TECHNISCHE UNIVERSITÄT WIEN
Vienna | Austria

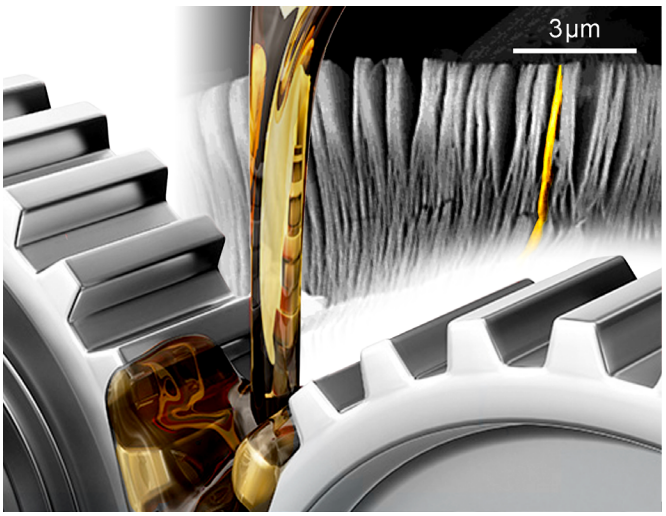
Institute of Engineering Design
and Product Development
Lehargasse 6
1060 Vienna, Austria
www.ikp.tuwien.ac.at

Advanced lubricant additives and surfaces for high-performance applications

Ionic liquids as oil additives and new 2D-materials for improved protection

Gears and other appliances tend to be operated under severe loading conditions, especially in aviation, space, heavy industry, and mobility applications. For example, rotorcraft transmissions consist of complex arrangements of gears and bearings that are intended to carry high loads, thereby raising operating temperatures. However, higher temperatures may cause rapid degradation of transmission components, leading to subsurface damage and eventually, failure. Such failures are catastrophic and endanger the safety of aircraft.

The protection of mechanical components working under severe operating conditions is therefore of the greatest importance.



Advanced conventional lubrication and new 2D-materials

Objective

Prof. Dr.-Ing. Carsten Gachot and his tribology research unit at TU Wien focus on advanced strategies to improve the lifetime of machine elements like gears and bearings. New materials, surfaces and lubricant additives are being investigated and characterized to improve friction and wear properties of machine elements. One major objective is to provide customised solutions based on the development of new 2D-materials and/or by fast precision methods in surface engineering.

Approach

At the TU Wien, a unique combination of fundamental tribology research at the nano- and microscopic scales meets highly specialised test rigs at the component level for rotorcraft transmissions, as well as high-resolution analytical tools available in the Analytical Instrumentation Centre (AIC), the X-Ray Centre, or the University Service Centre for Transmission Electron Microscopy (USTEM). The co-operation of these centres offers a unique environment to find scientific solutions, and to generate new product ideas to meet the challenging needs of industry.

This environment has inspired the creation and analysis of a new family of easy-shearing materials, comparable to a ‘deck of cards’, called 2D-materials, such as MXenes (e.g. Ti4C3), or graphene. Also, novel ionic liquids (basically, liquid salts) were developed and successfully tested within the group. Novel ionic liquids can be applied in rotorcraft transmissions. They offer higher performance, at the same time reducing the number of additives necessary in the base oil.

Furthermore, fast and precise laser-based techniques are used to create tailored surfaces that reduce the friction and wear of moving parts in high-performance applications.

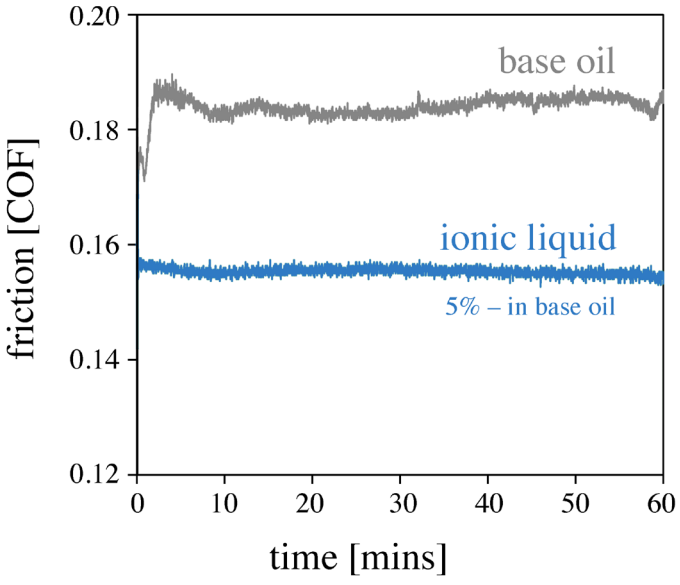
Results

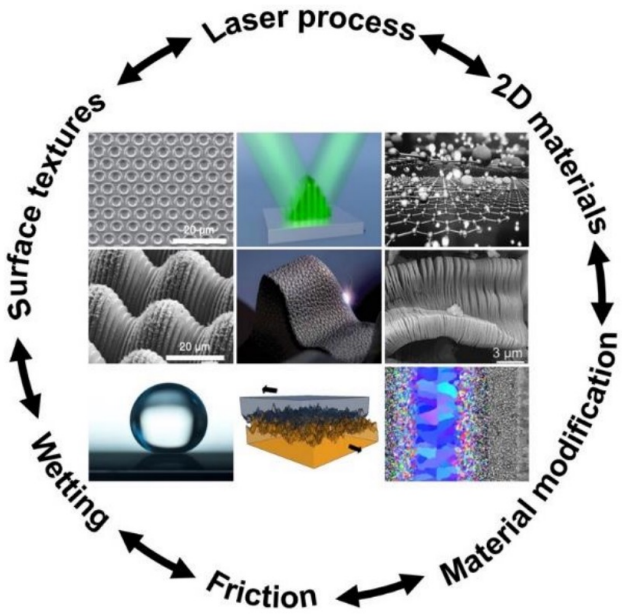
Ionic liquids are a very promising class of materials. Their performance in terms of friction and wear reduction were characterised in detail by mechanically testing them at the facilities of TU Wien according to certification specifications. Ionic liquids show intrinsic properties such as high thermal stability, low volatility, non-flammability, high heat capacity, and electrical conductivity– thus making them attractive candidates to outperform additives currently in use. Ionic liquids are composed of cations and anions, and depending on the type of molecule and structure of these ions the functionality of the liquid varies.

The ions react with metallic surfaces, forming single or multiple molecular layers that easily shear when metals or metallic components (e.g., gears) slide during transmission, thus preventing a direct metal to metalcontact, resulting in lower friction.

The formulation of a lubricant oil usually consists of 80 to 90 % of base oil and 10 to 20 % oil additives. Oil additives can be of different types. They can change, or in the best case improve, the base oil's characteristics.

A direct comparison between the conventional base oil FVA2 on the one hand and ionic liquid blends in a base oil of around 5 wt.-% on the other hand shows a very clear performance difference in terms of the coefficient of friction [COF]. The figure clearly illustrates that the friction measured for the ionic liquid blend with base oil is much lower compared to common oils. By using these ionic liquids, the number of additives in conventional oils can be substantially reduced, while providing excellent friction and wear performance. The synthesis of ionic liquids can be scaled up with tailored physical and chemical properties, depending mainly on the cations and anions used.





New lubrication concepts and tailored surfaces spawned by interdisciplinary co-operation at TU Wien

Applications

Strategies and products to reduce friction and wear have been developed at TU Wien and may be applied to:

- aviation problems such as loss of lubrication in rotorcrafts
- solid lubricants for space applications and harsh environments
- automobile brakes
- rail-wheel contacts
- e-mobility applications such as electrical connectors
- bio tribology: human joints, skin friction etc.

Notes

Contact

Prof. Dr.-Ing. Carsten Gachot
TU Wien – Research Unit Tribology
www.ikp.tuwien.ac.at/tribology
+43 1 58801 30763
carsten.gachot@tuwien.ac.at, rema@tuwien.ac.at