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Advanced wear protection for high performance

Improve lubrication by using ionic liquids as oil additives, new 2D materials as coatings or by laser texturing of surfaces

Gears and other machine elements such as bearings are often operated under severe conditions, particularly in aviation, space, heavy industry, and mobility applications. For example, geared turbo fans or 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 sub-surface 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 highest importance.

Objective

Prof. Dr.-Ing. Carsten Gachot and his tribology research unit at TU Wien focus on advanced strategies to lengthen the life of machine elements or even prosthetic joints. New materials, surfaces and lubricant additives are being investigated and characterized in order to develop new products for improved friction and wear properties. One major objective is to provide customised solutions.

Approach

At the TU Wien, a unique combination of fundamental tribology research on a nano- and microscopic scale is combined with highly specialised test rigs at the component level. High-resolution analytical tools from the Analytical Instrumentation Centre AIC, the X-Ray Centre or the University Service Centre for Transmission Electron Microscopy (USTEM) are used in the research. The cooperation of these centres offers a unique environment to find scientific solutions, and to generate new product ideas to meet the challenging needs of industry.

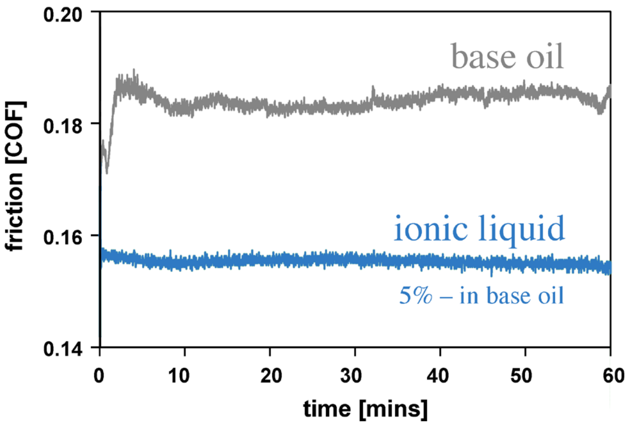
TU Wien creates and analyses novel friction and wear reduction techniques - including ionic liquids, 2D-materials, and rapid, precise laser texturing of surfaces.

Results

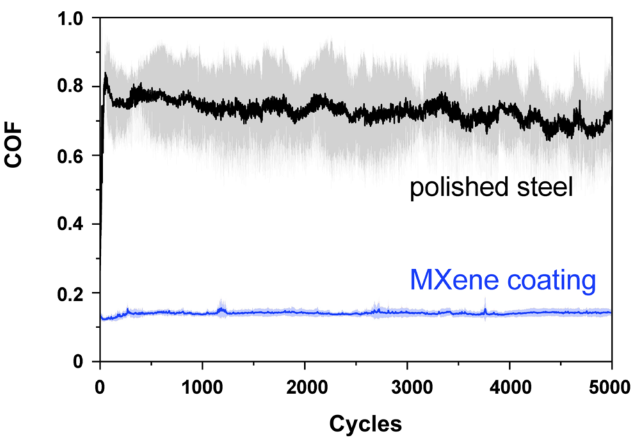
Ionic liquids are a very promising class of materials. Their performance in terms of friction and wear reduction was characterised in detail by means of mechanical testing at TU Wien facilities. Testing was done in accordance with certification specifications. Ionic liquids show useful intrinsic properties such as high thermal stability, low volatility, non-flammability, high heat capacity, and electrical conductivity – thus making them attractiv candidates to outperform the additives used today. Ionic liquids are composed of cations and anions. 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 slide (e.g., gears). They prevent any direct metal-to-metal contact, resulting in lower friction.

A direct comparison between the conventional base oil FVA2 and an ionic liquid blend of around 5 wt.-% in the same base oil shows a very clear performance difference in terms of the coefficient of friction [COF]. (Typical conventional additive contents are in the range of 15-20 wt.-%.) The figure below illustrates that the friction measured for the ionic liquid blend is much lower compared to the base oil.

By using these ionic liquids, the number of additives in conventional oils can be significantly reduced, at the same time providing excellent friction and wear performance. The synthesis of ionic liquids can be scaled up relatively easily. Their physical and chemical properties can be customised, depending on the cations and anions used.

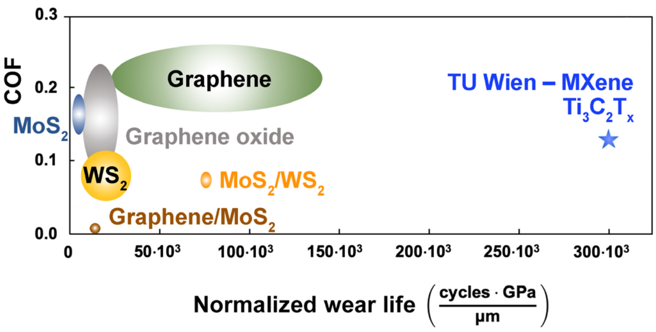


MXenes are novel 2D-materials which can be applied as additives in oils and greases, as coatings on metallic surfaces, and used in polymer composites.



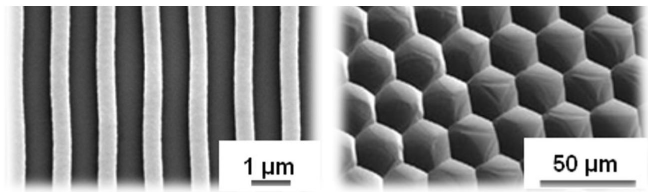
Friction reduction by applying a MXene coating of Ti_3C_2

When used as coatings, MXenes of Ti_4C_3 or Ti_3C_2 outperform well-established solid lubricants in terms of wear life – outperforming molybdenum disulfide (MoS_2), or even graphene.



New MXenes developped by TU Wien improve wear life by factor 2 to 10 compared to known MXenes

Still another way to mitigate friction and wear is to customise material surfaces for specific applications via **laser surface texturing**. Texturing allows for the rapid, precise generation of well-defined microscale topographical patterns in metals, ceramics and polymers (e.g., line- or honeycomb-like patterns).



The new texture enhances a surface's functionality, resulting in controlled friction, low wear or switchable adhesion. Researchers at TU Wien calculate the microscale topography needed based on industrial demand. They create these surface textures for real applications like journal or roller bearings, cylinder liners or even micro-electromechanical systems (MEMS).

Applications

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

- aviation problems such as de-icing of aircraft wings or loss of lubrication in rotorcraft
- 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.

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