Junge Tribologen

GfT Gesellschaft für Tribologie e.V.

7th Young Tribological Researcher Symposium

YTRS

22nd – 23rd of July 2024

at FAU Erlangen-Nürnberg

FAU Friedrich-Alexander-Universität Erlangen-Nürnberg

Lehrstuhl für Konstruktionstechnik
Prof. Dr.-Ing. Sandro Wartzack

KT mfk

Patron:

S. Wartzack

Program and organization:

F. Rummel
C. Morstein
M. Marian
K. Feile
C. Orgeldinger
B. Rothammer

Content

Location

FAU Erlangen-Nürnberg
Engineering Design (KTmfk)

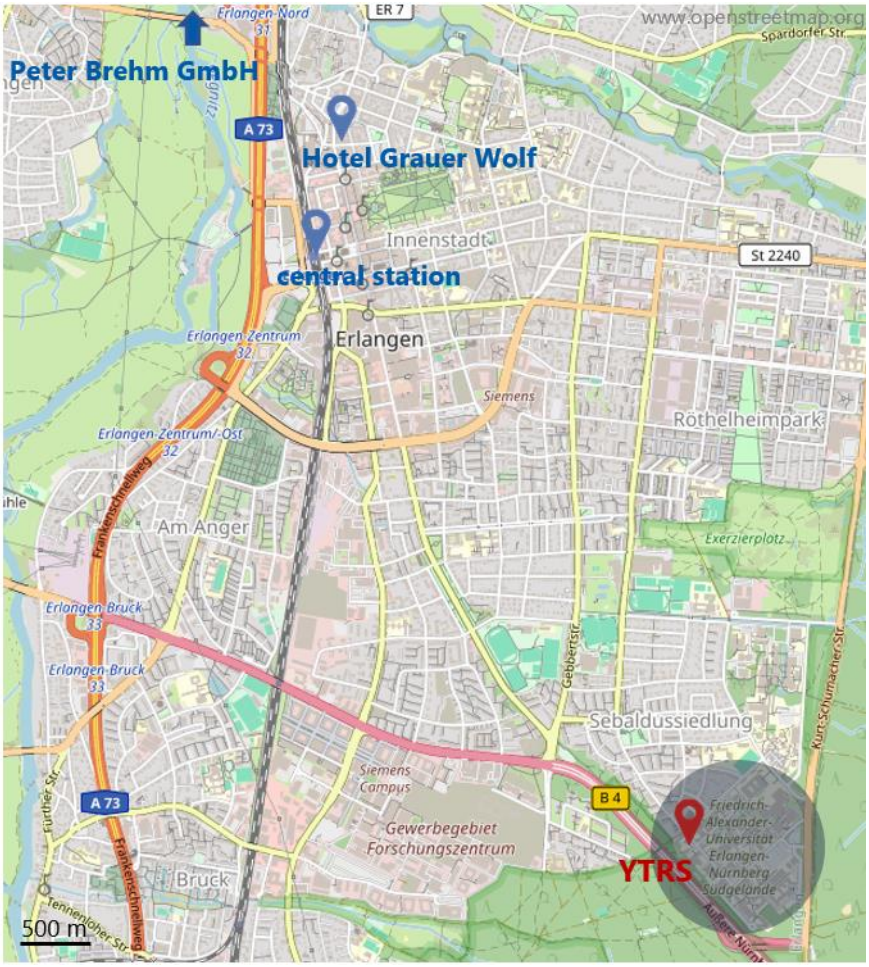
Chair location:
Martensstraße 9
91058 Erlangen

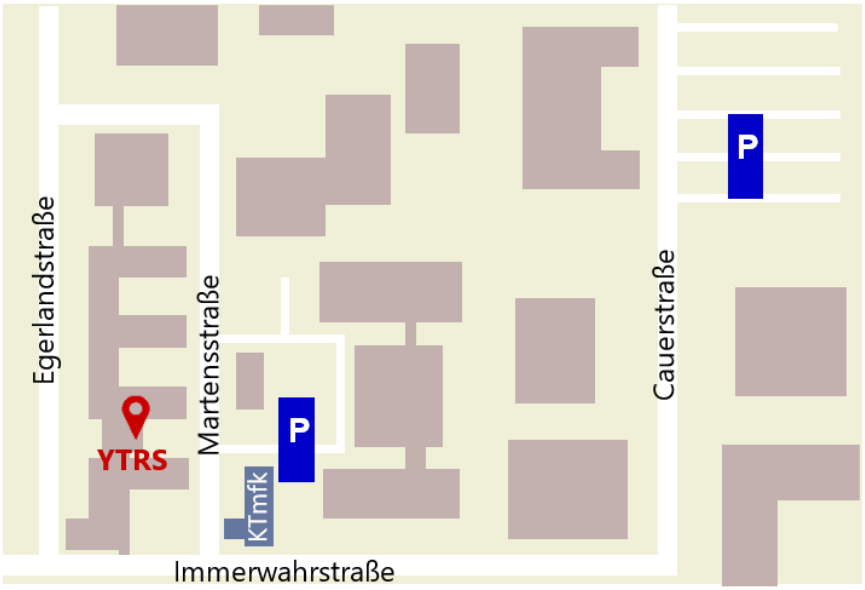
Symposium location:
KTmfk-Projekthaus (0.103)
Egerlandstr. 11
91058 Erlangen

The symposium takes place at the campus of the Faculty of Engineering of the FAU Erlangen-Nürnberg in the south of Erlangen. The symposium rooms are located opposite of the chair of Engineering Design (KTmfk).

Arrival by car: Leave the highway A73 at the exit Erlangen-Bruck and follow the main road B4 until reaching the exit "Technische Fakultät". Then turn left to the faculty campus. Free parking is available around the symposium location.

Arrival by public transportation: The bus lines 287 and 293 run from the forecourt of Erlangen central station to the symposium location at the Faculty of Engineering. The stop "Stettiner Straße" is located in the Egerlandstraße in front of the event building.





Program overview

Monday, 22nd July 2024

10:00 – 11:00	**Opening and welcome** C. Morstein, F. Rummel, B. Rothammer *Working group "Young Tribologists", GfT* S. Wartzack *Engineering Design, FAU Erlangen-Nürnberg* M. Bartz *Engineering Design, FAU Erlangen-Nürnberg*
11:00 – 12:00	***Institute tour***
12:00 – 13:00	***Lunch break***
13:00 – 15:00	**Presentation session "Lubrication"**
15:00 – 15:30	***Coffee break***
15:30 – 17:30	**Presentation session "Tribo-Testing and -Simulation"**
From 19:00	***Get together and dinner***

Program overview

Tuesday, 23rd July 2024

09:00	**Meeting on the forecourt of Erlangen central station**
10:00 – 11:30	**Excursion** Peter Brehm GmbH, Am Mühlberg 30, 91085 Weisendorf
12:30 – 13:30	***Lunch break***
13:30 – 15:00	**Presentation session "Tribo-Chemistry"**
15:00 – 15:30	***Coffee break***
15:30 – 16:00	**Plenary talk "Nowear to be found"** K. Neusser *Engineering Design, FAU Erlangen-Nürnberg*
16:00-16:30	**Best presentation award and symposium closing** C. Morstein, F. Rummel, B. Rothammer

Presentations

Monday, 22nd July 2024

Session "Lubrication"

Session Chair: B. Rothammer, FAU Erlangen-Nürnberg, Germany

13:00 **Presentation 01**

Enhancement of Fretting Wear Resistance by Laser Fusing of Self-lubricating Composites

Bianca Preuß, Chemnitz University of Technology, Germany

Thermal post treatment for surface functionalization to adjust the wear and corrosion properties represent a promising approach in coating technology. Self-fluxing alloys (SFAs) are a proven thermal spray material system, which forms a dense coating with high bonding strength by a subsequent fusing step. Such coating systems represent the state of the art in valve technology. For further improvement of the tribological behavior, solid lubricants are suitable additives. However, the processing or fusing of solid lubricant-modified systems poses a challenge due to the often-divergent properties of the individual components. Molybdenum disulfide (MoS2) was studied as promising solid lubricant for the SFA NiCrBSiFe. Microstructure, hardness and wear behavior of the spark-plasma sintered (SPS) composites with MoS2 contents up to 10 wt% were determined in this study. By reducing the test force under oscillating wear, a significant decrease in coefficients of friction (COF) was observed for higher MoS2 contents. In contrast, the wear rate is reduced by MoS2 cooperation under higher loads. Laser fusing of MoS2-containing composites favor the formation of an adherent Fe/Ni sulfide top-coat and CrS precipitates, whereupon the hardness and wear resistance was improved. Hence, a transfer of decomposed composite to coating technology is a promising concept.

13:30 **Presentation 02**

Programmable friction: Development of stimuli-responsive tribosystems based on ionic liquid mixtures

Felix Gatti, Fraunhofer-Institut für Werkstoffmechanik IWM, Germany

An important challenge in tribological systems is the monitoring and active influencing of friction by a non-mechanical stimulus so that tribological systems can be operated with the perfect coefficient of friction (COF) for the specific application in terms of sustainability and efficiency. Among various combinations of fluids and external triggers, the use of an electrical pulse in combination with ionic liquids (ILs) or their mixtures (ILMs) as lubricants was identified as a promising option for active friction control. When lubricating

two metallic friction partners with ILs or ILMs, the application of an electrical potential can lead to a permanent change in the COF. The charges on the surface influence an interaction, whereby a molecular arrangement of the ions is generated near the surface by adsorption. The quality and quantity of the desired COF differences can be influenced and specifically controlled by the surface charge density, but also by the size and elemental composition of the anions. Significantly higher COF changes can be achieved with ILMs than with pure ILs. ILMs appear to have an advantage over pure ILs in terms of the density and stability of the adsorption layer. The implementation of "programmable friction" represents a first step towards tribological systems that can adapt independently to changing conditions.

14:00 **Presentation 03**

Examination of Tribological Effect of VI Improvers

Sevda Şahan, Petrol Ofisi AŞ, Turkey

It is well known that VI improvers effect the tribological performance of lubricants. In this study we have been examined effects of different ratios of VI improvers on surface properties and tribological performance of lubricants.

14:30 **Presentation 04**

Solid lubrication with PTFE in rolling contacts

Eleonor Carberry, RWTH Aachen University Institute for Machine Elements and Systems Engineering, Germany

Under certain conditions such as vacuum, high temperatures or in medical applications, the use of oil or grease lubrication is not suitable. Hence solid lubricants such as polytetrafuoroethylene (PTFE) are used. PTFE shows excellent lubricating performance in sliding contacts, however its suitability and lubricating mechanisms in rolling contacts are poorly understood. Therefore, to elucidate the tribological behaviour and lubricating mechanisms, a ball-on-disk tribometer is enhanced by a pin-on-disk sliding contact that transfers PTFE to the disk, which is used to lubricate the ball-on-disc contact. The friction and optically measured film height was studied for different temperature, rolling speed, Slide-Roll-Ratio, ball load and loads in the pin-on-disc contact, showing the potential corridor of sufficient transfer film formation. Due to its high wear rates, the PTFE was substituted by a PEEK-PTFE compound. PEEK contributes with its lower wear rate and minimises the film thickness by holding similar coefficient of frictions throughout different parameters and therefore providing sufficient lubrication with a higher lifetime. The results can be used to conceptually design a bearing with PEEK/PTFE transfer-film lubrication.

Session "Tribo-Testing and -Simulation"

Session Chair: K. Neusser, FAU Erlangen-Nürnberg, Germany

15:30 **Presentation 05**

Tribological behavior of additively manufactured 316L steel

Benjamin Ignacio Alvear Quilpatay, Pontificia Universidad Católica de Chile, Chile

Tribological analysis of parts manufactured with additive manufacturing in 316L steel at different temperatures and with the application of different lubricants.

16:00 **Presentation 06**

Prediction of Lubricant Film Parameters of Deviated EHL Line Contacts using Machine Learning Approaches

Klara Feile, FAU Erlangen-Nürnberg, Germany

Friction losses are, among other factors, significantly caused by manufacturing-related shape deviations of surface topographies, e.g. due to tool vibrations. Until now, the consideration of these shape deviations within the calculation of EHL contacts in the design process of low-friction machine elements with lubricated contacts has only been possible by means of complex and time-consuming numerical simulations.
Consequently, the objective of this contribution is to utilize machine learning (ML) approaches in order to significantly accelerate the prediction of lubricant film parameters in 2D line contacts, while accounting for shape deviations in the form of waviness. The numerical simulations used to generate the training and test data sets are discussed first. Subsequently, Gaussian process regression and neural network models are compared, whereby the number of input parameters is reduced due to the use of dimensionless parameters. The results demonstrate the potential of ML models to predict lubricating film parameters quickly and precisely, even when taking shape deviations into account.

16:30 **Presentation 07**

Excitation and Attenuation of surface waves in disordered materials

Ibrahim Ghanem, University of Freiburg, Germany

We use amorphous silicon (a-Si) as a model system for studying frictional energy dissipation in disordered solids. Our core hypothesis is that frictional dissipation occurs through excitation and attenuation of surface phononic modes. We use a combination of atomistic and continuum calculations to study these modes. Our atomistic a-Si system comprises a free surface and an opposing rigid one, with periodic boundary conditions enforced on the remaining boundaries. We determine the normalized eigenmodes of this system by diagonalizing its Hessian matrix. Conversely, at a continuum scale, amorphous materials are modeled as isotropic solids. We use the theory of

linear elasticity to derive semi-analytical expressions of the phononic modes of an isotropic system subject to the same boundary conditions. We characterize the atomistic normal modes by computing their phonon order parameter in reference to the continuum solution. Further analysis involves examining the vibrational density of states and participation ratio. Additionally, we measure the vibrational lifetime of each mode from the decay of its energy-energy autocorrelation function in microcanonical simulations. In a Langevin scheme, the vibrational lifetimes correlate with the frictional forces acting on the normal modes. We use this to make predictions on the rate of energy dissipation in an a-Si system subject to surface excitation.

17:00 **Presentation 08**

Study the characteristics of novel ionic liquid functionalized graphene oxide on the mechanical, tribological and thermal properties of silicone rubber nanocomposites

Sarath Pampayil Sasikumar, TKM College of Engineering, India

In recent years, considerable improvements in bulk strength, modulus, and toughness with lightweight polymers have led to the development of tribological applications in industry and other fields. In the present work, we investigated the effect of ionic liquid (1 ethyl 3-methylimidazolium dicyanamide) modified graphene oxide (ILGO) on the mechanical and thermal behaviour of silicone rubber (QM) nanocomposites. Silicone rubber nanocomposites (QMILGO) were prepared by the conventional two roll mixing method. The interactions of ILGO and silicone rubber nanocomposites have been investigated using Fourier- transform infrared spectroscopy, Raman spectroscopy, Dynamical mechanical analysis and thermal conductivity measurements. The surface treatment of graphene oxide with IL resulted in significant changes in the mechanical and thermal properties of nanocomposites, which can be attributed to increased filler–polymer interaction. The pin on disc triobometer was used to examine the tribological properties experimentally, with load, sliding velocity, and temperature as the varying parameters. With load, sliding velocity, and temperature as the variable parameters, the pin on disc triobometer was utilised to investigate the tribological properties experimentally. Ionic liquid performed as a self-lubricating layer for graphene, producing a strong GO-IL interface connection with the rubber matrix. The wear mechanism involves formation of transfer film at the interphase between composite and steel counter surface.

Tuesday, 23rd July 2024

Session "Tribo-Chemistry"

Session Chair: C. Orgeldinger, University of Bayreuth, Germany

13:30 **Presentation 09**

Unleashing Lightweight Potential via ULTRACERAMIC®

Anutsek Sharma, ELB - Eloxalwerk Ludwigsburg Helmut Zerrer GmbH, Germany

Lightweight metals such as aluminum and magnesium play a crucial role in industries prioritizing weight reduction. Their enhanced strength-to-weight ratio makes them versatile for various applications. However, they are susceptible to significant wear and corrosion.
Exploring customized surface solutions to address these challenges could pave the way for new applications and potentially new markets. Plasma Electrolytic Oxidation (PEO) is an eco-friendly and effective process that offers superior mechanical, tribological, and corrosion protection properties. PEO refinement unveils the full lightweight potential of light metals produced from casting, novel additive techniques and even parts with metal matrix composites. This talks reports on how PEO could effectively enhance tribological and corrosion properties of light metals. ULTRACERAMIC® surfaces are tested via pin on disc tribometer and are further analyzed by SEM (Scanning Electron Microscopy) and EDS (Energy Dispersive X-ray spectroscopy). Initial wear studies have already revealed interesting findings with approximately 1000x decrement in wear volume of PEO surfaces in comparison to unprotected samples.
In the end, recent insights into two ongoing BMWF (German Federal Ministry of Economic Affairs and Climate Action) funded projects in field of Ceramics on Additive Manufactured Metals (CAMM) and Ceramics for Magnesium based bio- resorbable Implants (MagImp) will be provided.

14:00 **Presentation 10**

Tribological behaviour of Co-based glaze layer at transient temperatures

Tobias König, Fraunhofer-Institut für Werkstoffmechanik IWM, Germany

In the field of high temperature tribology, where degradation and evaporation prevent lubrication with liquids, the formation of wear and friction reducing glaze layer is a preferential behaviour of the materials. Especially Co-based alloys were used for these operating conditions due to their stable glaze layer formation over a broad temperature range. Several publications already exist, analysing the influence of temperature, normal force, sliding speed, frequency and displacement for reciprocating motion and of course time on wear and friction, using diverse model test setups.
This contribution focuses on the application-oriented material characterisation of a Co-based Tribaloy© T400 – T800 pairing with a shaft bushing test. Beside the comparison to model test results and the influence

of contact conformity, the influence of transient temperature profiles on the tribological behaviour will be discussed, as temperature variations caused by start-stop cycles are characteristic of any application.

14:30 **Presentation 11**

Oxidation of a ZrN coated knee implant after 2 years within the human body

Julia Rau, Chalmers University of Technology, Sweden

The surface of an up to 5 µm thick multilayer on a knee implant was investigated in terms of its oxidation behavior. After explanting the implant after ~ 2 years from the human body due to aseptic loosening, the coatings surface (ZrN) was partially oxidized. To that point, the characteristics and formation of the oxide and its influence on the tribological performance was unclear.
In this work, the oxide was analyzed using scanning (transmission) electron microscopy (STEM), time of flight secondary ion mass spectrometry (TOF-SIMS) and atom probe tomography (APT). This combination of techniques revealed oxide formation on the whole surface, having an effective passivating behavior against further oxidation of the underlying substrate. The oxide was formed through a combination of corrosive and tribologically-induced oxidation. Understanding these formation processes allows to elucidate the oxides influence on the tribological performance of artificial knee joints and eventually extending their lifetime.

Contact information

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