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Conductive lubricants to prevent hydrogen assisted rolling contact fatigue

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Electrically conductive lubricants offer the opportunity to reduce premature failures and increase the bearing lifetime. Rolling contact fatigue tests with conductive lubricants show very promising results with nearly double the lifetime of the bearing. Oxidation and fragmentation reaction of the lubricant, electrical fields and micro current passage through the rolling contact cause free hydrogen formation and eventually WEC formation in bearings. Ionic liquids as an additive for fully formulated lubricants can help to increase lubricity and reduce their electrical resistance. Improving the conductivity of the lubricant helps to avoid bearing WEC damage and additionally improves the tribological properties of the lubricants.

Keywords: Ionic Liquids, White Etching Cracks, Rolling Contact Fatigue, Hydrogen Embrittlement

1. Introduction

In order to increase the reliability and availability of wind turbines, bearings must be protected against premature failures. White etching cracks (WEC) is one of the most frequent damages in rolling element bearings. It is suggested that WEC is caused by hydrogen embrittlement [1]. The formation of hydrogen in a tribological contact is caused by lubricant degradation. Electrical fields and micro current passage through the rolling contact possibly influence lubricant degradation and hydrogen formation.

2. Methods

Eclectically conductive lubricants can be a possible solution to reduce a micro current passage in tribological contacts and prolong bearing life. Adding ionic liquids (IL) to non-polar lubricants is challenging because their solubility is limited. Impurities in the ILs can strongly affect the tribological behavior. Therefore, structural motifs of ILs were selected, for which sufficient solubility in lubricants can be expected to achieve sufficient electrical conductivity of the lubricant (Figure 1). Rolling contact fatigue (RCF) tests with thrust roller bearings offer the opportunity to characterize different lubricants concerning their affinity to hydrogen embrittlement in bearings. Various test series with different oils and IL and additive contents have so far shown that a significant improvement in running behavior is achieved by adding ILs. Figure 2 shows a comparison of the results of a RCF test for a gearbox oil with different IL contents. 3 test were conducted for each lubricant sample. The pure gearbox oil leads to a bearing damage after a test duration of 80 – 95 hours in all cases. Adding a low content of IL to the gearbox oil improves the bearing performance (Fig. 3). Maximum test duration of 150 hours was achieved in 2 of 3 tests. With higher IL content no damage occurred within the test duration of 150 h.

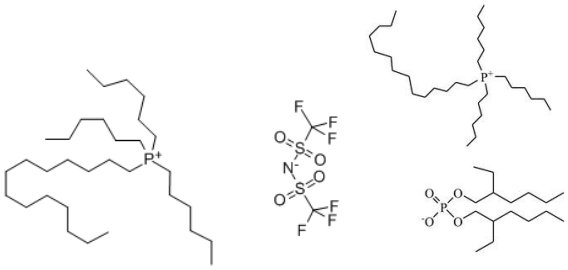

Figure 1: Basic structural formulas of ionic liquids potentially suitable for oil additives.

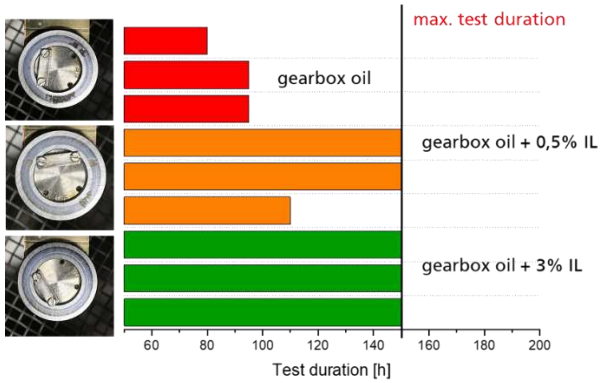

Figure 2: Comparison of the running time for different model lubricants.

3. Discussion

These results already show that the addition of ionic liquids to lubricants, increase the lifetime of a bearing and reduces premature failures. Therefore significant improvements may be achieved in wind power applications. In addition, the expected reduction in friction helps to reduce power losses in the gearbox.

4. References

[1] Kürten, D. et al., "Hydrogen assisted rolling contact fatigue due to lubricant degradation and formation of white etching areas," Engineering Failure Analysis, vol. 99, pp. 330-342, 2019