Physico-chemical characterization of a third body adherent deposit on highly loaded greased oscillating ball bearings

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Abstract

Oscillating bearings have a wide range of industrial applications in robotics, wind energy, aeronautics, amongst others. In aeronautics, they are crucial component of aircraft flight control surfaces such as ailerons or flaps. In those applications, bearings are greased and submitted to very high loads (resulting in several GPa between the ball contact and the raceways) and almost zero speeds. In such conditions, the bearing is operating in mixed or even boundary lubrication regimes. In previous studies, numerous repeatable tests (1, 2) were carried out to understand the effect of grease lubrication on bearings lifetime and observed failure. It was demonstrated that the lifetime was related, among other things, to the formation of a protective nanometric layer at the contact interface, resulting from interactions between the grease and its environment (1). In addition, a more detailed analysis of the bearing life showed a long period of steady state without major disturbance in friction and of the bearing surface. Thanks to previous work, this modified layer has been highlighted, but only after the bearing has failed.
This communication will focus on the formation and behaviour of this layer over the life of the bearing. For the purpose, interrupted tests are carried out. The experimental approach allows to understand the mechanisms of formation of this protective layer, its adaptation with its environment, its evolution (physical, chemical and mechanical properties) throughout the bearing life cycle, as well as the triggering of its failure. The samples used for this analysis are tested on a dedicated test bench that reproduces an oscillation motion on bearings inner ring of 20$\circ$ amplitude, at a frequency of 5Hz with a radial force equivalent to a stress of 5GPa between the most loaded ball and the inner ring. Deep groove ball bearings are used which are greased to at least 80% of their free volume.

Simulations (1) show that the most stressed element is the inner ring in the radial force axis. Therefore, the study will focus mainly on this contact. Optical microscopy, scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS) and an interference

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profilometry were used to analyse the surface to obtain information about its chemical composition, as well as its deformation, wear and failure. Cross sections were made to observe the change in microstructure in the depth of the samples.

The first results show a softening of surfaces observed at the SEM confirm by profilometry. This transformation is not homogeneous over the entire surface of the inner ring, and its morphology can be granular or a result of plastic flow. XPS analyses show that this adhesive deposit is formed from the elements of the grease and of the contacting surfaces, and this deposit is stratified, i.e. its chemical composition is not homogeneous throughout its thickness.

References:

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