Does Laser Surface Texturing Really Have a Negative Impact on the Fatigue Lifetime of Mechanical Components?

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Laser surface texturing (LST) has been proven to improve the tribological performance of machine elements. However, not many studies have investigated the use of LST in the boundary lubrication regime, likely due to concerns of increasing surface roughness. This study aims to examine the influence of LST on the fatigue lifetime of thrust rolling bearings under boundary lubrication. The textured patterns not only retain lubricant but also enhance the formation of anti-wear tribofilm. In contrast to the negative concerns, the ball bearings with cross patterns were instead found to increase the fatigue life by a factor of three.
Keywords: Thrust rolling bearing, laser surface texturing, direct laser interference patterning, ZDDP, boundary lubrication.

1. Introduction

Novel methods of surface engineering, such as laser surface texturing (LST), have been proven to be beneficial for the tribological performance [1]. It is suggested that LST provides positive contributions in almost every lubrication condition. Furthermore, the combined uses of LST and anti-wear additives such as zinc dialkyldithiophosphate (ZDDP) reduce tribological damage [2]. Since there is still only few LST studies under boundary lubrication, this study aims at evaluating the fatigue lifetime of laser textured rolling bearings. Four different pattern geometry designs were initially tested regarding their performance in terms of wear, and the best of these designs were used for the subsequent fatigue tests. The results are statistically analyzed by a Weibull distribution. Finally, the effect of the laser patterns on the contact pressure distribution has been examined by contact simulation models.

2. Laser Surface Texturing

Two geometrically different LST patterns were tested in the present study: dimple and cross patterns; and the schematic of the LST pattern on the rolling bearings is shown in Figure 1. The periodic distance between dimples was set as 200 and 500 µm, respectively. Moreover, the cross patterns were textured with a periodicity of 9 and 30 µm (cross9 and cross30).

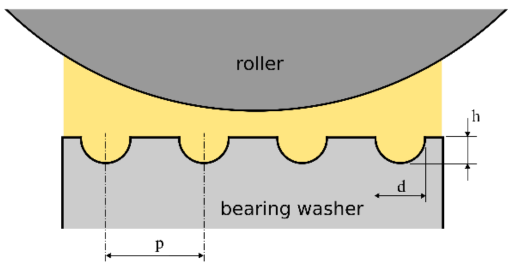

Figure 1: A schematic of the profile of the laser textured surface in a lubricated contact condition.

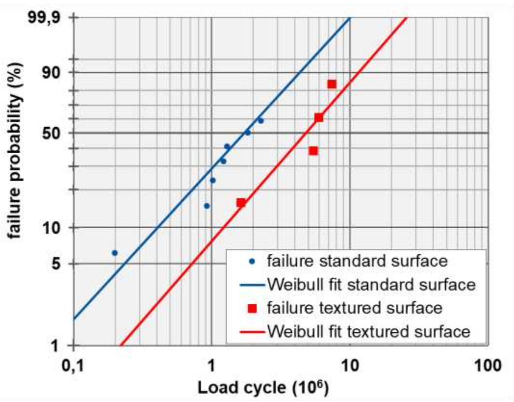

Figure 2: Weibull distribution of the fatigue tests of the reference and the Cross30 laser textured thrust ball bearings.

3. Results and conclusions

Firstly, topographic parameters R_k and R_{sk} demonstrated the capacity of lubricant storage produced by LST patterns. Furthermore, a subsequent Raman analysis identified the ZDDP anti-wear tribofilm on top of the surfaces, which decreases wear loss significantly.
Finally, a three-fold increase in fatigue lifetime was demonstrated for the laser textured thrust rolling bearings with cross patterns. This is attributed to the ability of the LST patterns to retain lubricants within the contact, which ensures sufficient lubrication under such high-load conditions, combined with the enhanced formation of the ZDDP tribofilm that prevents direct contact between surfaces. LST has been proven to reduce wear of roller bearings in the boundary lubrication regime.

4. References

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