TINT IS ORGANISING

POLYTRIB 2016

The Slovenian Society for Tribology and Laboratory for Tribology and Interface Nanotechnology organized the 2nd edition of PolyTrib 2016: International conference on Polymer Tribology, which was held on 15th and 16th September 2016 in Ljubljana. The conference attracted over 70 participants from 18 different countries. Academic and industrial institutions were almost equally represented, as PolyTrib 2016 was attended by 18 research institutions and 23 companies. The main topic was polymer tribology, with an added emphasis on polymer gears, which are a growing industrial trend. The conference consisted of 31 presentations and 7 posters, including 5 invited lectures, given by prof. dr. Klaus Friedrich (Technical University of Kaiserslautern, Germany), dr. Aljaž Pogačnik (KissSoft, Switzerland), prof. Nazanin Emami (Luleå University of Technology, Sweden), dr. Janez Navodnik (Navodnik d.o.o, Slovenia), and dr. Jennifer Renee Vail (DuPont, USA). The conference was more than positively accepted and had a great attendance, which sets high hopes for the next edition of **PolyTrib 2018.** For more information please visit: **www.tint-polytrib.com**

SLOTRIB 2016

On 17th of November 2016 the Slovenian Society for Tribology organized the 12th edition of Slotrib: Conference on Tribology, Cooling fluids and Technical diagnostics at Radisson Blu Plaza hotel (Ljubljana). Slotrib is held every 2 years and its main goal is bringing together researchers from industrial and academic institutions, dealing with friction, lubrication, wear and maintenance.
Opening speech was followed by 16 presentations in 4 sections, including 4 invited lectures, given by Dr. Marta Svoljšak Jerman (Petrol d.d.) , Prof. dr. Maja Remškar (Jožef Stefan Institute), Mr. Gregor Sablič (SKF Slovenia) and Prof. dr. Tomaž Katrašnik (Faculty of Mechanical Engineering). 23 institutions attended, including 18 companies. Olma d.o.o and Petrol d.d. once again financially contributed, and Hennlich, Ventil, IRT300 and Scan displayed their wares. **Next Slotrib** conference will be held in the year **2018**. For more information please visit: **www.tint.fs.uni-lj.si**.

ECOTRIB 2017

The 6th European Conference on Tribology, Ecotrib 2017, was held in Cankarjev dom in Ljubljana on 7th and 9th June 2017. The conference is organized on a biennial basis by the tribology societies of four countries: Austria, Italy, Slovenia and Switzerland and is devoted to a continuous update of the cutting edge of tribology research in Europe and world-wide, reviewing the most advanced developments and research beyond the state of the art in traditional and more modern areas that continue to expand rapidly, such as nano-, bio- and green-tribology as well as interface phenomena.
The conference was attended by more than 180 participants from 31 countries and from 77 different research institutes and 18 different companies. 153 contributions, of which 8 plenary lectures, 16 invited lectures, 104 technical presentations and 31 posters were presented by distinguished scientists from all over the world. Among them there were also three recipients of the prestigious award "Tribology Gold Medal Award", which is awarded by the English prince Philip.
The Ecotrib 2017 conference was financially supported by many renowned international and Slovenian companies, such as Rtec Instruments, Bruker, Ducom, Anton Paar, Nanovea, IRT, Ventil, Scan and others.
In the scope of the Ecotrib 2017 conference, a selection of three best PhD contributions/papers took place. The Ecotrib 2017 conference was supported by the three renowned tribological journals, namely Tribology International, Wear and Lubrication Science. The selected contributions from the conference will be published in special issues of these journals. **Next Ecotrib** conference will be held in **Austria, in 2019**.

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Tribology and interface nanotechnology

Tint

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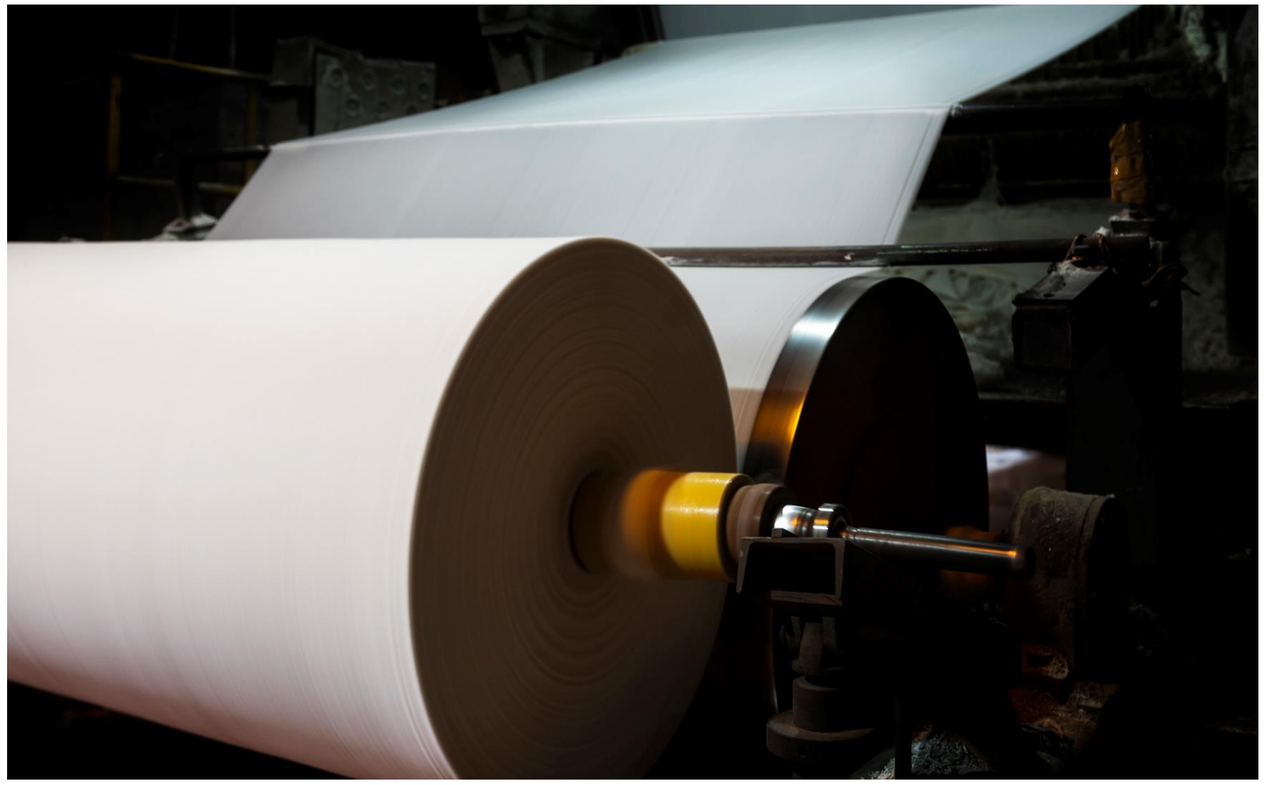


FRICTION ON PAPER

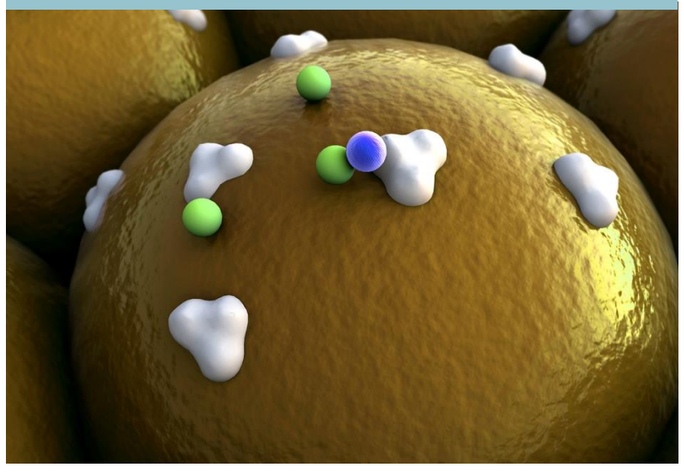
The frictional properties of cellulose products, such as paper and cardboard, are important in a variety of applications. For example, when the coefficient of friction between the paper sheets is too high, this can prevent the paper sheets in the printing and copy machines to be stacked properly, causing paper curling, jamming, and damaging paper sheet edges. On the other hand, a too low coefficient of friction can, due to a slippery surface, contribute to difficulties in precise positioning of the paper sheets, which is critical, for example, in the paper cutting process. In addition to the self-mated contact, the appropriate frictional properties of paper in contact with metal or rubber surfaces are also important for a smooth and repeatable processes, such as paper production, printing processes, and other processes involving metal or rubbing rollers. In this context, the very surface of the paper or cardboard plays a key role, namely its composition, which is influenced by additives and/or contaminants, as well as the product surface treatment, which determines surface topography. Additionally, an important role plays also wettability, not only for friction properties, but also for other important processes, such as printing.
With a waste knowledge in characterization of surfaces (topography, porosity) and interfaces (surface energy, wetting) as well as rich experience in the field of experimental friction determination, TINT Laboratory together with our partner, Pulp and paper Institute (ICP) can offer a comprehensive treatment and determination of friction properties of paper and cardboard for various applications and thus contribute to the product or production process optimization and development.

www.tint.fs.uni-lj.si

NEW EQUIPMENT

QUARTZ CRYSTAL MICROBALANCE DEVELOPMENT

In TINT laboratory, we are currently developing and testing Quartz Crystal Microbalance (QCM), a measuring device used for sensing small mass changes. QCM operation works on a principle of piezoelectric effect and is based upon measuring the change in resonant frequency of a quartz crystal as a consequence of mass change on the surface of the crystal; in the idealized conditions it can reach mass sensitivity of less than 1 ng. The QCM system is being developed as an alternative to the existing measuring systems used for adsorption analysis. In particular, we are interested in analyzing adsorption on the surfaces that are hard to analyze with the existing spectroscopic methods, such as diamond-like carbon coatings. The main elements in coatings are carbon and hydrogen, as well as in the majority of the additives and in the base oils – consequently, any useful information obtained by (currently used) spectroscopic methods, may be obscured by the signals of those two elements. Besides, QCM also allows measuring the viscosity of base oils or measuring higher masses, such as coatings. Therefore, we could also implement our device as an in-situ sensor for monitoring the quality of lubricating oils or as a very accurate measuring device for detecting wear.
The main idea behind the project was to develop a low-cost and application-focused quartz crystal microbalance. The electronic circuit in use has been developed especially for operation in viscous media – high gain in the feedback loop allows continuous oscillation of the crystal even under full immersion of the quartz crystal in oil, which presents the main advantage of our system to the similar quartz crystal microbalances in the market.



CURRENT RESEARCHES

GREEN LUBRICATION FOR HEAVY-DUTY FLUID-POWER HYDRAULIC SYSTEMS

The M-Era Net: GreenCOAT project will design a new type of green, DLC-coated interface based on an innovative DLC-deposition technology that can be tailored to operate with ionic liquids, a harmless form of lubrication that will comply with tough new restrictions relating to greenhouse-gas emissions. This compliance will soon be demanded for all heavily loaded, lubricated mechanical components in transportation and industrial systems. In fact, current UN, EU and national emission legislation already restricts the use of some of today's key lubricants, for which there are no acceptable alternatives available.
This means that if a new green interface lubrication is not developed in very near future this could lead to massive technical, economic and social consequences.
The GreenCOAT project is about developing innovative DLC coatings tailored for chemical activity with ionic liquids, combining a unique, in-situ,

Ionic-liquid-DLC adsorption and a simultaneous tribological study, to establish the boundary films' adsorption kinetics, reveal their electrochemical and tribocorrosion behavior, then perform a detailed (sub)nano-scale surface characterization and a full-scale, green-interface validation for heavy-duty fluid-power hydraulics systems.

FRICTION REDUCTION VIA TAILORING SURFACE LIQUID INTERACTIONS

Over the past two years our laboratory in collaboration with company TOTAL started with novel researches in the field of effects of interactions between un-conventional surfaces and lubricants on friction. The emphasis is on the innovative surface and lubricant preparation that will enable significant friction reduction of lubricated mechanical systems with usage of different base oils and additives. The project originates from our past researches. Namely, during past several years we showed that friction in lubricated contacts can be reduced over 45 % by tailoring surface – liquid interactions. These relevant findings result in research cooperation with TOTAL that support our further researches in this field and also provided their experiences about lubricants.

NON-MARKING TUBULAR HOISTING

TINT Laboratory together with Laboratory for machine elements LASEM, University of Ljubljana, is currently involved in the project with Texas Institute of Science (TXIS), which main objective is to evaluate feasible technical solutions for the handling equipment's pad development that would enable a non marking tubular hoisting in the oil pumping process.
The main task of the TINT laboratory is to propose applicable and suitable polymer-based materials that will ensure a high static friction against steel pipe, which includes review of materials mechanical and tribological properties, considering the contact conditions under dry and lubricated contact conditions, experimental static friction verification and proposing the most appropriate materials for the application.

CONFERENCES

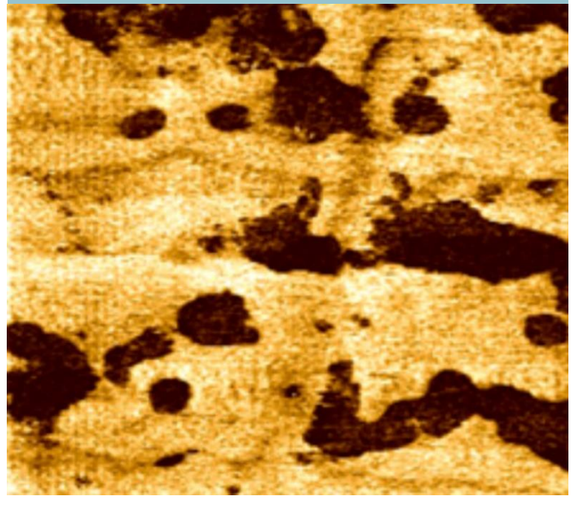
WEAR OF MATERIALS – WOM 2017

The 21st International Conference on Wear of Materials took place in California, USA, from 26th to 30th of May. The conference focused on both the fundamental and applied aspects of wear and friction of materials at the macro–, micro–, and nano–scale. Sections of the conference concentrated on the topics of wear of tools and tooling materials, hot and cold erosion (droplet, solid and cavity-based erosion), wear of brakes and frictional materials, marine wear systems, role of third bodies during wear and surface texturing for wear reduction.
Members of TINT attended the conference with a paper entitled: *The dominant effect of temperature on the fatigue behavior of polymer gears*, A. Kupec and M. Kalin. The article was well accepted and the conference provided an opportunity for researchers and engineers from different fields of expertise to interact and exchange opinions and latest's understandings.

PhD DISSERTATIONS

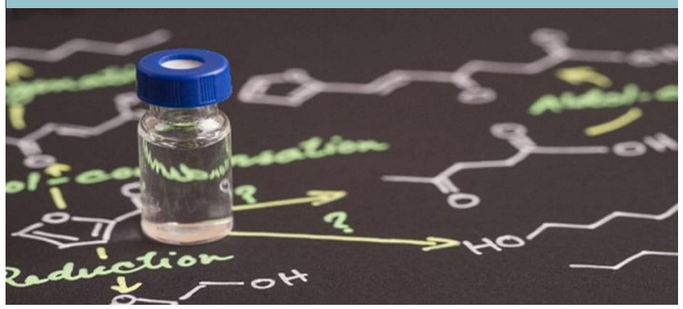
DR. EVA OBLAK: NANO-TRIBOLOGICAL PROPERTIES OF SURFACE BOUNDARY FILMS

The properties of tribolochemical films play an important or even key role with respect to friction in boundary lubrication. While their chemical behavior has been already widely studied, their mechanical properties are much less well understood. Steel/steel, steel/a-C:H and steel/Si-DLC contacts lubricated using three oils containing different amount of SAPS additives (E6 and E7 grade), mineral base oil containing the ZDDP additive and mineral base oil only, were investigated. The evolution of the nanomechanical and nanotribological properties of tribofilms formed in selected contacts were examined for two very different time periods. An atomic force microscope (AFM) was used in different modes to measure the topography, nanoroughness, nanofriction, nanostiffness, film thickness and adhesion, while the nanohardness was measured with a nanoindenter. The results have confirmed tribofilm formation on all selected surfaces and showed that the tribofilm's evolution and growth are very much surface and additive dependent. Moreover, the correlations between nanomechanical and nanotribological tribofilm properties have been evaluated.



DR. VLADIMIR PEJAKOVIĆ: EFFECT OF IONIC LIQUIDS ON THE BOUNDARY LUBRICATION OF STEEL SURFACES

In this doctoral thesis we have investigated tribological properties of different variations of cations and anion alkyl substituents in sulphate ionic liquids as additives in base oils for lubricated steel contacts under boundary lubrication conditions. This sulphate group of ionic liquids has not yet been investigated in the literature, which implies a scientific novelty of the study. Results have revealed strong influence of the cation composition as well as the anion alkyl chain length on tribological behavior of lubricant mixtures and for some specific contact conditions, optimum ionic liquid additive concentration was found. The surface protective films, which are generated during the sliding contact are mainly based on sulphides, which promotes friction reduction.



DR. SOMAYEH AKBARI: TRIBOCHEMICAL MECHANISMS IN THE BOUNDARY AND MIXED LUBRICATION REGIMES

In this doctoral thesis the focus is on a fundamental understanding of the interactions between the coating and the ZDDP additive. Based on the obtained results, we proposed mechanisms for the thermal film reaction of the ZDDP additive on DLC coatings. We determined the chemical interactions of ZDDP with the surfaces in static condition. After studying the thermal film formation of ZDDP on all the surfaces, we evaluated the tribological film formation of ZDDP on them at different temperatures and concentrations, the same as the static tests. We determined the influences of these parameters on the tribological behaviors of the all contacts towards ZDDP in the boundary-lubrication regime. The reactivity of all the surfaces with ZDDP in both the static thermal and tribotests were attempted mostly by chemical characterization using Attenuated Total Reflection-Fourier Transform Infrared (ATR-FTIR), which is not often used in the literature, and X-Ray Photoelectron spectroscopies.

PROMINENT PUBLICATIONS

M. Valant, U. Luin, M. Fanetti, A. Mavrič, K. Vyshniakova, Z. Siketić, M. Kalin

Fully transparent nanocomposite coating with an amorphous alumina matrix and exceptional wear and scratch resistance

Advanced functional materials, Vol. 26, no. 24 (2016) 4362–4369

V. Golja, G. Dražič, M. Lorenzetti, J. Vidmar, J. Ščančar, M. Zalaznik, M. Kalin, S. Novak

Characterization of food contact non-stick coatings containing TiO_2 nanoparticles and study of their possible release into food

Food additives & contaminants. Part A., Chemistry, analysis, control, exposure & risk assessment, Vol. 34, no. 3 (2016) 421–433

K. Simonović, M. Kalin

Experimentally derived friction model to evaluate the anti-wear and friction-modifier additives in steel and DLC contacts

Tribology International, Vol. 111 (2017) 116–37