Overview of recent dissertations in the field in Finland

Environmentally friendly lubricants can be used to reduce failures in machine elements

Lubricant formulations are undergoing changes as a result of environmental and sustainability concerns. For example, reduced oil reserves and rising oil costs have increased interest in environmentally friendly lubricants. In his doctoral dissertation **MSc (Tech) Reza Bayat** investigated the performance of these oils. His results enable engineers to comprehend the risks and benefits associated with these lubricants' use in machine components.

Today's design trend is toward the higher power density, longer life, and higher energy efficiency of machines. This high-performance demand results in a more challenging operational environment for components. The failure probability of machine elements can be reduced by geometrical design, material improvement, or by using a better lubricant. Lubrication may be improved by using a better base oil to reduce the friction and temperature, and/or using additives that protect the surface against failures such as scuffing.

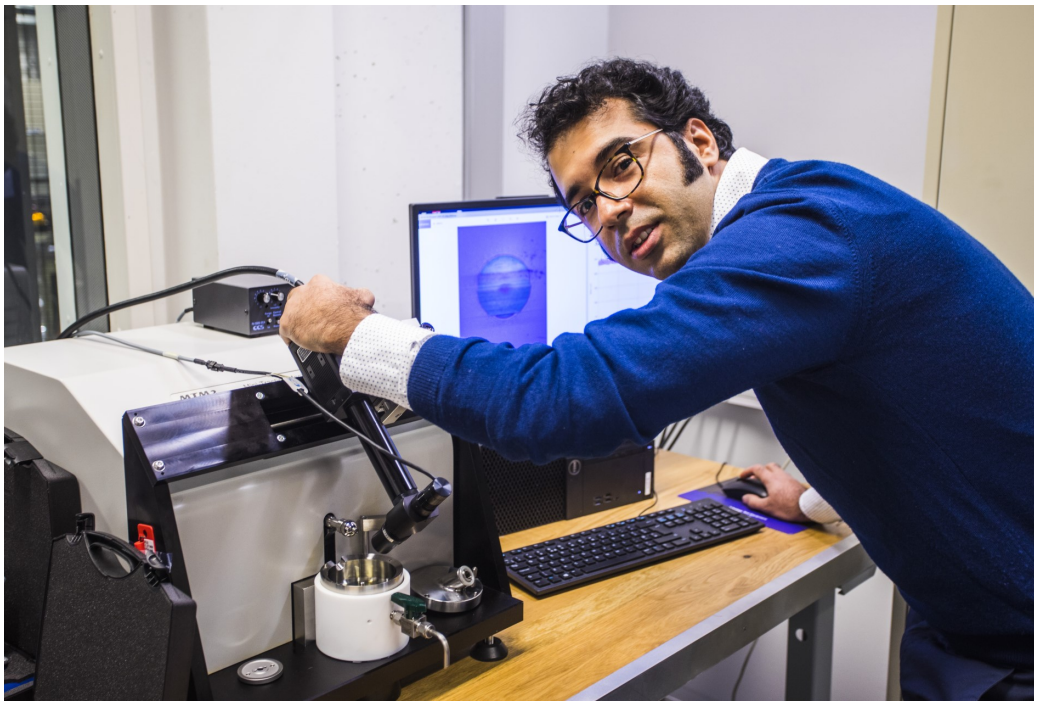
There exist standards that provide test methods for measuring the load-carrying capacity of lubricants, but these tests do not provide fundamental information on what occurs at a gear tooth in different locations. Also, these tests are expensive and time-consuming. On the other hand, a purely scientific approach is usually far from real conditions and cannot easily be used in an industrial approach. Thus, it is very important to develop a method that presents a scientific insight into scuffing and friction, while being applicable for an engineering approach.

Laboratory tests such as the ball-on-disc test may be used for primary screening and achieving scientifically analyzed findings that can be applied to actual components. It is also essential to conduct this preliminary laboratory testing using a fully formulated lubricant, such as industrial EALs (Environmentally Accepted Lubricants) whose usage is growing.

"Using industrial oils will be beneficial as the findings can be linked to the actual component tests. Additionally, it is critical to examine how the base oil and tribofilm contribute to gear lubrication," Bayat says.

The doctoral dissertation of MSc (Tech) Reza Bayat in the field of Material Science and Environmental Engineering titled Evaluation of Gear Oils Lubrication Performance in a Rolling/Sliding Contact was publicly examined in the Faculty of Engineering and Natural Sciences at Tampere University on Friday 06.05.2022. The Opponent were Professor Jorge Humberto Oliveira Seabra, University of Porto, Portugal and Professor Ulf Olofsson, Royal Institute of Technology (KTH), Sweden. The Custos was Professor Arto Lehtovaara from Faculty of Environmental Engineering and Natural sciences.

The dissertation is available online at https://urn.fi/URN:ISBN:978-952-03-2358-5.



Improved quality of hardmetal coatings can expand the use of cost-effective alternative compositions

Tungsten carbide (WC) -based hardmetal coatings have traditionally been the thermal spray industry's go-to solution for wear protection. Risks related to tungsten and cobalt as raw materials, the recent geopolitical turmoil and constant search for manufacturing cost reductions have increased the interest in alternative compositions. Chromium carbide -based coatings can provide a competitive low-cost option in several applications especially when applied with the modern HVAF (high-velocity air-fuel) spray process.

In his doctoral dissertation, **MSc (Tech) Ville Matikainen** studied the formation, properties, and performance of chromium carbide -based coatings, which were manufactured with the modern HVAF spray process. The goal was to produce coatings with improved properties and performance to provide a real alternative to the industry's standard high-velocity oxygen-fuel (HVOF) sprayed tungsten carbide -based materials.

"In thermal spraying, hardmetal coatings are produced by injecting powder into a combustion spray process, which heats up the particles and accelerates them to high velocity before they impact on a surface and build up a coating. In the HVAF spray process, the particles are accelerated to higher impact velocities compared to other processes, which results in denser and mechanically stronger coatings," Matikainen summarises his study.

This improved coating quality is one of the key factors determining the performance of the selected coating compositions. Moreover, improved performance enables using cheaper materials in the coatings, such as chromium carbide based hardmetals, while maintaining sufficient performance. In his study, Matikainen investigated several coating compositions and thoroughly tested them in several wear environments to assess their potential. The results showed improved mechanical properties and performance compared to HVOF sprayed coatings.

"Tampere Wear Center (TWC) provided an ideal environment to carry out the wear testing of manufactured coatings. In some wear conditions, the HVAF-sprayed chromium carbide -based coatings performed even better than HVOF sprayed WC-CoCr coatings, offering a cost-efficient alternative to the standard solution," Matikainen says.

Chromium carbide -based coatings also provide an alternative for reducing the use of tungsten and cobalt, which are on the EU's list of critical raw materials because they come with verified risks caused by their economic significance and high supply risks.

"In addition to the already existing supply risks, the current global situation is yet another factor and a real wake-up call for many companies to look for more optimised and tailored coating solutions because of increased costs. The results of the dissertation provide new insights into the HVAF spray process as well as to chromium carbide -based coatings, serving the thermal spray industry," Matikainen explains.

The doctoral dissertation of MSc (Tech) Ville Matikainen in the field of surface engineering titled Modern HVAF Spray Process and Cr3C2 -Based Coatings: Exploring the process, structure, properties and performance was publicly examined at the Faculty of Engineering and Natural Sciences at Tampere University on Friday 13 May 2022. The Opponents were be Professor Christian Moreau from Concordia University and Professor Michael Gasik from Aalto University. Professor Minnamari Vippola from the Faculty of Engineering and Natural Sciences was the Custos.

The dissertation is available online at http://urn.fi/URN:ISBN:978-952-03-2403-2