PolyTrib 2022

December 5th – 6th, 2022
Stockholm, Sweden

Tribology and interface nanotechnology

BECHEM LUBRICATION TECHNOLOGY

Anton Paar

LULEÅ UNIVERSITY OF TECHNOLOGY

POLYTRIB 2022 Full Program

Sunday, 4th December		
17:00	**19:00**	**Registration Opens at Clarion Hotel**

Monday, 5th December			
7:30	**Registration at Conference Venue, Clarion Hotel**		
8:45	9:00	Opening remarks	
Podium Talks		**Presentation title**	**Session**
9:00	9:30	**Polymeric-based materials in hydropower bearings: Challenges and Opportunities: Jan Ukonsaari, Vattenfall, Sweden**	Industry and Applications
9:30	9:50	Material properties of heat resistant polyamide GENESTARTM PA9T for gear applications: Kazuma Yanagisawa, Kuraray Co. Ltd., Tokyo, Japan	
9:50	10:10	Tribological solutions with sustainable HOSTAFORM® POM ECO-B materials: Qamer Zia, Celanese Services GmbH, Frankfurt, Germany	
10:10	10:40	**Polymer based tribomaterials for heavy equipment: Patrick De Baets, Ghent University, Belgium**	
10:40	11:10	Coffee Break	
11:10	11:40	**Polymer Tribology in Hydrogen: Yoshinori Sawae, Kyushu University, Japan**	Environmental Conditions
11:40	12:00	New approach for accurate determination of Influence of Humidity on (Static) friction between Polymer-Steel Tribocontacts: Paul Staudinger, Anton Paar GmbH, Graz, Austria	
12:00	12:20	Tribological evaluation of thermosets in lubricated conditions: Sebastjan Matkovič, University of Ljubljana, Slovenia	
12:20	12:40	Development of BSR Thermoplastic Grades at SABIC© Specialties: Erik Schwartz, SABIC, The Netherlands	
12:40	13:10	**Effect of hydrogen pressure on the fretting behavior of elastomers: Géraldine Theiler, Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany**	
13:10	14:10	Lunch Break	
14:10	14:40	**The importance of environmental impact assessment in the product's life cycle: Life Cycle Assessment and Sustainable Development: Mitja Mori, University of Ljubljana, Slovenia**	Material Structures and Manufacturing
14:40	15:10	**Influence on the tribological properties caused by different specimen fabrication methods: Tanja Stiller**	
15:10	15:30	Short cellulose fiber composites as sustainable tribo-materials: Lucas Kneissl, Luleå University of Technology, Sweden	
15:30	15:50	Real contact area evolution of POM in sliding contacts with low sliding speed: Petra Jan, University of Ljubljana, Slovenia	
15:50	16:10	Synergistic effect of multiscale reinforcement on wear of wood polymer composites: Zainab Al-Maqdasi, Luleå University of Technology, Sweden	
16:10	16:40	Coffee Break	

Podium Talks		Presentation title	Session
16:40	17:10	**Oil-lubricated polymer contacts of high-performance gears: Thomas Lohner, Technical University of Munich, Germany**	Lubrication
17:10	17:30	Impact of aged lubricants on tribology of elastomer-based sealing materials: Martin Tockner, Polymer Competence Center Leoben GmbH, Leoben, Austria	
17:30	17:50	Lubrication of high-performance polymers with biodegradable esters: Effects of temperature and aging: Pedro Martins Ferreira, University of Ljubljana, Slovenia	
17:50	18:10	In-situ microscopy for polymer transfer film characterisation: Kian Kun Yap, Imperial College London, UK	
18:10	**18:15**	**First day ends**	
Conference Dinner at 19:30			

Tuesday, 6th December			
8:00	**Registration at Conference Venue, Clarion Hotel**		
Podium Talks		**Presentation title**	**Session**
8:30	9:00	**Properties of Delignified Compacted Wood: Bernd Wetzel, Leibniz-Institute fuer Verbundwerkstoffe GmbH (IVW), Germany**	Industry and Applications II
9:00	9:20	Polyurea Thickened Lubricating Grease—The Effect of Degree of Polymerization on Rheological and Tribological Properties: Patrick Degen, Carl Bechem GmbH, Hagen, Germany	
9:20	9:40	Lubrication on Demand & New Interactive Functionalities of Plastic Elements by Microcapsules: Stephan Henzler, Carl Bechem GmbH, Hagen, Germany	
9:40	10:00	Polymers tribology in food packaging equipment: Silvia Rossi, Tetra Pak Packaging Solutions Spa, Modena, Italy	
10:00	10:30	Coffee Break	
10:30	11:00	**Tribological performance of PA nanocomposites and micro-nanocomposites: Helena Ronkainen, VTT Technical Research Center, Finland**	Composites and Modeling
11:00	11:20	Novel twin-disc tribometer setup with small slip conditions for composite materials: Balazs Jakab, AC2T research GmbH, Austria	
11:20	11:40	All-Hydrocarbon Single Component Composites with Structure Formation under Tribological Loading: Raimund Jaeger, Fraunhofer Institute for Mechanics of Materials IWM, Freiburg, Germany	
11:40	12:00	A statistics-based approach to polymer durability: enabling AI?: Dirk Drees, Falex Tribology NV, Rotselaar, Belgium	
12:00	12:20	In-situ tribological observation of macro and nano-sized structures applied on thiol-acrylate photopolymers: Andreas Hausberger, Polymer Competence Center Leoben GmbH, Leoben, Austria	
12:20	13:30	Lunch Break	

Podium Talks		Presentation title	Session
13:30	14:00	**Are low friction coatings based on transition-metal dichalcogenides good solutions for sliding against polymers?: Albano Cavaleiro, University of Coimbra, Portugal**	Surface Phenomena
14:00	14:20	Development of ternary atmospheric plasma deposited coatings generated under low oxygen conditions with low-friction properties on thermoplastic surfaces: Dietmar Kopp, JOANNEUM RESEARCH GmbH, Austria	
14:20	14:40	Upscaling the Thickness of Metallic Coating on Polymer Surface: Sandra Carvalho, University of Coimbra, Portugal	
14:40	15:00	Frictional nanosoldering sheets of pseudocomposite for reducing surface roughness in electrical: Paul Olaru, MNT Research Lab, IMNR-Bucharest, Romania	
15:00	15:30	Coffee Break	
15:30	15:50	The choice for thermoplastic lubrication by surface and interfacial energies: Christof Koplin, Fraunhofer Institute for Mechanics of Materials IWM, Freiburg, Germany	Thermoplastics
15:50	16:10	In-situ transfer film measurement: Andreas Gebhard, Leibniz-Institute fuer Verbundwerkstoffe GmbH (IVW), Germany	
16:10	16:30	Influence of load, sliding speed and heat-sink volume on the tribological behaviour of polyoxymethylene (POM) sliding against steel: Muhammad Siddiqui, University of Ljubljana, Slovenia	
16:30	16:50	Mechanical and tribological characterization of commercially available PEEK composites for demanding environments: Maksim Nikonovich, Luleå University of Technology, Sweden	
16:50	17:10	Wave power - new tribological challenges for reciprocating motion in the offshore environment: Antoine Bonel, CorPower Ocean, Sweden	
17:10	**17:15**	**Final remarks**	

Presenter's Biography and Abstract

PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Polymeric-based materials in hydropower bearings: Challenges and Opportunities

Vattenfall AB R&D, Machinery Laboratory

Dr Jan Ukonsaari
Title: Senior Research Engineer

Presenting author´s biography

Ph. D. Studies and M. Sc. Studies Mechanical Engineering at Luleå University of Technology. Ph. D. studies was on EALs boundary lubrication performance in hydropower Kaplan runners. Worked at Vattenfall R&D since 2005 with various studies for hydropower and wind power regarding performance verifications for technology implementations and measurements for exploring general running conditions, andparticipating in failure investigations. A lot of work has concerned oil systems, bearings and governing hydraulics, for long life and environmental development. Examples are studies on oil cleanliness in wind power gearboxes, EALs function and water lubricated guide bearings in hydropower. Master thesis workers, research publications and public reports has been natural parts of the work.

POLYMERIC-BASED MATERIALS IN HYDROPOWER BEARINGS: CHALLENGES AND OPPORTUNITIES

J. Ukonsaari
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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

The electrical system in Sweden and several other countries utilize hydropower as one important main grid stabilizing renewable energy source. Striving towards minimizing environmental footprint the introduction of polymeric-based bearings has led to usage and planning of environmentally safer designs and reduction of fossil based lubricants in the Nordic and Vattenfall's hydropower. The usage of the bearings has provided experiences looking 20 years back in time. In a discipline expecting 40 years of problem free operations, there are still challenges to overcome and opportunities to explore. The bearings in systems for water control, turbine power regulation and rotating shaft string operate under various conditions. This presentation guides through the bearing conditions in the different systems and presents the current status and view on the future for polymeric-based bearings in hydropower, a partially successful story but also in need for future improvement and development.

Keywords: Hydropower, environment, bearing, water, lubricants, oil free designs

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PolyTrib2022
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Material properties of hear resistant polyamide GENESTAR™ PA9T for gear applications

Affiliation Kuraray CO., LTD. Genestar division, Research & Development Department

Kazuma Yanagisawa
Title: Development Engineer

Presenting author´s biography

Short educational background, research activities/interest, and R&D expertise and experiences, publication background

Education/ Academic studies:
2004 until 2009 Nuclear physics at Sophia University

Professional career:
2009 until 2018 R&D Engineer in automotive industry

- R&D of injection molding process using FEM analysis.
- Development of plastic part for automotive.

Current job:
2018 until present R&D engineer in chemical company.

- R&D of tribological material for plastic gear.
- Prediction of the fracture of plastic material.

Material properties of hear resistant polyamide GENESTAR™ PA9T for gear applications

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

. GENESTAR™ is a brand name of heat resistant polyamides developed by Kuraray. GENESTAR™ PA9T in that brand is a well-balanced long-chain polyphthalamide (PPA). It combines a low water absorption with a high heat and chemical resistance. These properties make GENESTAR™ PA9T an excellent choice for demanding applications in the automotive industry. In this report, fundamental material properties of PA9T required for the gear application were shown.

Polyamide is generally known as a material with high water absorption, but among them, PA9T exhibits low water absorption(Fig.1) due to its molecular structure. Furthermore, due to its high glass transition temperature (125°C), its coefficient of thermal expansion is small in environments from room temperature up to about 100°C. Considering these facts, it can be said that PA9T has the highest level of dimensional stability among thermoplastic resins in a wide temperature range and humidity environment. In addition, PA9T has a high limiting PV value(Fig.2) due to its high melting temperature (305°C) and low friction of coefficient, therefore it can be used in applications where frictional heat is large and where severe wear is expected. Because of these combined unique characters, GENESTAR™ PA9T can be applied to a wide range of gear applications

Keywords: Polyamide, Water absorption, CTE, Dimensional stability, Limiting PV,

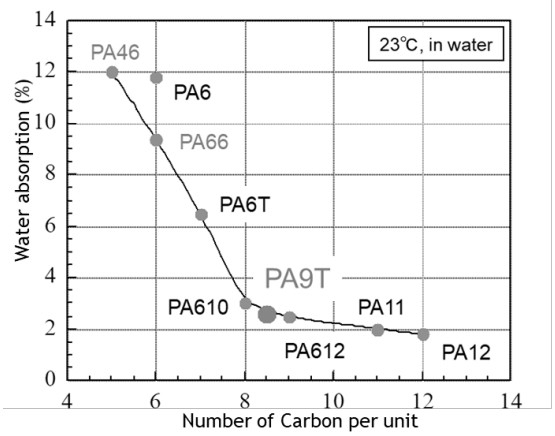

Fig.1 Comparison of water absorption of polyamide

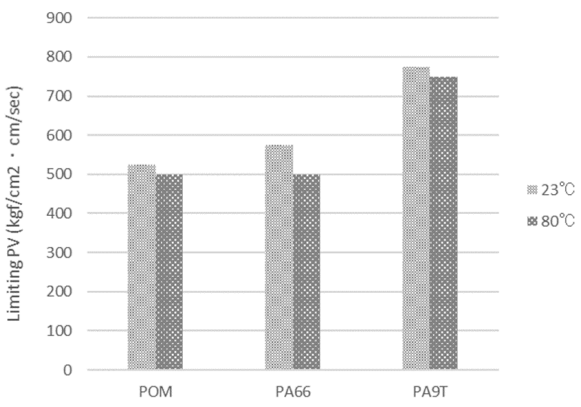

Fig.2 Comparison of Limiting PV value of polymers

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TRIBOLOGICAL SOLUTIONS WITH SUSTAINABLE HOSTAFORM® POM ECO-B MATERIALS

Celanese Services Germany GmbH, Frankfurt, Germany

Dr. Qamer Zia
Title: Principal Engineer Product Development

Presenting author´s biography

Qamer Zia received his doctoral degree from Martin-Luther University, Halle-Germany in 2009. His research work was focused on studying the effect of nano-structure and morphology on properties of semi-crystalline polymers. He then joined Fraunhofer Institute, Halle-Germany as a research scientist and lead key projects for material and application development.
He joined Celanese in 2012 and is currently working as product developer for POM and PBT. In his career at Celanese, Qamer extensively worked in the area of tribology covering engineering thermoplastics, high heat polymers and elastomers. He is the author of several peer-reviewed articles and holds numerous patents. He works in cross-functional, global teams to develop new material solutions for Celanese customers to meet current and future market needs for medical, automotive, E&E, consumer and industrial applications.

TRIBOLOGICAL SOLUTIONS WITH SUSTAINABLE HOSTAFORM® POM ECO-B MATERIALS

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

In electric vehicles, passenger cabin is naturally quieter compared to an internal combustion engine. As a result, the squeaky noise caused by the sliding movement of auxiliary components, especially at slow to moderate driving speed, becomes audible. For an improved driving experience, materials with intrinsic low friction and squeak-free sliding are required. This makes POM an excellent material of choice with its good tribological properties, dimensional stability and balanced mechanical properties. Its inherent low friction and wear properties can be further optimized to a level where it can help replace external lubricants to enable low break-away force; consistently low coefficient of friction over time; reduced wear and squeak-free sliding.

To support an environmentally sustainable future, a key element to success will be transitioning to carbon neutral materials. Based on Life Cycle Assessment (cradle-to-gate; ISO 14040/44) at Celanese factory in Frankfurt-Germany, Hostaform® POM ECO-B contains up to 97% bio-content using an ISCC+ certified mass-balance approach; the respective CO_2 footprint per kilogram of polymer (GWP) is less than half of fossil based POM. Hostaform® POM ECO-B with right choice of tribo-modification allows customers to meet regulatory and sustainability targets for tribological applications involving a broad range of boundary conditions and counterpart materials.

Keywords: Polyoxymethylene, sustainability, LCA, ISCC+ certification, electric vehicle, squeak-free sliding

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Stockholm, Sweden

Polymer based tribomaterials for heavy duty equipment

Ghent University, Dept. of Electromechanical, systems and metal engineering
KTH, Systems and component design

Patrick De Baets
Title: professor

Presenting author´s biography

Patrick De Baets in 1995 obtained a PhD on Thin Layer Activation. In 1997 he was appointed as assistant professor and founded a research group for machine elements and tribology. That group initially concentrated on dry friction, but today there are three research lines: dry friction characterisation, experimental and numerical wear modelling, and advanced lubrication. The research work of Patrick De Baets is found in about 140 journal publications and 200 conference proceedings. The group also conducts applied research for industry and in 2016 Patrick De Baets set up an industrially oriented research consortium “METALS” of circa 120 researchers that valorises research into metals, ranging from atomic structure to large-scale metal constructions.
Today Patrick De Baets is director of the Soete laboratory, active in both experimental and numerical research on fatigue, fracture, friction, wear, reliability and durability and since 2017 he acts as a Dean of the faculty of Engineering and Architecture, hosting 5000 students, 250 professors and a scientific staff of 1500 people.

Polymer based tribomaterials for heavy duty equipment

Patrick De Baets
Ghent University, Dept. of Electromechanical, systems and metal engineering
KTH, Systems and component design
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Abstract

Today polymer-based plain bearings are increasingly used in heavy duty machines because they are cheaper than metal bearings and can operate without externally added lubricants such as oil or grease. Very often the bearing system, mounting and sealing is simpler compared to lubricated bearing systems. Polymer based bearings also score well with respect to their chemical resistance and anti-corrosion properties. On the other hand they have a less extensive track record than metal bearings, making them sometimes less trusted by designers and constructors. Prior experimental verification of their tribological properties is therefore often requested or recommended.

Based on several examples of heavy duty machinery (lock gates, flood barriers, chain stoppers,...), the friction and wear properties of some polymers and of reinforced and internally lubricated polymer-based bearing materials are presented. Some influencing factors such as surface pressure and sliding speed, surface roughness, presence of contaminants, and others, are discussed. It is also indicated how the tribological properties of bearings can be determined in representative test set-ups and lessons learnt from these cases are highlighted.

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Polymer Tribology in Hydrogen

Yoshinori Sawae [1,2]

[1] Department of Mechanical Engineering, Faculty of Engineering, Kyushu University, Fukuoka, Japan

[2] International Institute for Carbon Neutral Energy Research, Kyushu University, Fukuoka, Japan

Presenting author´s biography

Prof. Yoshinori Sawae was awarded the degree of BS in 1991, MS in 1993 and Dr.Eng. in 1996 in Mechanical Engineering from Kyushu University. He joined Department of Mechanical Engineering, Kyushu University as a lecturer in 1996 and became a Professor of Machine Elements and Design Engineering Laboratory in 2011. From 2022, he is Head of Department of Mechanical Engineering. His primal research area is biotribology, especially working on the *in vivo* wear mechanism of prosthetic joint materials and the boundary lubrication mechamism of natural synovial joint. He is also conducting tribology research on polymer composites used in hydrogen energy systems as a professor of International Institute for Carbon -Neutral Energy Research, Kyushu University.

Polymer Tribology in Hydrogen

Yoshinori Sawae [1,2]
[1] Department of Mechanical Engineering, Faculty of Engineering, Kyushu University, Fukuoka, Japan
[2] International Institute for Carbon Neutral Energy Research, Kyushu University, Fukuoka, Japan

Abstract

Hydrogen is expected to be a clean and renewable energy carrier in the future society. It can be generated from many types of resources including renewable energies and suitable for mass transport and mass storage. The development of hydrogen energy networks will contribute to the reduction in fossil fuel consumption and greenhouse gas emissions. A fuel cell vehicle (FCV) is a conspicuous example of the machine system utilising hydrogen. It is a type of electric vehicle that uses a fuel cell as its power source. FCVs use hydrogen gas instead of gasoline as their fuel and release only vapour during operation. Consequently, it is known as 'ultimate ecologically friendly car'.

Since fuel cells are susceptible to hydrogen gas contaminants, the use of volatile lubricating oils and greases is strictly forbidden. Consequently, polymer composite with an excellent self-lubrication ability has a significant importance as a tribo-material in FCV and the related hydrogen gas infrastructure for ensuring the smooth and secure operation of machine elements. However, there are still a lot of uncertainties about tribological behavior of polymeric materials in high purity hydrogen. The aim of our polymer tribology research in hydrogen is to gain the basic knowledge on the physical and chemical phenomena arose at the tribo-interface between polymer composites and their metal conterface during sliding in high purity hydrogen gas environment.

Keywords: hydrogen, PTFE composite, carbon fiber, PPS, tribo-film formation

PolyTrib2022
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New Approach for accurate Determination of Influence of Humidity on (Static) Friction between Polymer-Steel Tribocontacts

Anton-Paar GmbH

Presenter First and last name Title:	**Paul Staudinger** DI

Presenting author´s biography

Paul Staudinger received a degree in Electrical Engineering from the Technical University of Graz, Austria, in 1998, whereafter he worked in warehouse automation and process engineering with ceramic semiconductors. In the year 2008, he joined the scientific instrument manufacturer Anton Paar and was responsible for the first fully-automated Rheometer, the High Throughput Rheometer. He has wide experience in Rheometry and has applied this into the field of Tribology in developing numerous customer-specific solutions. In the beginning of 2020, he assumed the role of Global Product Specialist for Tribology. While his areas of specialization are lubricants and greases, over the years, he has also gathered experience in the area of bio tribology (hydrogels as cartilage replacement) and food tribology. His current focus is on the development of test methodologies for carrying out tribological measurements combined with measurement of electrical properties, especially for the field of electro mobility.

NEW APPROACH FOR ACCURATE DETERMINATION OF INFLUENCE OF HUMIDITY ON (STATIC) FRICTION BETWEEN POLYMER-STEEL TRIBOCONTACTS

[1]P. Staudinger*, [2]J. Heinrich, [3]K. Pondicherry, [4]M. Tockner, [4]A. Hausberger
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New approach for accurate determination of Influence of Humidity on (Static) friction between Polymer-Steel Tribocontacts

Tribological behavior of materials in general, and polymers in particular, is strongly influenced by their surface characteristics which include roughness, chemical potential, visco-elastic properties, presence of adsorbed layers, humidity, etc. In the current report, the authors elucidate how changes in humidity can affect the tribological behavior of steel-polymer tribocontacts in a ball-on-3-flats setup using a novel test and analysis methodology. Tests were carried out to determine the break-away friction of polyamide 66 (PA 66) and polyoxymethylene (POM) against a steel surface at different levels of humidity. The results indicate that changes in friction, especially the transition from static to kinetic friction, depend on the humidity conditions and the propensity of the polymer to adsorb water molecules. Overall, an increase in humidity led to an increase in the limiting friction and correlated to the affinity of the polymer to adsorb water. However, in the case of tests with filled polytetrafluoroethylene (PTFE), a different trend was noticed as higher humidity led to lower friction. Moreover friction increased over time in air atmosphere but remained constant in nitrogen atmosphere. To conclude, in addition to the influence of humidity, one can also observe the effect of oxygen on the tribological behaviour of select polymer surfaces with the help of this novel test methodology.

Keywords: Polymers, Tribology, Humidity, Nitrogen Atmosphere, Breakaway Friction, Hygroscopic.

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Tribological evaluation of thermosets in lubricated conditions

Laboratory for Tribology and Interface Nanotechnology, Faculty of Mechanical Engineering, University of Ljubljana, Slovenia

Sebastjan Matkovič
Title: M.Sc.

Presenting author´s biography

He finished bachelor and the master study program at the Faculty of Mechanical Engineering in Ljubljana, direction of Machine Design and Mechanics: Engineering Design and Product Development. He completed a part of his postgraduate studies in Belgium at the KU Leuven. After graduating he was employed as a researcher at the Faculty of Mechanical Engineering in Ljubljana and started his PhD. thesis on the influence of tribology on the fatigue failure of polymer gears. He researches tribology of different polymer materials under various conditions with the strong focus on gear application. He studied the effect of slide-to-roll ratio on tribological behavior of polyoxymethylene and he conducted wear-coefficient analyses for polymer-gear life-time predictions. Along the work as a researcher, he also assists in the development of the computer software for the design, optimization and verification of machine elements according to international standards and literature.

Tribological evaluation of thermosets in lubricated conditions

[1]S. Matkovič, [1]U. Klanjšček, [1]M. Kalin*
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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Although thermoset materials cannot be recycled, they can offer superior properties compared to thermoplastic polymers, and composite thermosets can also replace metallic components even in the most demanding applications. Key benefits of the thermoset components are primarily related to lightweight, temperature resistance, and electrical insulation, which is especially needed for EVs. Therefore, they are making giant strides in the mobility sector. However, before the thermosets can fully impact green mobility, there are a number of tribology challenges to overcome in contacts like involute gear meshing, sliding bearing radial and axial contacts, hydraulic piston-cylinder contacts, etc. As a minimum, they must have the same or superior performance compared to metallic components. At this stage, however, the behaviour of thermosets in tribological contacts is greatly unknown.

Therefore, tribological evaluation was conducted on several reinforced thermoset/thermoset contacts with water lubrication. The study was carried out on a pin-on-disk instrument together with the use of a scanning electron microscope to determine the wear mechanisms. The results show exceptional wear behaviour of some reinforced thermosets at high PV values.

Keywords: thermoset, composite, wear, water

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Development of BSR Thermoplastic Grades at SABIC© Specialties

SABIC

Erik Schwartz
Title: Dr.

Presenting author´s biography

Erik Schwartz is Staff Scientist of LNP & Copolymers product line for SABIC's Specialties business. He obtained his PhD in Polymer Science from the University of Nijmegen in 2010. Before joining SABIC he spent two years at the Scripps Research Institute in California and two years at Eindhoven University of Technology as a postdoctoral fellow. He has co-authored >30 peer-reviewed research papers, > 20 patent applications and a book chapter. His current focus is on developing lubricated and structural solutions as well as sustainable thermoplastic products.

Development of BSR Thermoplastic Grades at SABIC© Specialties

E. Schwartz*, L. Jenkins, Edward Williams III
SABIC Specialties LNP™, BoZ, the Netherlands,
*Corresponding author: Erik.Schwartz@sabic-hpp.com

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X **Oral Presentation** ☐ Poster Presentation ☐ Not yet known

Abstract

Sometimes neat resins may not provide the performance needed in term of strength, fatigue or wear. SABIC's Specialties' LNP™ compounds portfolio is based on a variety of reinforced and internally lubricated thermoplastic compounds to address such needs. In this contribution, we will present internally lubricated solutions and our fully compatibilized olefinic alloys which can serve as an alternative to PTFE based material and show that these can emulate the tribological performance and colorability of traditional lubricated materials while avoiding the use of PTFE.

In addition, we will demonstrate how a Ziegler Instruments SSP-04 Slip Stick tester is being used at SABIC's Specialties business to develop and test new thermoplastic grades for potential/possible use in the control of BSR (buzz, squeak, and rattle) to serve the automotive industry. This presentation will outline SABIC's default testing profile and how this test data is used to develop and compare BSR grades for communication to customers for proper product selection.

Keywords: Buzz-squeak-rattle, Slip-stick, Thermoplastics, alloys, lubrication

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Effect of hydrogen pressure on the fretting behavior of elastomers

Bundesanstalt für Materialforschung und -prüfung
(BAM), Berlin, Germany

Géraldine Theiler
Dr.-Ing.

Presenting author´s biography

Dr. Géraldine Theiler studied and earned her Master's degree in Materials Engineering in Rennes, France, in 1995. She worked four years as senior scientist in the Federal Modul Research Center, Rugby, England, before joining in 2000 the Federal Institute for Materials Research and Testing (BAM), Berlin, Germany. She obtained her PhD in 2005. Her main research activities focus on polymer tribology in extreme environments like vacuum, cryogenic and hydrogen. She has published over 100 publications in journals, books, or conferences.
Leader of the Polymer Tribology group, since 2018
Co-coordinator of MatCom2 (Polymer compatibility in Hydrogen) in H2Safety@BAM, since 2020

Research topics
Tribology of polymers and coatings for extreme conditions like in vacuum, in hydrogen and at cryogenic temperature. Research projects include:

- Polymer materials for friction systems in vacuum technology.
- Carbon-based coating for tribological applications in vacuum and dry
- atmospheres.
- Investigation of influences on the rolling resistance of DLC coatings.
- Static Friction Tests in LHe on Insulation Materials for Superconducting Coils,
- High-performance polymer composites for tribosystems in hydrogen
- environments.
- Tribological testing of polymers in cryogenic hydrogen
- Friction and wear of DLC in high pressure hydrogen
- Polymer compatibility in hydrogen

EFFECT OF HYDROGEN PRESSURE ON THE FRETTING BEHAVIOR OF ELASTOMERS

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[2]Polymer Competence Centre Leoben GmbH (PCCL), 8700 Leoben, Austria
*Géraldine Theiler: Geraldine.theiler@bam.de

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Safety and reliability are the major challenges to face for the development and acceptance of hydrogen technology. It is therefore crucial to study deeply material compatibility, in particular for tribological components that are directly in contact with hydrogen. Some of the most critical parts are sealing materials that need increased safety requirements. In this study, the fretting behavior of elastomer materials against 316L steel balls were evaluated in air and in hydrogen environment up to 10 MPa. Several grades of cross-linked hydrogenated acrylonitrile butadiene (HNBR) and acrylonitrile butadiene rubbers (NBR) filled with different amount of carbon black (CB) were investigated. Furthermore, aging experiments were conducted for 7 days under static conditions in 100 MPa hydrogen and the physical and mechanical properties of the rubber materials were examined before and after hydrogen exposure. Fretting tests revealed that the wear of these compounds is significantly affected by the hydrogen environment compared to air, especially with NBR grades. After aging experiment, the friction response of HBNR grades is characterized by increased adhesion due to elastic deformation, leading to partial slip.

Keywords: Fretting wear, elastomers, hydrogen, high-pressure

PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

The importance of environmental impact assessment in the product's life cycle

Subtitle: Life Cycle Assessment and Sustainable Development

Mitja Mori
Assistant Professor

Dr. Mitja Mori is a member of the Department for Energy Engineering at Faculty of Mechanical Engineering, University of Ljubljana. He is a leading expert in life cycle assessment in Slovenia working with industry, international projects, and government. His fields of research are strongly connected with LCA, carbon footprint, hydrogen economy, eco design and problems inspired by the contemporary energy conversion systems, thermo-economic methods, numerical modeling, and analyses of complex energy systems. He is a leader for sustainable development (LCA, S-LCA) and techno-economic analysis (TEA) in several H2020 funded projects: Best4Hy-SustainaBlE SoluTions FOR recycling of end-of-life Hydrogen technologies, eGhost-Establishing Eco-design Guidelines for Hydrogen Systems and Technologies, Serengy NETS-Increase the Synergy among different ENERGY NETworkS, and Sure2Coat-Sustainable surface treatments of complex shape components for transsectorial industrial innovation. His work is published in more than 100 scientific/expert papers, conferences, and reports.

The importance of environmental impact assessment in the product's life cycle

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Environmental impact assessment is high on the priority list for all projects in the EU. The EU Green Deal is the main document guiding all research and industry activities in identifying environmental impacts of technologies, hot spots and scenarios that would reduce environmental impacts in the life cycle of products. In many cases, the studies conducted focus only on the manufacturing phase and ignore the functionality of the product. For emerging technologies, a holistic approach is needed that targets the use phase of the product and, where appropriate, the end-of-life phase. For bio-based materials, we need to be especially careful to choose the right environmental indicators and not just rely on the carbon footprint, which can be misleading. To properly evaluate the product, the benchmarking strategy is most effective to compare the new, improved ("greener") product with the existing product. In this context, we need to match the functionality of both products to make a correct evaluation.

In the case of green lubricants, this means extending the system at least to the use phase in order to cover not only the production process but also the technological and technical parameters of lubricants in the use phase.

Keywords: environmental impacts, life cycle assessment, green technologies, holistic approach.

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«Influence on the tribological properties caused by different specimen fabrication methods»

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Operative Projekt Leader

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Presenting author´s biography

Tanja Stiller finished the Montanuniversitaet in Leoben in 2018 in the field of Polymer Science. The background of her study covers the fields of polymer chemistry, processing on different machines as well as the testing of the polymer parts. During studying she was employed as a student worker in the research company PCCL with the focus on tribology of thermoplastic polyurethanes for sealing applications. The master thesis dealt with the tribology of different materials and their wear mechanisms. After finishing university, she got a position as a doctoral student in the field of additive manufacturing and tribology of thermoplastics.

Influence on the tribological properties caused by different specimen fabrication methods

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

It is known that tribological characteristics are a system property, dependent on several factors. The core of this system is the material pairing. The materials are often reinforced to reduce wear and friction. Depending on the processing technology (extrusion, injection moulding, additive manufacturing, or compression moulding), the orientation can differ from the filling direction in the bulk. Not only for fibres and fillers, the orientation plays a crucial role, but also for unfilled matrices. The orientation originating from the production has an impact on the mechanical and tribological properties.

Another factor, which can be influenced by production is the morphology of the matrix, i.e. the crystalline structure of the polymer. A highly nucleated material will crystallise fast and is therefore less affected by the production than a slower crystallising polymer. The crystallinity on the surface can be influenced by the cooling rate, which depends on the process. Some processes cool the surface with air or water, others cool it inside the mould. Thus, it influences the morphology and therefore, the mechanical properties. In general, these dependencies are summarised by the structure-property-relationship, which show the correlations between process, polymer structure, and properties.

Keywords: processing technologies, structure-property-relationship, orientation, fillers

PolyTrib2022
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Short cellulose fiber composites as sustainable tribo-materials

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Presenting author´s biography

Lucas Kneißl received his Bachelor's degree in Chemical Engineering at the University of Applied Sciences Krefeld and continued his studies with a Master's in Sustainable Materials with a focus on Polymers at the University of Freiburg, Germany with specialization on polymer chemistry, production and characterization.

He currently pursues his PhD as part of the GreenTRIBOS Marie-Curie double degree program at Luleå University of Technology and the University of Ljubljana under the supervision of Prof. Nazanin Emami and Prof. Mitjan Kalin. His work deals with the development and characterization of green, sustainable composite systems for tribological applications, especially for use in the automotive industry.

Short cellulose fiber composites as sustainable tribo-materials

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Abstract

Polyoxymethylene (POM) as a classic engineering thermoplastic is commonly used in tribological applications due to its low coefficient of friction, high abrasion resistance and good mechanical properties. To further improve these properties, it is often reinforced with glass or carbon fibers, which in turn are problematic with respect to their sustainability. Therefore, natural fibers are investigated as possible reinforcements to substitute these mineral-based materials, as they usually also are advantageous in terms of cost, weight and abrasiveness to manufacturing equipment.

POM/natural fiber composites were processed with a varying weight fractions between 10% and 30%. The highest fiber content led to the biggest enhancement in both flexural and tensile modulus of up to 75% and 120% respectively. Preliminary tribological studies were performed using a pin-on-disc apparatus at 0.7 m/s and 5 MPa, showing a significant increase in coefficient of friction for all composites, while exhibiting a decreasing trend with higher fiber percentage. The wear rate was significantly reduced for the composites containing only 10% fibers, while the other two composites were on similar levels as the neat polymer.

The reduction in wear rate is a promising outlook for upcoming investigations. Adjustments in the material composition with the possible addition of a third phase of different scale should be considered for improvements in the friction behavior.

Keywords: Sustainability, polymer composites, natural fibers, manufacturing, POM

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Real Contact Area Evolution of POM in Sliding Contacts with Low Sliding Speed

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Presenting author´s biography

Petra Jan was born in Ljubljana, Slovenia in 1994. She completed her B.Sc in Mechanical Engineering at the University of Ljubljana, Slovenia in 2017 and continued her studies in the joint European Master's programme in Tribology of Surfaces and Interfaces (TRIBOS). She finished her M.Sc. in 2019 at the Technical University of Luleå, Sweden with a thesis in the field of Polymer Tribology. Afterwards she obtained a government funded PhD position in Tribology and is currently employed as a researcher at the University of Ljubljana, Slovenia. Her PhD deals with in-situ experimental determination of real contact area in sliding contacts under the supervision of prof. Kalin. She has successfully developed a custom test rig and is currently finalizing her upcoming publications. Besides her PhD, she is actively involved in educational activities with students, industrial consulting projects and other research work related to polymer and composite tribology, contact mechanics and fretting.

REAL CONTACT AREA EVOLUTION OF POM IN SLIDING CONTACTS WITH LOW SLIDING SPEED

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Real contact area remains a widely researched topic in Tribology, particularly in the context of adhesion studies on polymeric and elastomeric materials. Although there are several established theoretical models, experimental validation and detailed multi-asperity contact studies are still lacking in the literature, particularly for sliding contacts that include the combined tangential and normal loading.

Within the scope of this study, we investigated the effect of different low sliding speeds up to 2 mm/s on the real contact area evolution and friction of rough POM polymer samples in dry sliding contact with ideally smooth sapphire glass. The samples were prepared with two different surface roughness conditions: Ra = 0.1 µm and Ra = 1 µm, the normal load was kept constant during the test at approximately 60% of the material yield strength and the total sliding distance was 5 mm. The actual surface area in contact was determined in-situ through optical observation of the whole multi-asperity contact at the asperity scale, where microscopy images of the contact were taken during sliding and then graphically processed. The results indicate that sliding speed has a significant effect on the real contact area and friction coefficient evolution during sliding, as polymers typically demonstrate a speed-dependent friction relation.

Keywords: real contact area, sliding speed, sliding contact, POM, in-situ experiments.

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Synergistic Effect of Multiscale Reinforcement on Wear of Wood Polymer Composites

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Zainab Al-Maqdasi
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Presenting author´s biography

Zainab Al-Maqdasi received the bachelor's degree in chemical engineering from University of Baghdad/Iraq in 2009. In 2016 she obtained the master's degree in composite materials from the Division of Materials Sciences at Luleå University of Technology/Sweden. In June 2022, she was awarded the doctoral degree for her research work enclosed in the doctoral thesis "Multifunctionality and Durability of Cellulosic Fiber Reinforced Polymer Composites" which was focused on development and characterization of functional bio-based composites further reinforced at the nanoscale for advanced applications. She has 8 scientific journal contributions and several conference papers on diversity of topics related to sustainability of composites, time-dependent performance, nondestructive characterization techniques, and tribology of polymers and composites. Recently, she is involved in the study of graded interphases on glass fibers reinforced composites and the study of parameters (temperature, moisture, aging, degree of cure) on the time-dependent properties of epoxy and its nano- and microscale composites.

SYNERGISTIC EFFECT OF MULTISCALE REINFORCEMENT ON WEAR OF WOOD POLYMER COMPOSITES

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Abstract

The conventional wood polymer composites (WPC) are used in large volumes but for applications limited by mechanical and environmental loads due to their moderate performance. Despite their environmental friendliness, under load natural fibres are known to show an inelastic nonlinear response which needs to be considered for particular applications. This may be changed by adding nano-reinforcement to these materials, as multi-scale composites are known to have strong potential for advanced applications. The role of the different scales varies based on their contributions in sharing the applied load, resulting in changes in the mechanical properties in general. For example, creep strains shown in Figure 1a [1] indicate that the wood micro-fibres contribute to enhancing the creep resistance at higher loads while nanoparticles (graphene nanoplatelets) are more efficient at lower loads. Current study makes such comparison for the wear resistance and mechanism at low/high contact pressures to understand the role of the reinforcements at different scales. Contrary to previous results, materials with nano-reinforcements show higher wear rates at lower contact pressure. Possibly, the wear mechanisms change because wood fibres at high loads prevent releasing particles that promote third body abrasion while graphene nanoplatelets act as solid lubricants reducing the severity of contact.

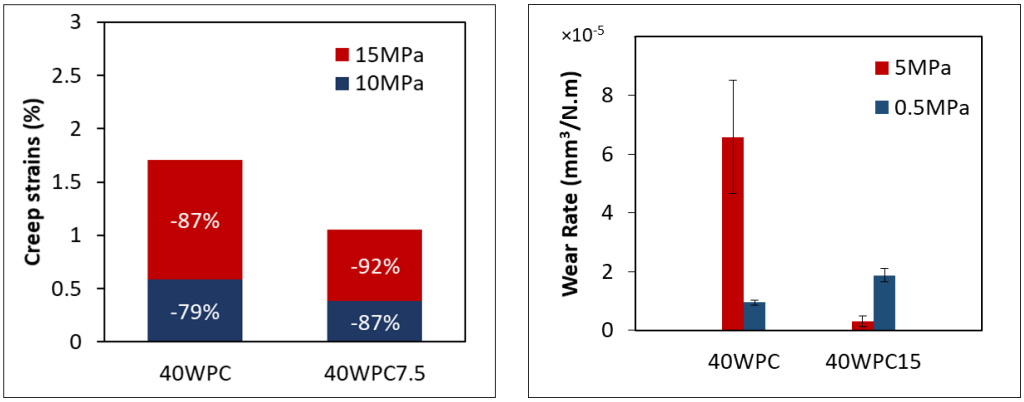

Figure 1. a) creep strains at two different creep stresses. Data labels refer to the reduction compared to the neat polymer (difference between % improvements at the addition of the nanoparticles shrinks at higher loads). b) wear rate of the materials at two different contact pressures.

[1] Z. Al-Maqdasi, L. Pupure, N. Emami, R. Joffe, *Polym. Compos.* **2022**, in Production.

Keywords: nanocomposites, Tribology, parameters, mechanical performance.

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OIL-LUBRICATED POLYMER CONTACTS OF HIGH-PERFORMANCE GEARS

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Presenting author´s biography

Thomas Lohner received his PhD (Dr.-Ing.) in Mechanical Engineering from the Technical University of Munich (TUM) in 2016. He is head of department "Tribocontacts and Efficiency" at the Gear Research Center (FZG) of TUM. He is specialized in the fields of tribology of gears and efficiency and heat balance of geared transmissions. His interests in gear tribology includes elastohydrodynamics, lubrication regimes, roughness, friction, wear, tribofilms and thermoplastics. In the field of gearbox efficiency and heat balance, he is concerned with power loss, lubricant flow and temperature in terms of lubricants, lubrication methods, coatings, surfaces, materials and gear geometry. He is author and co-author of more than 50 peer-reviewed publications and participates regularly in scientific conferences. He is member of the advisory board of the German Tribology Society (GfT), head of the GfT Working Group Munich and member of the body of experts of the Research Field Tribology of BMWK (Federal Ministry for Economic Affairs and Climate Action).

OIL-LUBRICATED POLYMER CONTACTS OF HIGH-PERFORMANCE GEARS

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Abstract

Oil-lubrication of rolling-sliding contacts improves heat dissipation and reduces friction and wear. It allows to use polymer gears even in high-performance applications. However, the polymer behaviour in lubricated contacts is poorly understood. This affects the optimal design of power-transmitting polymer gears and the exploitation of its potentials like lightweight design, low-noise operation and cost-effective manufacturing.

This contribution characterizes oil-lubricated rolling-sliding contacts with technical thermoplastics in hybrid material pairings. Friction and bulk temperature were measured on a twin-disk tribometer for different oils and polymers. In-situ thin-film sensors give insights into the contact temperature, and tribosimulations provide insights into the contact film thickness, elastic deformation and heat management. The potential of diamond-like-carbon coatings was evaluated experimentally.

Results show that oil-lubricated thermoplastic rolling-sliding contacts operate in a transition regime between hard and soft elastohydrodynamic regime. Internal damping can increase polymer bulk temperature even for interfacial friction in the range of superlubricity. The contact geometry of hybrid pairings shows a local surface conformity. The contact temperature is governed by shearing and backflow in the contact inlet zone at low slip and shearing in the contact zone at high slip. Hard diamond-like carbon coatings show effective wear protection of the thermoplastic surface under severe lubrication.

Keywords: gears, oil lubrication, thermoplastics, elastohydrodynamics, thin-film sensor, diamond-like carbon coating

PolyTrib2022
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IMPACT OF AGED LUBRICANTS ON TRIBOLOGY OF ELASTOMER-BASED SEALING MATERIALS

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Presenting author´s biography

Martin Tockner studied Polymer Science at the Montanuniversitaet Leoben in Austria and received his master's degree in 2019. In his master's thesis, he dealt with “tribological method development of abrasive resistant polymer coatings”. He has been working at Polymer Competence Center Leoben as a researcher in the field of polymer tribology since 2020 and started his Ph.D. studies in 2021 at Montanuniversitaet Leoben. In his Ph.D., he is dealing with the tribology of elastomer seals, in particular lubrication states and their application in harsh environments.

IMPACT OF AGED LUBRICANTS ON TRIBOLOGY OF ELASTOMER-BASED SEALING MATERIALS

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

As a result of the change in energy policy and the establishment of new technologies in the transport and energy sectors, the requirements for elastomeric sealing materials are increasing. Aging mechanisms are particular challenges for these materials, as well as for lubricants when it comes to service life optimization. These mechanisms affect not only the material but also the applied lubricant, which in turn affect the tribological system.

To investigate aging effects, unaged and aged lubricating oil were tested on a Ring-on-Disk (RoD) test setup with thermoplastic polyurethane (TPU) samples against steel counterparts. In the first instance, a suitable test method was developed using parameter screening. Since surface roughness plays an important role concerning wear mechanism, their impact was also considered. Therefore, the counterpart roughness was varied between 0.03–0.5 µm to get impressions of wear behavior over a broad range of surface roughness used in the industry.

The parameter screening revealed a method that is able to distinguish between changes in the tribological system. Furthermore, it was observed that adhesive wear is more likely to occur when the aged oil and smooth countersurfaces are applied. Besides, lubricant reservoirs were preferably present at higher countersurfaces' roughness, resulting in superior stability of the tribological system.

Keywords: Thermoplastic polyurethane, elastomer seals, Ring-on-Disk, aging

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Lubrication of high-performance polymers with biodegradable esters

University of Ljubljana and University of Coimbra

Pedro Martins Ferreira
Title: Mr.

Presenting author's biography

Pedro was born in 1993 in Campinas, Brazil. He has a bachelor's degree in mechanical engineering from the University of Campinas (Brazil) and a master's degree in generalist engineering from École Centrale de Lyon (France), which includes notions of civil, electrical, electronic, chemical, physical, materials and mechanical engineering. In 2019 he concluded a specialized MSc degree in IFP School (France) called "Energy and Products". It was focused on fuels and lubricants formulation and properties for engine and industrial applications.

He is currently employed at the Laboratory for Tribology and Interface Nanotechnology, at the University of Ljubljana, since October 2020 as a young researcher part of GreenTRIBOS consortium. He is working on a PhD thesis about the green lubrication of polymer mechanical parts under the supervision of Prof. Dr. Mitjan Kalin. The project is in collaboration with the University of Coimbra, under the supervision of Prof. Dr. Bruno Trindade.

LUBRICATION OF HIGH-PERFORMANCE POLYMERS WITH BIODEGRADABLE ESTERS: EFFECTS OF TEMPERATURE AND AGING

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

High-performance polymers are proven to be a good replacement for metals in many demanding applications. While oil lubrication is widely used in metallic contacts, it is not common practice for polymeric ones. There is a lack of scientific research in this field and a consequent lack of fully formulated lubricants dedicated to polymeric contacts. Therefore, this work aims to contribute to the field by studying the interactions between high-performance polymers and biodegradable lubricant base oils. Samples of polyetheretherketone (PEEK) were aged in oil at room temperature and 100°C for 30 days. DSC, DMTA, FTIR, XRD, and contact angle techniques were used to assess the effects of aging on the properties of the polymers. Moreover, polymer-on-polymer tribotests and microhardness measurements were performed for a more complete study. Results show that aging has a limited effect on the chemical, structural and mechanical properties of PEEK. The consequences are more considerable when aging occurred at 100°C, but they also depend on the oil in which it took place. Regarding the tribological behavior, higher testing temperatures caused changes in the coefficient of friction and in the wear mechanism. Aging on the other hand has less impact.

Keywords: tribology of polymers, oil lubrication, synthetic esters, aging of polymers, polyetheretherketone

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

In-situ microscopy for polymer transfer film characterisation

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Kian Kun YAP
Title: PhD Candidate

Presenting author´s biography

Yap is a final-year PhD candidate at the Tribology Group of Imperial College London. His main research explores the formation of polymer transfer films and their influence on the friction and wear of polymer-metal sliding interfaces utilising advanced in-situ tribometry techniques. These include spatiotemporal mapping, digital holographic microscopy, scanning electron microscopy, and white light microscopy. His work is supervised by Dr Marc Masen and Dr Janet Wong and supported by collaborators from Europe, Asia, and the USA. Yap has a wide interest in tribology. Apart from polymer tribology, he is also a fan of mechanical transmission technology and bio-tribology. He co-invented and patented a gearless speed reducer that features zero backlash and being compact in size. He was also involved in developing lubricants to alleviate PPE-induced skin injuries among healthcare workers during COVID.

In-situ microscopy for polymer transfer film characterisation

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

The properties of polymer transfer films can change significantly with time and have a strong influence on the tribology of polymer/metal sliding systems [1]. This work demonstrates how in-situ white light microscopy (WLM), digital holographic microscopy (DHM), and scanning electron microscopy (SEM), are utilised to achieve real-time multiscale characterisation of transfer films in a humidity-controlled PTFE/AISI 304 sliding system. Results indicate that PTFE is already transferred to the steel counterface even at the first sliding cycle. In dry air, WLM reveals that new transfer substances are constantly generated throughout the sliding duration, and they migrate on the steel surface, grow, and are eventually discharged as wear debris (Fig. 1), leading to severe wear. In humid air, the transfer of PTFE to the steel surface stops after the running-in period, due to the formation of a uniform tribo-chemical induced protective film on the PTFE surface, which leads to mild wear. DHM shows that the refractive index of PTFE transfer substances changes with time and has a strong correlation with friction and wear. The change in refractive index is due to the change in thickness and chain orientation of these transfer substances during repeated sliding. These in-situ techniques provide better insights into how transfer films govern the tribological performance of polymers.

Keywords: In-situ microscopy, PTFE, transfer films, humidity.

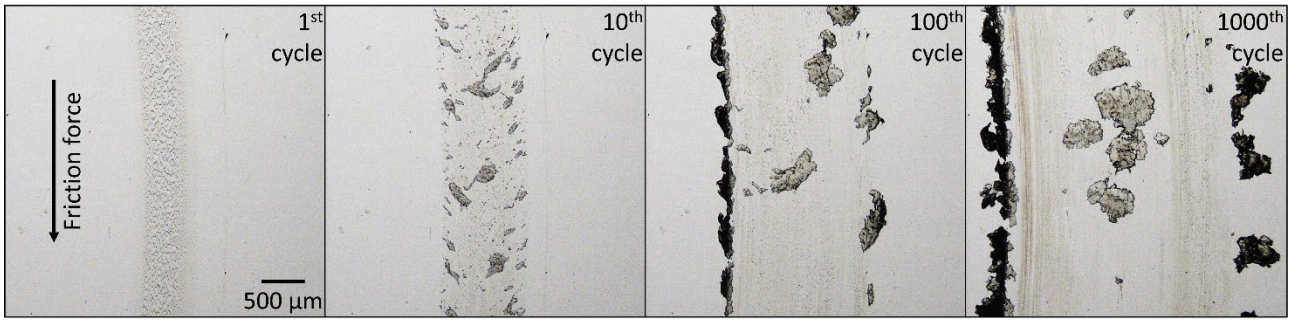

Fig. 1 In-situ WLM images showing the evolution of PTFE transfer films on an AISI 304 surface at different sliding cycles at 0.1% relative humidity.

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PROPERTIES OF DELIGNIFIED COMPACTED WOOD

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Bernd Wetzel
Title: Professor

Presenting author´s biography

Bernd Wetzel has studied mechanical engineering with major focus on materials, damage theory and energy systems at the University of Karlsruhe (TH). After conducting his Diploma Thesis at the California Institute of Technology, USA, he graduated in 1999.From 2000 to 2006 he worked as scientific assistant to Prof. Dr.-Ing. Klaus Friedrich at the Institute of Composite Materials (IVW) in Kaiserslautern.
In 2004 he conducted research at the Materials Science Institute, Zhongshan University in China with Prof. Mingqiu Zhang. After finalizing his dissertation on "Mechanical properties of ceramic nanoparticle reinforced epoxy nanocomposites" and receiving his doctorate degree from the University of Kaiserslautern in 2006, he took a Postdoc position as Representative Group Leader of the BMBF Young Researcher Group ”Nanoparticle reinforced high performance polymers: technological performance and economical manufacturing techniques“ at IVW. In 2008 he joined the company SchäferRolls in Renningen, Germany, as the Head of Composites Research and Development and Product Line where he developed calender roll covers.
In 2012 he responded a call as the Research Director Materials Science of the Institute of Composite Materials (IVW). Since then he manages the competence field "Tailored Thermosets & Biomaterials", and from 2012 to 2017 he was also head of the competence field "Tribology" from 2012 to 2017.

PROPERTIES OF DELIGNIFIED COMPACTED WOOD

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Abstract

The use of sustainable resources and bio-based materials in technical systems to reduce CO_2 emissions are important measures that aim to influence climate change. Current actions of researchers and industry aim to find solutions for replacing current fossil-based materials and to drive innovation. Wood is a valuable, renewable, and sustainable bio-based material and a natural carbon sink with an excellent technical performance-to-weight ratio but deficiencies in its suitability as a material for structural or tribological applications. However, it is possible to transform wood into a high-performance material by manipulating its cellular and molecular structures. This is done by a chemical treatment to remove lignin, followed by functionalization and subsequent densification and consolidation of the wood structure. Accordingly, a high-performance, energy-efficient structural materials made of wood has been developed using environmentally sound, scalable processes. A systematic variation of key influencing factors such as lignin content, degree of densification and process parameters was used to achieve a high volume fraction of wood fibers in the material, resulting in improved performance. The delignified and compacted wood showed an increase by a factor of 8-12 in mechanical properties, i.e. specific strength and modulus of elasticity, and furthermore, the wear resistance at sliding conditions achieved an order of magnitude improvement. Current activities are striving to reduce the coefficient of friction of densified wood to enable its broader application in tribological sliding systems.

Keywords: Delignified compacted wood, mechanical properties, tribology

PolyTrib2022
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Polymeric, bio-based urea thickener for lubricating greases

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Patrick Degen
Dr.

Presenting author´s biography

Since 2016 Head of Innovation Management at BECHEM
Doctoral thesis at the Dortmund University of Technology: Ultrathin films of molecular sensors and magnetically switchable polymers at liquid and solid interfaces.
Study of chemistry at the University of Essen, Dortmund and Chicago

Research Interests: Colloidal Systems (Foams, Emulsions, Gels)

R&D expertise and experiences: Colloidal and Interface, Rheology, Tribology, Nanotechnology

Publication background: 44 refereed articles in professional journals and books

Polyurea Thickened Lubricating Grease—The Effect of Degree of Polymerization on Rheological and Tribological Properties

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X Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Lubricating greases based on urea thickeners are frequently used in high-performance applications. Surprisingly one property, that has so far been neglected, is to better understand how the degree of polymerization affect such polyurea lubricating systems. In this work, we prepared three different oligo- or polyurea systems with different degrees of polymerization (DP) and investigated the influence of DP on rheological and tribological properties. The results allow for the first time a clear correlation of different molar mass of the urea thickener with the rheological and tribological properties such as extreme pressure behaviour (EP) and the anti-wear behaviour (AW) of the resulting greases. Future work will be devoted to an in-debt analysis of the structure of the grease and the urea thickener within the grease as a dependence of DP and molecular structure to better understand the tribological behaviour.

Keywords: Urea greases, rheology, tribology, degree of polymerization

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Lubrication on Demand & New Interactive Functionalities of Plastic Elements by Microcapsules

Stephan Henzler
Head of Tribology

Presenting author´s biography

Short educational background, research activities/interest, and R&D expertise and experiences, publication background

Mechanical Engineer with more than 10 years' experience I Automotive and Tribology.

- **R&D Engineer @Mercedes** / friction optimization in combustion engine (> 2 years)
- **Engineer for method development @Brose** / Application orientated testing and implementation of KBE Toole (Knowledge Based Engineering) focus on Tribology (> 6 years)
- **Technology Manager @Bechem** / focused in tribological issues and challenges in automobile industry (> 3 years)
- **Head of Tribology @Bechem** / focused in method development in tribological testing & defining new test standards
- **Since 2016 lecturer for Tribology @University of applied science Coburg**

Personal interests:
Tribology is more than testing and calculation. Always try to show people the potentials of these complex subject. Enabler between science and industry interests with tribological impacts

Lubrication on Demand & New Interactive Functionalities of Plastic Elements by Microcapsules

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Abstract

Self-lubricating plastics are not a new idea, and some use polymers such as silicone that migrate to the surface of the component where they form a boundary lubricant layer. Using a liquid lubricant contained in a microcapsule mixed with plastics such as polypropylene, poly oxy methylene and polyamide offers better distribution since it is only released when a capsule is destroyed by mechanical stress caused by friction, lubrication on demand. Furthermore, the classic plastic can be equipped with a "semi intelligence" through this approach. Simplified condition monitoring. In addition, the interaction between humans and surfaces can be expanded; additional functionalities can be integrated into the plastic through microcapsules.

Keywords: lubrication on demand, surface interaction, microcapsules

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Polymers Tribology in Food Packaging Equipment

Tetra Pak Packaging Solutions Spa

Presenter Silvia Rossi
Title: Development Engineer

Silvia Rossi's biography

Silvia was born in the '92 in Viadana, north of Italy. She has bachelor's degree in Civil and Environmental Engineering, at Universita' degli Studi di Parma and master's degree in Materials Engineering, Department of Engineering Enzo Ferrari in Modena.
She has been working at Tetra Pak Packaging Solutions Spa, in Modena, in R&D department since 2017 starting from the Master thesis 'New innovative plastic doors for Filling Machines'. Specialist in Polymers, from materials advanced selection to components failure analysis and characterization. She has been involved in different verification and validation activities of new materials and polymers-based coatings. She managed interactions with suppliers to quickly find solution that guarantee quality and certifications compliance. Driver of root cause analysis of polymers degradation and wearing issues.
Research interests in polymers tribology, polymers wettability and polymers accelerated lifetime tests. Continuous scouting of new compounds and high-performance plastics to mitigate current global raw materials shortage.

POLYMERS TRIBOLOGY IN FOOD PACKAGING EQUIPMENT

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Abstract

In food packaging equipment plastic bushings and rollers can be exposed to demanding conditions in terms of loads, running speed, surrounding temperature and chemical environment. The choice of material coupling with lowest wear rate is critical to maintain the lifetime of the Filling Machine components. A distinctive requirement for material selection in food industries is the compliance to the regulation requested for food contact applications, thus excluding many polymeric grades that are containing fillers not approved. Reference material tribological coupling, PEEK bushing against AISI 316L shaft, suffers of premature wear with generation of black particles. The wear mechanism has been studied both with pin on disk tests and in a test rig, which replicates the coupling of the real components, in terms of geometries and operative conditions. The impact of friction coefficient on interfacial temperature was investigated through measurements and virtual simulations. Due to the high CoF and environmental conditions, an interface temperature exceeding polymer Tg is developed generating black particles. FT-IR characterization of wear debris showed the presence of thermally oxidated PEEK, confirming the root cause. The same methodology and experimental setup have been successfully applied to select alternative plastic grades.

Keywords: PEEK, thermal oxidation, pin on disk, interfacial temperature

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Tribological performance of PA nanocomposites and micro-nanocomposites

VTT Technical Research Centre of Finland, Espoo, Finland

Helena Ronkainen
Title: Dr.

Presenting author´s biography

Helena Ronkainen is a Principle Scientist at VTT Technical Research Centre of Finland. She obtained her M.Sc. degree in Mechanical Engineering and Dr. (Tech) degreed in Materials Science from the Helsinki University of Technology (at present the Aalto University). She has worked in the field of tribology over 30 years and carried out tribology research to provide solutions for energy and material efficiency. The main areas of interest have been surface coatings and materials to provide low friction and high wear resistance for various applications, including the use of computer modeling and simulation to increase the understanding of wear phenomena. Her current research interest has been the development of wear resistance and friction performance of polymers.

TRIBOLOGICAL PERFORMANCE OF PA NANOCOMPOSITES AND MICRO-NANOCOMPOSITES

[1]H. Ronkainen*, [2]J. Pelto, V. Heino, E. Huttunen-Saarivirta
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Abstract

Polymers are used widely in different applications due to their lightweight. Often the wear resistance can be the limiting factor for the use of polymers in demanding applications. In this study the PA1010 polymer was studied and the tribological performance was improved by different nano- and micro-scale fillers. The composites were injection moulded and the friction and wear properties were evaluated in sliding contact against steel counterpart in pin-on-disc tests. Also, the abrasive wear of composited was studied by sand abrasion tests.

The tribological performance of PA1010 was improved by nanofillers and with the combination of micro- and nano-size fillers. The hybrid concept combining the micro-size and nano-size fillers provided the lowest wear losses and friction coefficient in the sliding tests. The lowest wear was received with the PA-GFL-GO hybrid filler concept reducing the wear by 84 % compared to neat PA. The lowest friction was measured for PA-GFL-SiO_2 composite with 24 % reduction compared to neat PA. The tribolayer formation played a key role in both wear and friction performance of the polymer composites.

The abrasive wear was also reduced by filler additions. The abrasive wear of PA1010 was reduced 52% by PA-SiO_2 when the higher loading level was used, and 13 % by PA-HNT when the lower loading level was used.

Keywords: polymer, polyamide, composite, wear, friction, fillers

PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Novel twin-disc tribometer setup with small slip conditions for composite materials

AC2T Research GmbH, Viktor Kaplan Straße 2C, Wiener Neustadt, Austria

Balazs Jakab
Title: Dipl.-Ing.

Presenting author´s biography

Balazs Jakab completed his Master's degree in Mechanical Engineering at Budapest University of Technology and Economics in 2007, from where he moved on to the Austrian Competence Center of Tribology (AC2T). There he works in Project and Work package leadership. His main research interests focus on characterization of tribosystems, including wear diagnostics and friction processes, as well as functional coatings and advanced composite materials.

Selected publications (2015-2021):

- Jakab B., Panaitescu I., Gamsjäger N.: The action of fillers in the enhancement of the tribological performance of epoxy composite coatings, Polym. Testing, 2021
- Gamsjäger N., Jakab B.: Funktionelle Walzenoberflächen in der Papierindustrie, ÖTG 2020, Wr. Neustadt, 2020
- Jakab B., Jakab M., Gamsjäger N.: Tribological modelling and surface characterization of composite calender rolls, program, PolyTrib 2018, Portoroz (SI), 2018
- Jakab B., Gamsjäger N., Steiner H., Ruthner M., Krenn J.: Innovative Komposite-Bezüge mit hoher Verschleißbeständigkeit und verbesserten Antihafteigenschaften für funktionelle Walzen in der Papierindustrie, BHM, 2018
- Jakab B., Gamsjäger N., Steiner H.: Wear resistant coatings with anti-stick properties, stick, PolyTrib 2016, Ljubljana (SI), 2016
- Bianchi D., Scheichl B., Guerrieri Paleotti F.S., Jakab B.: Dynamic behaviour of the doctor blades used in paper industry, Proc, 42nd Leeds-Lyon Symp., Lyon (FR), 2015
- Jakab B., Franek F., Bianchi D., Guerrieri Paleotti F.S.: Tribotechnische Zustandsanalyse im System Schaber/Walze, Zukunft. Forum Papier, Papierfachtagung 2015, Graz (AT), 2015

NOVEL TWIN-DISC TRIBOMETER SETUP WITH SMALL SLIP CONDITIONS FOR COMPOSITE MATERIALS

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

The present work describes a special twin-disctribometer designed for modelling the rolling-sliding contact situation that occurs between the rolls in a paper machine. The crucial aspect was the realisation of low relative circumferential speed differences ("slip"), which can be continuously varied in a wide spectrum. To attain this goal, a special design based on air bearings was implemented. As the internal friction of the device is negligible, the test rig allows measuring friction losses even in free running.

Current results were obtained with winded roll covers and metal rolls. Here the changes of the surfaces at slip variations below 0.5% were investigated. The focus was on the wear phenomenon barring or polygonisation, which is caused by excited vibrations. The implemented accelerometers were able to detect the formation of polygonality. The long-term goal is the characterisation of the the tendency to barring of different covers as function of the roll material.

In the control system it is implemented that the slip ratios can be kept constant under consideration of the wear. In this context, PET discs were tested against metal discs with high slip ratios. This driving method can be used advantageously for wear-intensive materials or for gear components.

Keywords: twin-disc tribometer, low slip ratio, barring, roll covers, slip control

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

All-Hydrocarbon Single Component Composites with Structure Formation under Tribological Loading

Fraunhofer Institute for Mechanics of Materials IWM,
Polymer Tribology and Biomedical Materials Group, Freiburg, Germany

Raimund Jaeger
Title: Dr.

Presenting author´s biography

- Undergraduate Degree in Physics from Albert-Ludwigs-Universität Freiburg, focus polymer physics (1991)
- PhD in Chemical Physics of Polymers, University of Toronto, Canada (1995)
- Post Doc in Materials Science of Polymers at Universiteit Twente, Enschede (1996 – 1998), and work as a researcher in packaging technology at the Agrotechnological Research Institute (ATO) in Wageningen (1998 – 2002), both in the Netherlands
- Since 2002: Head of the group “Polymer Tribology & Biomedical Materials” at the Fraunhofer-Institute for Mechanics of Materials IWM
- Research activities and R&D expertise:
    - Reliability of biomedical materials & implants
    - Additive Manufacturing
    - Polymer Tribology, in particular friction mechanisms, wear of elastomers, polymer-lubricant-interactions

All-Hydrocarbon Single Component Composites with Structure Formation under Tribological Loading

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Abstract

All-hydrocarbon composites ("all-HC") are ideal sustainable materials for lightweight construction: since the matrix and the reinforcing component of the composite are made from the same polymer, the composite can be mechanically recycled several times without detrimental effects on its mechanical properties. All-HC are reactor blends of a low (PE-wax), middle (HDPE) and high molecular weight (UHMWPE) fraction of polyethylene. They can be processed with conventional processing techniques. The UHMWPE-fraction forms nano-fibrils when subjected to extensional flow and shear during processing which re-enforce the material. As a result, the mechanical characteristics of all-HC improve by a factor 4-6 in comparison with HDPE. The current study focusses on the question whether or not the re-enforcing structures can also form in the tribological contact due to the frictional heat and shear forces – do all-HC "run-in" and improve their tribological performance? The formation of the re-enforcing structures was studied with a pin-on-disk tribometer with a heated steel pin and an all-HC disk. For temperatures above 80°C, SEM images showed shish-kebab-structures in the wear track which were aligned in gliding direction. Polymer pins prepared from the wear track showed a reduction of the wear rate by half when gliding lubricated against a steel disk.

Keywords: Single component composite, all-hydrocarbon composite, structure formation, run-in behaviour, shish-kebab-structures, wear

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

A statistics-based approach to polymer durability: enabling AI?

Affiliation: Falex Tribology

Presenter First and last name : Dirk Drees.
Title: Dr

Presenting author´s biography

Metallurgical and Materials Engineer Catholic University Leuven, Belgium and PhD and postdoctoral research on tribocorrosion. In 1999, set up Falex Tribology, European sales and support centre for the Falex group.

Since 2002, CEO of Falex Tribology and grown the lab's testing activities from zero to a million Euro annual turnover, 1000 tests per year. By focus on quality, and understanding the major issues of industrial customers, the test lab has developed numerous new testing methods.

Falex Tribology runs small to large test programs solving industrial questions and plays a key role in many European funded cooperation projects. These projects aim at improvements for quality of life, environmental impact and societal benefits, depending critically on correct evaluation of new materials in their applications.

A statistics-based approach to polymer durability: enabling AI?

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Durability of polymers (wear resistance) is measured in many ways, both non-standardized and standardized. Non-standard methods are used to be close to an application. Here, test geometry, conditions, environment are optimised to correlate to the application. However, such methods cannot be used to compare materials objectively. Standard methods for polymer wear are limited, the major ones are ASTM D3702 and G137, each with their advantages but both with one important disadvantage: large variation in test results. This large variation is not so much instrument or test dependent, but the result of inhomogeneity in materials and their wear mechanism. Dry wear of polymers is inherently a statistical property. Since it is not possible to vastly improve on repeatability of test methods, it is better to produce multiple data points and evaluate trends and outliers of wear resistance, rather than fixating on a single wear-rate number with a large variation.

In this presentation, we will show how multiple data points can be easily produced by reversing the mind set of the tribological experiment. Instead of starting with an expensive single station tribometer with different sensors, we use a ten-station parallel wear generator with only one type of measurement result, namely the wear loss. This enables the plotting of wear trends, rather than a single point with a very wide variation. The risk of misinterpreting outliers reduces, and an interpretation of wear evolution becomes more feasible. The ability to produce larger datasets may also open possibilities for AI based evaluations.

Keywords:
Polymer wear, parallel testing, wear data, statistics

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

In-situ tribological observation of macro and nano-sized structures applied on thiol-acrylate photopolymers

Polymer Competence Center Leoben GmbH, Leoben, Austria

Andreas Hausberger
Title: Dr.

Presenting author´s biography

Dr. Andreas Hausberger has studied polymer engineering at the Montanuniversitaet Leoben. After his master degree he finished his PhD in the field of polymer tribology. Mr. Hausberger is employed at the Polymer Competence Center Leoben GmbH (PCCL) working as a division manager in the field of elastomer technology and process optimization and is the leader of the polymer tribology working group. His main activities are the coordination of governmental founded projects (e.g. COMET-K1, COMET-Module, BRIDGE, Production of the Future) and contractual research. Mr. Hausberger has more than 15 years' experience in polymer tribology related topics. His main research interests are in the field of failure analysis, method development, optimization of materials and components for tribological systems. In an academic context he is lecturing at the faculty of polymer technology in Slovenia the subject's polymer physics and material characterization. He is author and co-author of over 30 articles in scientific journals with IF.

In-situ tribological observation of macro and nano-sized structures applied on thiol-acrylate photopolymers

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Abstract

For the demand of renewable energy and green mobility, tribology plays a decisive role. The reduction of friction and wear is in the foreground here. For these new challenges, in addition to existing concepts based on solid lubricants and material optimization, new approaches, e.g. flexible structures for controlling friction, must be pursued.

In the present work, structures from thiol-acrylate photopolymers with different aspect ratios and shapes were produced using a nanoimprint lithographic process. These structures were investigated regarding their local friction and deformation behaviour. By using an in-situ tribometer, besides the observed the transition from static to dynamic friction, an estimation of the real area of contact could be made, which is generated by the contact points of the structures.

In the study, detailed observations of the mechanisms of different structures could be made in relation to the expression of the local friction including the deformation of the structures. A clear influence of the real area of contact based on the shape and height of the structures as well as the dependence of speed and load could be shown. In a further step, surface modifications are planned which, in combination with the deformation of the structures, can produce a frictional gradient.

Keywords: Elastomeric friction, in-situ, area of real contact, thiol-acrylate, photopolymers nanoimprint lithography

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Are low friction coatings based on transition-metal dichalcogenides good solutions for sliding against polymers?

SEG-CEMMPRE, Departamento de Engenharia Mecânica - Universidade de Coimbra, Coimbra, Portugal
Led&Mat-IPN, Instituto Pedro Nunes, Coimbra, Portugal

Albano Cavaleiro
Title: Professor

Presenting author´s biography

Albano Cavaleiro is Full Professor in the University of Coimbra, Portugal. In 1990, he received a Ph.D. from Coimbra University on the field of Mechanical Engineering, with a thesis on the surface modification of materials by the sputtering deposition of thin coatings. Presently, he is President of CEMMPRE - Centre for Mechanical Engineering Materials and Processes and head of LED&Mat at Instituto Pedro Nunes.
His field of research and publications is very diversified as e.g. on materials and surface engineering, structural transformations, deposition and characterization of thin films, tribology, nanocrystalline / nanocomposite materials. He published more than 400 papers from which about 350 in international journals of SCI. He has now about 9300 citations and H index 50 (Google Scholar).

Are low friction coatings based on transition-metal dichalcogenides good solutions for sliding against polymers?

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Abstract

Transition metal dichalcogenides-based (TMD-based) coatings have been extensively studied and used as dry self-lubricant coatings, especially in the aerospace and automobile industries, due to their low friction characteristics in diverse sliding environments. The low friction property of TMD-based coatings is associated with the easy shear tribolayers formation through a self-adaption process, which is a well-established concept in literature. In this talk, we will present the basis of this self-adaption process as well as the mechanisms governing the tribolayer formation which provides the low friction. Then, we will discuss the suitability of these coatings for providing low friction when sliding against soft materials, as polymers are examples. We will present some results concerning rubbers as counterbodies, as the limit cases for soft polymers.

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PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Development of ternary atmospheric plasma deposited coatings generated under low oxygen conditions with low-friction properties on thermoplastic surfaces

JOANNEUM RESEARCH GmbH/Institute for Surface Technologies and Photonics, Research Group Laser and Plasma Processing, Niklasdorf, Austria

Presenter First and last name: Dietmar Kopp
Title: MSc. (Chemistry), MSc. (Material Science)

Presenting author´s biography

Bachelor and master study in chemistry finished in 2013 at the University of Vienna, followed by a material science study at the Graz University of Technology and accomplishing the master program in 2020 with the topic: Development of the Atmospheric Pressure Plasma Deposition-based coating technology to achieve wear resistance films on a polymer substrate. Since 2020 PhD student at the Graz University of Technology involved in the process-structure relationship investigation of depositing dry lubricants by the atmospheric pressure plasma jet technique. The R&D experience is in the field of generating dry lubricants on polymeric based substrates *e.g.* PA, PEEK and ceramic based coatings for versatile medical applications.

Publication background:

D. Kopp, J. M. Lackner, R. Kaindl, R. Elter, M. Stummer, A. Hinterer, A. M. Coclite, W. Waldhauser, Low-friction, wear-protecting coatings on polymers by atmospheric pressure plasma spraying, Surface and Coatings Technol. 448, (2022). https://doi.org/10.1016/j.surfcoat.2022.128930

R. Kaindl, T. Homola, A. Rastelli, A. Schwarz, A. Tarre, D. Kopp, A. M. Coclite, M. Görtler, B. Meier, B. Prettenthaler, M. Belegratis, J. M. Lackner, W. Waldhauser, Atomic layer deposition of oxide coatings on porous metal and polymer structures fabricated by additive manufacturing methods (laser-based powder bed fusion, material extrusion, material jetting), Surfaces and Interfaces 34, (2022). https://doi.org/10.1016/j.surfin.2022.102361

Development of ternary atmospheric plasma deposited coatings generated under low oxygen conditions with low-friction properties on thermoplastic surfaces

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Abstract

Polyamides are one of the most important thermoplastic synthetic materials in industry with a wide range of applications for mechanical, tribological and thermally heavy-duty machine elements such as gearwheels, bearing elements and guide bushings. The system strength lies in the balance of those three properties. However, they suffer from low wear-resistance and high-friction coefficients in the unlubricated state. Deposition strategies were investigated to obtain low-friction and wear-resistant coatings on polyamide 4.6 (PA4.6) surfaces via atmospheric pressure plasma deposition (APPD). Several composite coatings based on molybdenum disulphide (MoS_2) and graphite were developed to achieve good adhesion and low-friction properties. MoS_2/graphite composite coatings wear rapidly, particularly on the smooth substrate surface (mean substrate roughness $R_a \leq 0.2$ µm of the uncoated PA4.6), which exposes the substrate and leads to friction coefficients higher than those of the uncoated PA4.6 with a rather limited potential for wear protection. However, ad-mixture of Zn to MoS_2/graphite drastically improved the tribological properties and durability in pin-on-disc testing, for which the mechanisms are shown by microstructural/-chemical studies and ANSYS-based fluid dynamic simulation of the interaction of the powder-feedstock with plasma.

Keywords: Polyamide 4.6 (PA4.6), dry lubricant, low-friction coating, atmospheric pressure plasma deposition

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Upscaling the Thickness of Metallic Coating on Polymer Surface

CEMMPRE Mechanical Engineering Department, University of Coimbra, 3030-788 Coimbra, Portugal

Presenter First and last name: Sandra Carvalho
Title: Professor

Presenting author´s biography

Sandra Carvalho is Full Professor at University of Coimbra. She received her PhD degree in Physics in 2004, with a work carried out in Portugal, France, Netherlands and Germany, in the field of hard PVD coatings. Her research activity is focused in innovative nanoscale coating for functional and protective surfaces such decorative, low friction coatings and nanostructured materials with bioactive and antimicrobial properties. She was PI in more than 26 projects at National and European levels. She has 3 submitted patents, more than 125 papers (ISI) and more than 2300 citations, h-index 28 (scopus). She is member from European Joint Committee on Plasma and Ion Surface Engineering and member from Executive Committee of Advanced Surface Engineering Division (*ASED*) of the American Vacuum Society (*AVS*).

Upscaling the Thickness of Metallic Coating on Polymer Surface

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

Polymer engineering comes out as a boon for the automobile industry. The added properties of polymers such as flexibility, durability, lightweight material with low cost production make them perfect for their various uses in automobiles and that is why they can be found almost everywhere from the dashboard, logos, and door panels to the exterior body and much more. In the present study, metallic coating of Chromium (Cr) is deposited on the most used polymer in automobile industry i.e. Polycarbonate (PC) via sputtering at ~0.74 nm/s deposition rate. Deposition of chromium directly onto polymer surface is a challenge as the coatings subjected to external thermal shocks or impact stresses and can easily crack. To overcome this challenge, the coating has been done after plasma etching treatment of the polymer surface, that not only help in saving from cracking of Cr coating as well as provide good adhesion on the polymer surface. The results with and without plasma etched coated surfaces were analysed for a wide thickness range from ~ 400 nm to ~1600 nm. The surface morphology, wettability and contact angle, surface energy, roughness, hardness, and tensile strength of the coated polymer surfaces have been characterized, such as reflectivity measurement and the observation of the coating on microscope to check the cracks and gaps. The tape test confirms the good adhesion of the coatings. It has been observed that up to ~1400 nm of thickness, a good quality (shiny, non-cracking, adhesive) of Cr layer can be deposited on plasma etched PC surface.

Keywords: Polycarbonate, Metallic coating, Plasma etching, Sputtering, Automobiles

PolyTrib2022
5-6 December 2022, Hotel Clarion, Arlanda Stockholm, Sweden

Frictional nanosoldering sheets of pseudocomposites for reducing surface roughness in electrical

Univ. POLITEHNICA-Bucuresti , IMNR-MTN Research-lab. AGIR Bucuresti, Romania

Paul Olaru
Title: Dr.rer.nat.

Presenting author´s biography

1.2013-today-Sr.Expert Engineer Metallurgist- AGIR & SCO Expert, Luzern, Switzerland; New non-ferrous wearing material and special rotocasting technology;, Eliminate H2S;
2. 2011-2013-Sr.Expert Engineer Metallurgist-DANIELI & C. S.p.A. – ITALY;
3.2010-2011-Scientific Manager, Head Technologic & Lab. team, IMNR-Romania;
4.2006-2010-Senior Materials Engineer and Tribology, Honeywell Brno, CZECH Rep; Engineering, Laboratory, Composites, NDT, Microscopy SEM & Optic; Metallurgy leading material &process, non-ferrous materials, wafer fabrication, tribology, evaluations projects, tests, metallography, heat treatments, microscopy, technology, studies, laboratory, aluminum alloys expertise developing aluminum Alloy and advanced metal development; expertise's; SAP activity; 2007- Honeywell Brno, Czech Rep.- Graduate Green Belt for Six Sigma-DFSS; solutions for turbochargers & pressure-vessels; determine wear volume loss - wearing materials-Brevet; Wear machine & the Wyko NT; Interferometallography analyses;
5.2002 <> 2006- Manager engineering casting & heat treatments-INAV Bucharest, RO;
6.1990 <> 2002- Sr. Scientific Researcher & Technologist, FAUR Bucharest-RO;
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FRICTIONAL NANOSOLDERING SHEETS OF PSEUDOCOMPOSITES FOR REDUCING SURFACE ROUGHNESS IN ELECTRICAL

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X Oral Presentation

Abstract:

Nanosoldering Unidirectional Carbon nFiber (UCnF) Reinforced Shape Memory Polymers-(SMPs) Nanostrip Multilayers for Space is pseudo-material which converts a difference in temperature to an electric potential or, conversely, an applied voltage to a difference in temperature. This phenomenon has made these materials attractive for their potential in applications extending from microprocessor cooling to turbocharger & power industry. Shape Memory Polymers-(SMPs). Shape Memory Polymers are a special type of polymer, which can recover the permanent shape upon the application of external stimulus. The main advantage of shape memory polymer the ability of recovering a large amount of strain (usually >400%) in comparison to shape memory alloys (SMP) (up to 15%) and shape memory ceramics (2 - 3%). The material used in this research is SMP due to its excellent shape recoverability. Before going into the details of the various topics of my work some of the basic features of SMP are discussed first. Nanosoldering Unidirectional Carbon nFiber (UCnF) Reinforced Shape Memory Polymers-(SMPs) Nanostrip Multilayers for Space is new pseudo-composite material performing thermoelectric phenomena which provide the direct conversion of heat into electricity or electricity into heat; the phenomena are described by three related mechanisms: the Seebeck, Peltier and Thomson effects.

Keywords: nanosoldering, shape memory polymer, pseudo-composite, multilayer, carbon

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The choice for thermoplastic lubrication by surface and interfacial energies

Fraunhofer Institute for Mechanics of Materials IWM,
Polymer Tribology and Biomedical Materials Group, Freiburg, Germany

Christof Koplin
Title: Dr.-Ing.

Presenting author´s biography

- Degree in Physics from University Bayreuth, focus organic glass former (2001)
- PhD in mechanical engineering, University of Karlsruhe, Germany (2007)
- Post Doc since 2002: in the group “Polymer Tribology & Biomedical Materials” at the Fraunhofer-Institute for Mechanics of Materials IWM
- Research activities and R&D expertise:
    - Polymer Tribology, in particular friction mechanisms, wear of elastomers, polymer-lubricant-interactions
    - Reliability of ceramic components and of biomedical materials & implants
    - Finite-Element-Simulation and methods of Additive Manufacturing

The choice for thermoplastic lubrication by surface and interfacial energies

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

The use of thermoplastic polymers as drive elements can provide a sustainable solution when a long service life can be achieved with bio-based polymer or bio-degradable lubricants. Typically, a range of polymer / lubricant combinations need to be considered to find an optimal replacement with sustainable materials. In addition to the rheological properties of the lubricant and the mechanical characteristics of the polymer, the interactions between the tribological partners and long-term effects on lubricants and polymers in contact have to be considered. Surface- and interfacial energies of the tribological partners can give a first insight into the performance of the tribological system and into the "ageing" behaviour of lubricant and polymer. The spreading tendency of the lubricant influences the adhesive contact of the frictional partners and the transfer- and wear behaviour. The interaction tendency of lubricant and polymer determines the solving, dissolution, adsorption, physisorption and softening behaviour. A higher deformability of a softened polymer surface reduces local stresses in the tribological contact, an increased real contact increases friction and thermal loading. For PA46, POM, PK, PEEK, and water, glycols, polyalkylene glycols, glycerols, PAO and ester oils, the correlation of the spreading- and interaction tendency was correlated with the adhesive and abrasive components of friction and wear.

Keywords: surface and interfacial energies, softening, spreading, sorption, thermoplastic polymers, lubrication

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In-Situ Detection and Quantification of Transfer Films

Affiliation: Leibniz-Institut für Verbundwerkstoffe GmbH (IVW), Kaiserslautern, Germany

Presenter First and last name: Andreas Gebhard
Title: Dipl.-Chem.

Presenting author´s biography

Andreas Gebhard studied Chemistry at the University of Kaiserslautern and at Edinburgh University, Scotland. From 2010 to 2017, he was owner-manager of Tribologic GmbH, before joining IVW in 2017 as Manager Tribology. His research interests are polymer on steel and polymer on polymer sliding with a special focus on transfer films, the design of new tribometers and testing procedures as well as the design and use of information systems for tribology laboratories. He is the author of 9 peer- and non-peer reviewed papers, of 16 conference contributions and of 2 book chapters. He is co-inventor of 4 German national and international patents, one of them on Transfer Film Luminance Analysis.

In-Situ Detection and Quantification of Transfer Films

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Abstract

In dry sliding of polymers on steel, typically transfer films form and greatly impact friction and wear. Despite their significance, until today, they are mainly investigated ex-situ or even ex-post and even then mainly in non-quantitative ways. Transfer Film Luminance Analysis (TLA) is a quantitative, in-situ applicable, laterally extensive and universally applicable method for the detection and quantification of transfer films. Its application to the dry sliding of PPS-based composites against steel has demonstrated that carbon fibers are involved in transfer film instabilities, which then cause fluctuations of the COF, that the adhesive interaction between bulk polymer and polymeric transfer film can outweigh the deformative interaction between bulk polymer and blank steel, and that the extent of transfer film formation is mainly governed by temperature. Its application to graphite composites of PA6 is expected to enable the deconvolution of the individual contributions of adhesion and abrasion to friction, wear and transfer film formation.

Keywords: Transfer Films, Polymers, Adhesion, Abrasion, Transfer Film Luminance Analysis

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Influence of load, sliding speed and heat-sink volume on the tribological behavior of polyoxymethylene (POM) sliding against steel

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Presenter: Muhammad Shoaib Naseem Siddiqui
Title: PhD student

Presenting author´s biography

After finishing high school in 2008, he pursued a bachelor's degree in Metallurgy and Materials engineering from Bahauddin Zakariya University, Multan, Pakistan. He completed his degree in 2012 with a thesis titled "Development, characterization, and heat treatment study of (AISI 5130) steel". Soon after, in 2013, he worked in a "Failure Analysis Center" of a Materials Testing Laboratory in Pakistan for a period of 03 years. In 2016, he joined a Joint European master's degree program with a focus on "Tribology of surfaces and interfaces" under the flagship of prestigious Erasmus Mundus program – TRIBOS. He successfully finished his master studies in 2018 with the thesis titled "Tribological Characterization of DLC Coatings deposited by HiPIMS". In the same year, he started working as a young researcher at the Faculty of Mechanical Engineering in Ljubljana, to continue his PhD studies under the mentorship of Prof. Dr. Mitjan Kalin where he is working on the thermal analysis of polymer containing tribological contacts.

Influence of load, sliding speed and heat-sink volume on the tribological behaviour of polyoxymethylene (POM) sliding against steel

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☐ Oral Presentation

Abstract

Tribological and contact-temperature investigation of unreinforced polyoxymethylene (POM) sliding against steel under a wide range of loads and sliding speeds, more than commonly studied, and at different heat-sink volumes of the steel counter-body is presented. Irrespective of the heat-sink volume, even with an 8-fold increase in the p.v value (0.6–4.8 MPa.m/s), the wear mechanism does not change significantly. This behaviour was understood through four novel empirical criteria, suggesting synergistic interplay of the mechanical and thermal loads, which suppresses the domination and critical state of a single wear mechanism, either mechanical-based or thermal-based. Higher heat-sink volume decreased the contact temperature, which is especially important for high p.v value (4.8 MPa.m/s), resulting in up to 17% lower wear of the polymer.

Keywords: POM, Steel, Wear, Temperature

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Mechanical and tribological characterization of PEEK composites for demanding environments

Department of Engineering Sciences and Mathematics, Luleå University of Technology, Luleå, Sweden

Maksim Nikonovich
Title: Mr.

Presenting author´s biography

Maksim Nikonovich studied Mechanical Engineering in his Bachelor's degree with the focus on thermal physics, fracture mechanics of polymer composites and design of rocket and space structures. He pursued his Master's studies at the Institute of Solid State Physics RAS, working as a junior researcher in high-temperature ceramics for space applications. After his graduation in 2020, he was offered a PhD position in the GreenTRIBOS Marie-Curie double degree program.

Currently, he is at the third year of his PhD studies at Luleå University of Technology and the University of Coimbra under the supervision of Prof. Nazanin Emami and Prof. Amilcar Ramalho. His project is focused on the experimental studies and development of the self-lubricating polymer composites with low-wear properties for cryogenic/hydrogen applications.

Mechanical and tribological characterization of PEEK composites for demanding environments

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Abstract

With the recent developments in industrial, energy and transport sectors, demanding environments, including low temperature vacuum and various cryogenic liquids like liquid nitrogen, hydrogen etc., has gained attraction. Therefore, need for new materials which are capable to perform steadily under these conditions has arisen. In the present study, selected commercial PEEK composites were characterised, before and after aging in liquid nitrogen for 5 months. The materials were tested for their thermal, mechanical and tribological properties to reveal the effect of matrix modification, fillers, environmental and aging on their performances. Addition of carbon fibres enhanced the thermal stability of the tested materials (particularly, temperature of thermal degradation increased by 5°C compared to unreinforced PEEK), while the matrix modification had a minor effect on thermal properties. At low temperature, some of the mechanical properties were improved, including increased toughness of unreinforced polymers. The competitive mechanisms were observed with addition of the fillers. Aging of the polymers revealed cryogenic embrittlement resulted in decrease of the fracture toughness by around 13% and wear resistance by 30%. Tribological tests in vacuum environment showed different mechanisms of transfer film formation, changing the adhesive and abrasive wear observed in air to abrasive and fatigue wear in vacuum.

Keywords: wear, cryogenic temperatures, polymer tribology, vacuum, PEEK

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Wave power - new tribological challenges for reciprocating motion in the offshore environment

CorPower Ocean

Antoine Bonel
Title: Mechanical Engineer

Presenting author´s biography

I am a mechanical engineering who joined CorPower Ocean in 2017 after studying in Strasbourg, France. After an initial master thesis about seals reliability, I joined the mechanical design team, and my missions expanded to:

- designing and using a reciprocating test rig for the evaluation of performance and lifetime of sealing systems
- designing the dynamic sealing and guiding solutions for the first full-scale Wave Energy Converter (called C4), and surrounding mechanical equipment (rods, seal housings, pistons, lubrication, and monitoring systems)
- leading applied research in tribology, lubrication, corrosion, biofouling, and combined loads

Besides my professional passion for R&D, I am also deeply passionate about sustainability topics such as climate change, biodiversity conservation, and management of natural resources.

Contributed to publications:

- “Early biofouling colonization stages: Implications for operation and maintenance planning in marine renewable energy projects” https://open-research-europe.ec.europa.eu/articles/2-108/v1
- “Marine Biofouling, Corrosion, and Wear Protection of Power Take Off Rods for Wave Energy Conversion - Laser Cladding and Scraping” https://onepetro.org/amppcorr/proceedings-abstract/AMPP22/2-AMPP22/D021S010R003/488857

WAVE POWER - NEW TRIBOLOGICAL CHALLENGES FOR RECIPROCATING MOTION IN THE OFFSHORE ENVIRONMENT

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☒ Oral Presentation ☐ Poster Presentation ☐ Not yet known

Abstract

World oceans hold large amounts of untapped energy, that can be converted into low-carbon electricity by different emerging technologies. Wave Energy Converters (WECs) like the ones developed by CorPower Ocean have an oscillating floating body that absorbs the elliptical motion of water particles and converts it into a linear reciprocating movement thanks to several dynamic guiding and sealing systems.

These systems are made of different materials and operate under a range of working conditions, including high side-loads, high speeds, frequent turning points, and strict media separation requirements. This combination brings new tribological challenges, to optimize friction and wear, and guarantee reliable operation in this harsh and remote offshore environment.

The lower guiding point for the WEC is created on a set of submerged metal rods by polymer guiding elements. These are sealed and lubricated with biodegradable oil and are particularly exposed to corrosion of the rod material, sea water and biofouling contamination. The upper guiding point shares the guiding and sealing functions with a high-pressure gas cylinder. The piston countersurface is a polymer liner inside the cylinder barrel.

An overview of these tribological systems will be presented along with an overview of their development through industrial research and collaborations with partners and suppliers. This includes subcomponent testing and validation through different setups, including a dedicated reciprocating seal test rig.

Keywords:
Wave energy, reciprocating motion, offshore environment, dynamic sealing, polymer tribology

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