"Tribofilm formation in helicopter gears and how novel lubricants overcome loss of lubrication conditions"

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Ionic liquids have been used effectively in many applications for reducing problems related to friction and wear. The influence of ionic liquids on gear scuffing has been studied with three different ionic liquids. The tribological experiments have been conducted using AFM on nanoscale and SRV tester on meso- and FZG test rig on macroscale at 40, 90 and 120 °C. All three ionic liquids showed a temperature dependent improvement as far as scuffing is concerned. The research work aims at elucidating the governing physico-chemical mechanisms and how these blends of base oil and ionic liquids could be further optimized for real applications.

Keywords: helicopter gears, tribofilms, ionic liquids

1. Introduction

Friction and wear in machine elements, such as gears or the piston cylinder assembly, is a major problem reducing the energy efficiency of these components [1]. Since ancient times lubricants have been used to lower friction and wear by separating the surfaces sliding in relative motion. This reduces or prevents direct contact between the solid surfaces and therefore diminishes adhesion and as a result friction and wear. The lifetime of machine elements and thus their safety is also of key significance. One example where this is highly relevant are helicopter gearboxes. In these transmissions, loss of lubrication can occur because of design, maintenance, or operational errors leading eventually to catastrophic failures. According to aviation standards, the gearbox still has to properly function for at least 30 minutes after loss of lubrication starts [2]. Here, we study the tribological performance of nanoscale liquid lubricants, namely three ionic liquids, on different scales, ranging from their nanoscopic behavior with AFM measurements, to an intermedium level with laboratory tribological testing to finally the application level in the form of gears, which are typically used in helicopter gearboxes. Especially, the influence of different testing temperatures is investigated with the aim of evaluating the possibility to tailor the IL lubricant to a specific operating temperature in a machine element.

2. Methods

In this work, three ionic liquids (IL´s) are evaluated for their tribological performance for rotorcraft transmissions. 5 weight percentage of each IL is mixed with a additive-free BO oil and stirred constantly for 2 hours. The base oil is free from any additive packages before adding the ILs. The IL1 & IL2 has similar cations whereas the IL2 & IL3 has similar anions with methyl phosphate unlike the anion of IL1, which consists of a butyl phosphate structure. Water content of the respective IL´s has been measured and synchrotron radiation was applied to determine the structure of the IL´s. Additionally, friction tests on nanoscopic level (AFM), mesoscale (SRV tester) and macroscale at a modified FZG test rig for gear parts were done at 40, 90 and 120 °C. Wear tracks were observed by optical microscopy and profilometry.

3. Results and Discussion

All three IL´s showed a significant tribological improvement on all three testing scales. Particularly, FZG test results showed a temperature dependent improvement regarding scuffing. The scuffing results clearly highlight that test pairs are still not scuffed even at load stage 12 of the standard test.
The wear track inspection indicates a pronounced difference in wear marks for all tested species with a clear preference for the IL 3.

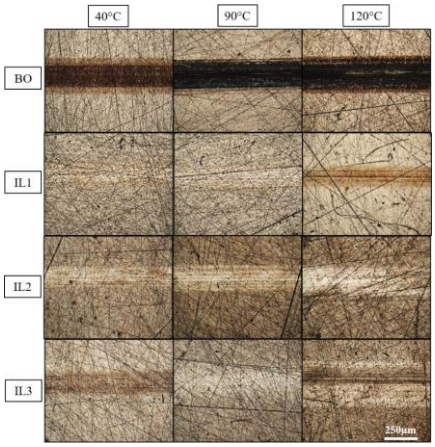

Figure 1: Confocal microscopy image of wear tracks on steel substrates after SRV tests under an additive-free base oil (BO) and IL´s 1-3 at distinct temperatures of 40, 90 and 120 °C.

4. Acknowledgements

The government of Lower Austria is gratefully acknowledged for funding the endowed professorship of tribology at TU Wien

5. References

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