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Study of Scale Effect in a Starved Elastohydrodynamically Lubricated Contact

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Abstract: One of the most important parameters determining the performance and life of machine parts is a lubrication film thickness and its distribution. Current experimental and numerical studies are mostly connected with oil lubrication. However greases are used in more than 80 % of all rolling bearings where the starvation phenomenon occurs most frequently. The question is whether the results obtained from the laboratory scaled contact test device are transferable to real operating conditions of full scale bearings. The aim of this work is to compare these two approaches to measuring film thickness of different greases. The use of multiple contacts optical test rig based on thin film colorimetric interferometry for film thickness measurement has enables to obtain film thickness of starved contact and the film distribution. The experimental observation of full-scale model of bearing will help to understand better the behavior of real bearing.

Introduction

In the rolling bearing there is always a slight slippage between the rolling elements and bearing ring. The rolling element is separated by a lubricant in the bearing ring, which greatly reduces the pressure, friction, wear and bearing life. Lots of articles dealing with the study of greases and influence of operation conditions on film thickness were already published. In subsequent studies it was found that the replenishment significantly affects not only the operating, but also bearing design, such as presence of a cage or spin of the balls bearings.

Cann further experimented with the relationship between the film thicknesses [1], the properties of the lubricant and variable parameters: oil volume, speed, load and viscosity. The thickness of the lubricant film in contact with non-conformal friction surfaces can be affected by a number of operational factors. It is essential to know how bearing works under the starved regime. The fully flooded regime is characterized by a film thickness, which increases with increasing speed, in accordance with the Hamrock–Dowson rules [2]. Interesting results in [1] were obtained when examining the effect of the ball spin. The spin motion helps to transfer the lubricant to the track after contact.

The effect of cage design on replenishment was also studied. With grease lubrication, the presence of a cage can have a significant effect upon film thickness. The onset of starvation is delayed until far higher speeds with the closely conforming cage. The cage appeared to work by redistributing the grease in the cage/ball contact [3]. In most of articles measurements was made on single contact ball-on-disc bearing simulator. One exception is a study [4] where a relationship between full-scale bearing test and laboratory simulation is described on the case of friction. These experiments have shown that friction is reduced for semi-starved contacts but increases dramatically for starved conditions.

Experimental measurement

Ball-on-disc device with single bearing contact (Fig. 1a) was used to establish the behavior of the film thickness with a range of speed conditions. For full-scale measurement two series of test were conducted. In the first series axial bearing with a full number of 16 balls (Fig. 1b) was used. In another series of tests dimensionally identical axial bearing with 8 balls were used.

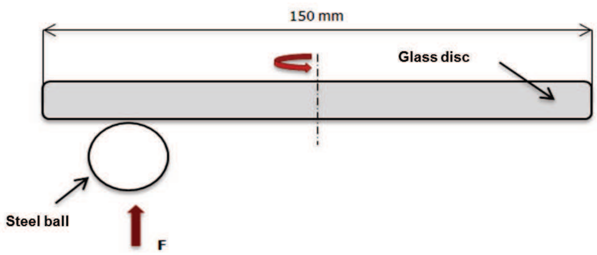

Fig. 1a: Single contact (ball-on-disc) device

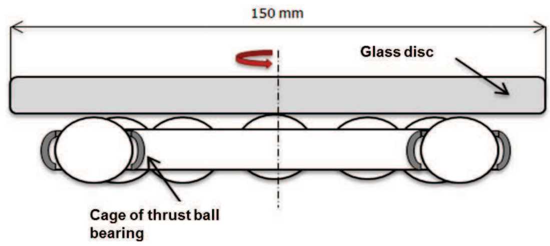

Fig. 1b: Full scale test device

If the gap between the cage and the ball is too small, the lubricant is wipe out by the cages and contact is starving. It is also necessary to consider the material selection of bearing cage. A metal cage is a potential source of wear particles that can act as a catalyst for oxidation and degradation of the grease. The early aging of lubricant may result in a reduction in the ability self-regeneration of lubricant in elastohydrodynamic contact and it can leads to surface contact and consequently to bearings damage.

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