ERA.NET programme is designed to develop green lubrication mixtures based on ionic liquids additives to operate with tungsten doped diamond-like-carbon (WDLC) coatings, which comply with demanding new environmental restrictions. Recently, at TINT we have been able to obtain ultralow friction with green ionic liquid additives on WDLC coatings against steel counter body under severe boundary lubrication conditions. We investigated different ionic liquids by variation in cations and anions of ionic liquids as additives in various lubricant mixtures to determine the effects of contact pressure and temperature on coefficient of friction and wear. At particular contact conditions, ultralow coefficient of friction of about 0.02 was obtained. The results were much better for WDLC in terms of wear resistance and lower friction than the steel surface, indicating that combination of ionic liquids on WDLC coatings constitute very prosperous solutions for providing anti-wear and low friction properties for many applications seeking for greener additives, which was in fact the starting aim for this project. The study is ongoing and new better and optimised results are expected in the future.





PROMINENT PUBLICATIONS

D. Poljanec, M. Kalin, L. Kumar
Influence of contact parameters on the tribological behaviour of various graphite/graphite sliding electrical contacts
Wear 406-407 (2018) 75-83

H. Kitano, K. Dohda, M. Kalin, K. F. Ehmann
Galling growth analysis in metal forming
Manufacturing Letters 18 (2018) 32-35

E. Strmčnik, F. Majdič, M. Kalin
Water-lubricated behaviour of AISI 440C stainless steel and a DLC coating for an orbital hydraulic motor application
Tribology International 131 (2019) 128-136