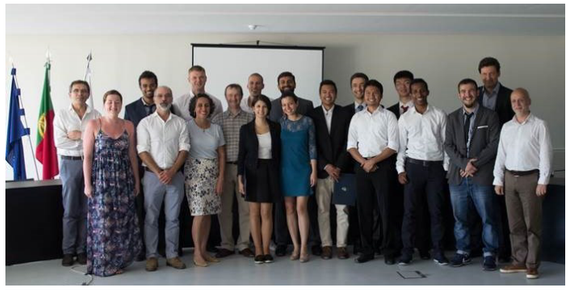
NEWS



FIRST EDITION OF TRIBOS STUDENTS GRADUATED

Students of the first edition of the international Master program TRIBOS graduated in July. The group consisted of 15 students from 11 different countries: China, India, Indonesia, Pakistan, Iran, Ethiopia, Turkey, Russia, Kosovo, Croatia and Slovenia. In the 2nd year of their studies the students were divided into two groups, so that eight students defended their master theses in Luleå (Sweden) and seven in Coimbra (Portugal). The joint closing ceremony was held in Coimbra on the 23th July 2015, which was attended by students, professors from all 4 partner Universities involved in the TRIBOS programme, vice-chancellor of the University of Coimbra and a representative of the EACEA agency, which funded the study. Each student prepared a short presentation to explain the purpose and the main findings of his master thesis. The general conclusion was that the students made a very good work by presenting comprehensive, high quality Master theses from various fields. A joint lunch was followed by a graduation ceremony and the graduates also revealed their plans for the future. Most of them will continue their professional careers in their home countries, however, thanks to the experiences they have gained during TRIBOS programme, some of them will continue their studies and face the research challenges in different European countries.

CONFERENCES

LUBRICATED CONTACT 2015

Conference Lubricated Contact, which was already the 5th in a series of conferences about boundary lubrication, was held this year from the 13th to the 17th April 2015 at Cádiz, Spain. It covered nano and macro aspects of boundary film formation and its influence on friction response. The program included advances in additives, additive chemistry, surface modifications, biotribology and surface analyses. Dr. Rok Simič gave a talk about »Detection of Adsorption layers on DLC coatings«, in which he presented the latest achievements on neutron reflectometry analyses of adsorption layers formed from common additives on DLC coatings. He showed the correlation with tribological performance, where polar molecules, which formed adsorbed layers on DLC surfaces, also successfully decreased friction of DLC contacts. This is an upgrade to the findings published in Applied Surface Science 288 (2014) 405–410 and Tribology Letters 53 (2014) 199–206.

WEAR OF MATERIALS 2015

The 20th international conference on Wear of Materials was held in Toronto, Canada from the 12th to the 16th April 2015. Organised every two years, the Wear of Materials Conference provides a unique international forum for researchers and practicing engineers from different disciplines to interact and exchange their latest results in the field of wear and friction of materials at the macro-, micro-, and nano-scale. Prof. dr. Mitjan Kalin participated in the conference with two papers: »The effect of temperature and sliding distance on coated (CrN, TiAlN) and uncoated nitrided hot-work tool steels against an aluminium alloy« and »Wear and friction behaviour of poly-ether-ether-ketone (PEEK) filled with graphene, WS_2 and CNT nanoparticles«.

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Tribology and interface nanotechnology

Tint

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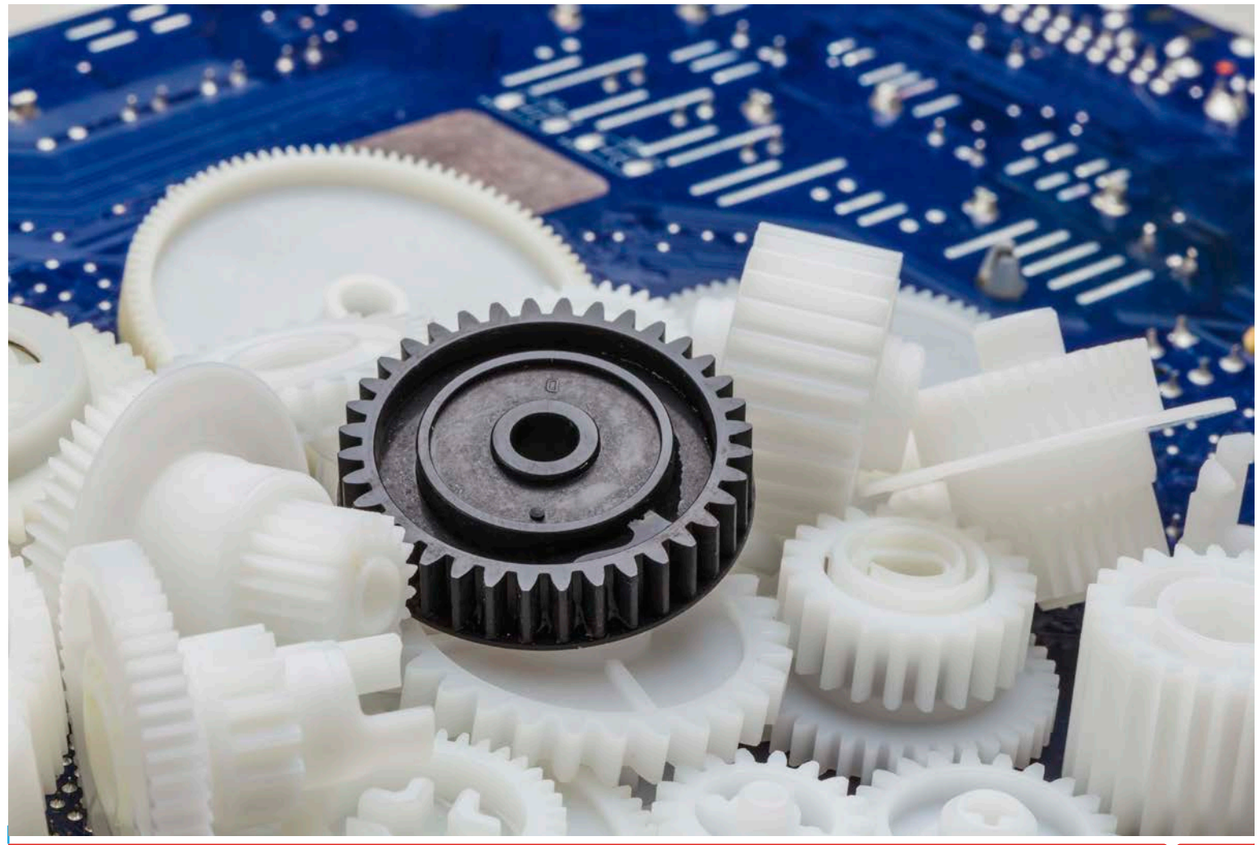

POLYMER GEARS – the future of mechatronic systems

Polymer gears play an increasingly important role in engineering applications due to their low production costs and lower weight compared to metals, while under the appropriate conditions, they are also distinguished by better tribological properties and, sometimes, by their ability to operate without lubrication. However, in addition to beneficial properties, they also possess some disadvantages, e.g. poorer mechanical and thermal properties, which need to be overcome. Consideration of the tribological properties is crucial for the selection of materials, operating conditions and geometrical parameters of gears. In TINT laboratory we are researching the tribological properties of various polymers and (nano)composites and we are developing test protocols and database for the development of polymer gears for mechatronic systems in household appliances and automotive components in close collaboration with companies from Slovenia, USA , Germany, Switzerland and the Netherlands. In the future the smaller mechatronic and drive systems will incorporate much more polymer components than today and therefore the understanding of tribological behaviour will represent an advantage on the competitive market.

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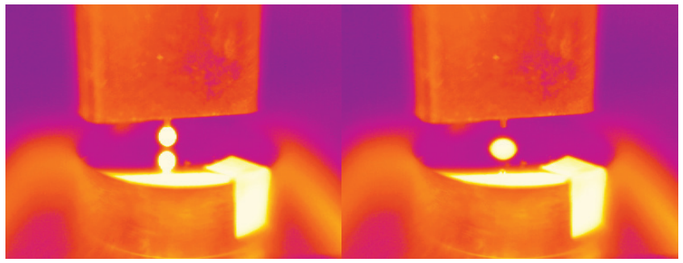
NEW EQUIPMENT

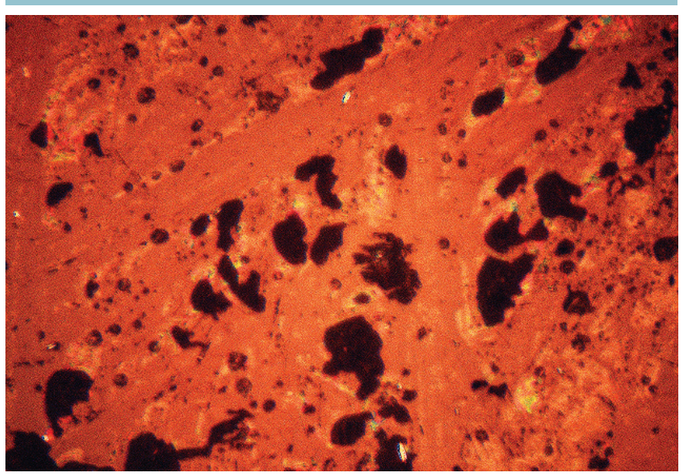
CONTACT ANGLE GONIOMETER FOR ELEVATED TEMPERATURES

Contact angle goniometer that enables monitoring and evaluation of wetting at elevated temperatures up to 150 °C has been developed in TINT laboratory. The apparatus is equipped with temperature-regulated and software supported system that enables separate heating of solid surface and liquid on the set temperature (with accuracy of 1 °C). Additionally, temperature changes within the liquid, on the solid surface and on the solid-liquid interface can be monitored with a thermal camera. These data enable us to determine interactions on the solid-liquid interface also at elevated temperatures, where parameters such as surface energy, surface tension and wetting can be analysed in real conditions at elevated temperatures.



NEW TEST RIG FOR IN-SITU INVESTIGATION OF THE REAL CONTACT AREA

In TINT laboratory a new test rig for real contact area analyses has been developed, which is suitable for testing various materials with different loads. With analyses normal load (load resolution: 0.5 N), deformation of the surface in vertical direction (vertical displacement resolution: 5 nm) and in-situ development and evaluation of the real contact area with the help of optical microscope (lateral optical resolution: 1 µm) can be simultaneously measured. The test rig enables us to investigate the correlations between real contact area at the micro/nano level, external load, topographic and material properties of the specimens. Comprehensive insight into the actual contact between two solids enables us to predict the actual loads and conditions inside the tribological contacts more accurately and consequently to improve the control of wear and friction.



PhD DISSERTATIONS

DR. JURE JERINA: TRIBOLOGICAL PROPERTIES OF HARD COATINGS AT ELEVATED TEMPERATURES

The PhD thesis discusses the contact engineering of tool surfaces, used in metal-forming processes of aluminium and its alloys, in a temperature range from 20 °C to 500 °C. Tribological properties of a sliding contact with an aluminium alloy EN AW-6060 were evaluated for two hard coatings, CrN and TiAlN, and for conventional hot-work tool steel. For this purpose a tribological test rig was developed. With advanced analysing techniques we showed that hard coatings can reduce the coefficient of friction. Furthermore, resistance of surfaces to aluminium transfer can be enhanced. We also investigated and determined the mechanisms behind the aluminium alloy transfer on the surfaces in relation to temperatures and sliding distances, as well as analysed the effect of solid lubricants on the tribological contact of hard coatings and aluminium alloys. The results were published in different scientific journals: Wear 330-331, 2015; Wear 319, 2014; Surface & Coatings Technology 206, 2012.

AWARDS

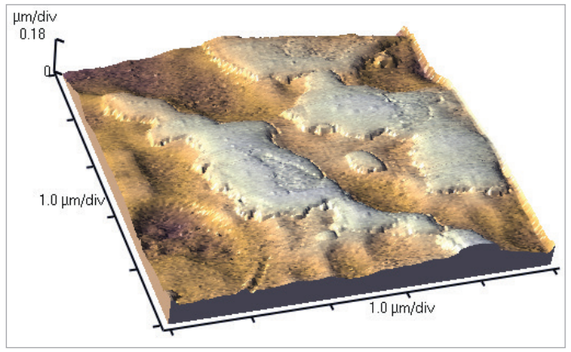
THE MOST PROMINENT RESEARCH ACHIEVEMENTS OF THE UNIVERSITY OF LJUBLJANA IN 2014

University of Ljubljana placed the work of prof. dr. Mitjan Kalin »Contact nano engineering for molecular control of boundary lubrication and friction« amongst the ten most prominent research achievements in 2014. Prof. dr. M. Kalin has shown that the molecular slip occurs at the interface between lubricant and surface, which importantly influences the friction. This phenomenon, which is dependent on the wetting and polar surface energy, was not considered in the tribological models up to now, since it was firstly empirically evaluated by prof. dr. M. Kalin and co-workers. These findings change the understanding of mechanisms of friction of lubricated engineering contacts. In addition, prof. dr. M. Kalin and co-workers showed that, in oil-lubricated contacts, the spreading parameter must be considered, instead of so-far used contact angle, for which they derived a new spreading coefficient. With this, he has also explained why, before now, it was not possible to determine the functional relation between wetting and friction. With such an innovative nano-engineering of advanced surfaces in interfaces our group achieved up to 60 % lower coefficient of friction compared to conventional contacts, which directly enables savings of energy in many mechanical systems.

CURRENT INVESTIGATIONS

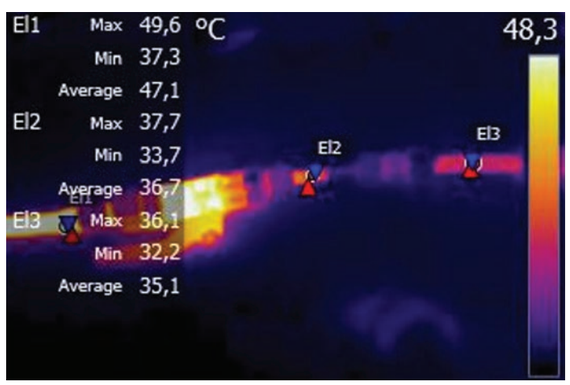
NANO SCALE EVALUATION OF TRIBOFILMS

Tribofilm is defined as a thin solid film generated as a consequence of sliding contact, which is adhered on its parent worn surface but has different chemical composition, structure, and tribological behavior and has a great influence on friction and wear. So the understanding of interactions and properties of formed tribofilms is of great importance. In our laboratory (TINT), topography, film thickness and mechanical properties (nano roughness, nano friction, elastic properties, adhesion properties, etc.) can be measured with use of Atomic Force Microscopy (AFM). With the obtained data a better understanding of nano-scale mechanical properties, tribological behavior and interface interactions on macro-scale can be achieved.



THERMOGRAPHY IN HYDRAULICS

In 2015 Laboratory for Fluid Power and Controls has started using the thermography on the field of diagnostics of hydraulic systems. Thermography is one of the nondestructive methods used to define pressure drops inside the working hydraulic components and systems. With a thermocamera it is possible, beside the measurement of the temperature of all outer surfaces of the hydraulic systems, to determine the intensity and the location of internal leaques, flow streams in reservoirs, during filter, etc. For more info please refer to: **http://lab.fs.uni-lj.si/lft**.



FOR THE FIRST TIME, NEUTRON REFLECTOMETRY WAS USED AT VARIOUS TEMPERATURES TO DETERMINE THE THICKNESSES OF ADSORBED ADDITIVES ON DLC

Researchers from the TINT laboratory in cooperation with colleagues from Japan were the first in the world to measure the formation of the adsorbed layers of additives on the surfaces of DLC coatings by using a neutron beam at Paul Scherrer Institute in Switzerland. We have shown that the organic friction modifiers, such as esters of glycerol, can form nanoscopic, relatively time- and temperature-independent adsorbed layers on DLC even in the absence of a sliding contact. On the other hand, conventional anti-wear additive Zinc dialkyldithiophosphates (ZDDP) showed temperature- and time-dependant formation of thicker layers. This is the first evidence of such growth of adsorbed layers on DLC in the absence of tribological contact and is an important basis for the continuation of similar studies in the actual tribological contacts.

GREEN NANOTECHNOLOGY-BASED LUBRICATION TECHNOLOGIES FOR MACHINING PROCESSES

We have recently shown in TINT that the addition of nanoparticles to lubrication oils has very large effects on the reduction of friction and wear, which we published in several publications. In this research area we are amongst the most active research groups and we are upgrading this area with the research in the field of cooling-lubrication agents for machining processes. In the project titled »Tribological effects of nanoparticles as additives to cooling-lubrication emulsions« we are studying in collaboration with the Olma d.d. company the effects of nanoparticles in cooling-lubrication agents for application in machining processes. The research has been focused on steel and aluminium, and as cooling-lubrication fluids we are using a wide range of both base and fully-formulated oils and also formulated water-based emulsions. The results show that in certain cases we can improve the functioning of the cooling-lubrication fluids in terms of friction and wear reduction by even more than 50 %. In some cases, the lowest friction can even be achieved, when we only add the nanoparticles to the base cooling-lubrication fluid, which means that the nanoparticles can replace the conventional additives in terms of achieving low friction. With such nano-lubricants it might be possible in the future to completely avoid the existing additives and to achieve innovative and greener lubrication technologies.

PROMINENT PUBLICATIONS

M. Zalaznik, S. Novak, M. Huskić, M. Kalin

Tribological behaviour of a PEEK polymer containing solid MoS_2 lubricants

Lubrication science 28, 2015

M. Kalin, J. Kogovšek, J. Kovač, M. Remškar

The formation of tribofilms of MoS_2 nanotubes on steel and DLC-coated surfaces

Tribology Letters 55, 381-391, 2014