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ROLLING ELEMENT BEARING LUBRICANT DEBRIS DAMAGE ASSESSMENT AND LIFE PREDICTION

MICHAEL R. HOEPRICH

The Timken Company
1835 Dueber Avenue, S.W.
Canton, Ohio 44706-0930, U.S.A.

Rolling element bearing fatigue life can be significantly reduced by debris particles in lubricants. The debris particles cause raceway surface dents that initiate early fatigue damage. Optical interferometry has been found to be the best method for characterizing bearing raceway debris dent damage. This technique is used to determine the important features, sizes and density of dents. The resulting data file is then used to determine bearing fatigue life. Tests show that bearings manufactured by different processes and material types are affected differently by debris damage and that these differences must be considered by life prediction methodologies. Bearings made by a specific enhanced process can significantly resist the deleterious effects of debris damage and outperform bearings made by other means.

Key Words : Rolling Element Bearings, Fatigue Life, Debris, Dents

INTRODUCTION

Debris particle contamination in lubricants can cause a significant reduction in rolling element bearing fatigue life. Raceway surface dents caused by these debris particles result in highly stressed fatigue initiation sites. The nature of debris particles (metallic, non-metallic) and their corresponding properties (hardness, friability) affect the severity of the dents caused by these particles and the resulting degree of fatigue life reduction. Material and manufacturing processes also significantly affect the ability of the bearing to succumb to or resist the effects of debris denting damage. This paper discusses techniques for assessing the severity of debris denting on raceway surfaces and for analytically predicting the effect of these dents on bearing fatigue life.

DEBRIS DAMAGE ASSESSMENT PROCEDURE

The best method for characterizing debris dent damage on bearing raceways has been found to be a direct measurement procedure that uses optical interferometry [1]. By this technique, the dent density and their features are recorded. This information, along with bearing geometry and load, are used to determine bearing fatigue life [2].

It is recognized that in some situations it may be necessary to determine bearing life from lubricant contamination analysis. By denting bearings with known particle distributions, the optical interferometry method was used to correlate lubricant contamination with surface damage and, hence, fatigue life. Figure 1 shows the effect of different cleanness levels on life. The cleanness level ISO 15/12 is the base cleanness level in laboratory life testing. Note that fatigue life is more sensitive to debris dents at lighter loads. The rate and timing of the introduction of debris into the lubricant can follow various paths. The life of bearings subjected to a variable exposure to debris can be evaluated by considering the changing effects on life [3].

LIFE TEST PERFORMANCE COMPARISONS

A standardized method to evaluate the debris resistance of bearings has been developed and is described in reference [4]. In this procedure the test bearings are pre-dented, cleaned and life tested with no additional debris being added during testing.

In Figure 2, the performance comparison for five major tapered roller bearing manufacturers is shown and illustrates the differences in material responses to debris dents [5]. This testing was performed on standard product, manufactured with the conventional process common to each respective manufacturer. The results within this group varied by a factor of about three with Brg A having the highest relative performance. Brg B and Brg E used through hardened material and processing.

IMPROVED MATERIALS AND PERFORMANCE

By studying the unique metallurgical design and processing parameters used to produce Brg A, an improved debris resistant material was developed by enhancing the bearing's mechanical properties of strength, ductility and toughness. The performance results of this new debris resistant design and processing approach are shown in Figure 3. The life testing shown was performed on a mid-sized, 248mm O.D. bearing. In this test, the enhanced bearing performed 2.3 times better than the standard bearings. Figure 4 shows the relative performance of the enhance debris resistant bearing, the standard bearing and bearings of through hardened material.

CONCLUSIONS

The new life prediction model provides a practical connection between actual debris dents and subsequent fatigue damage. The direct optical measurement of damage method provides more precision over other approaches involving lubricant contamination analysis.

Standardized life testing with debris showed that bearings made by various manufacturers perform at significantly different levels. These differences should be considered when making comparisons concerning the relative hierarchy of product debris resistance and when applying performance prediction tools.

ACKNOWLEDGMENTS

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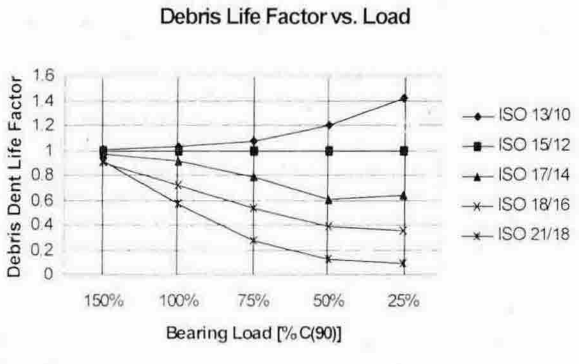

Figure 1 — Debris life adjustment factor as a function of load and various ISO Codes.

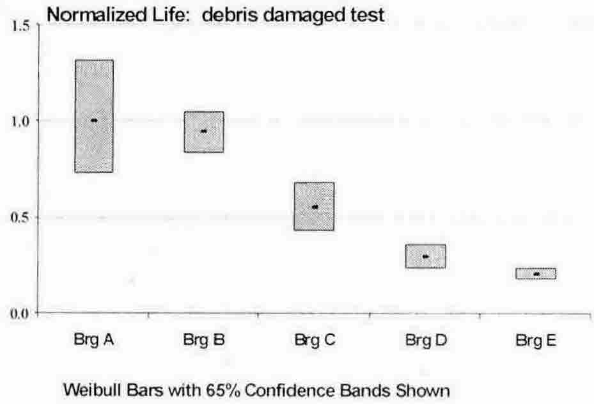

Figure 2 – Life test comparison of 5 conventional process bearings from different manufacturers, bearing O.D. 73 mm.

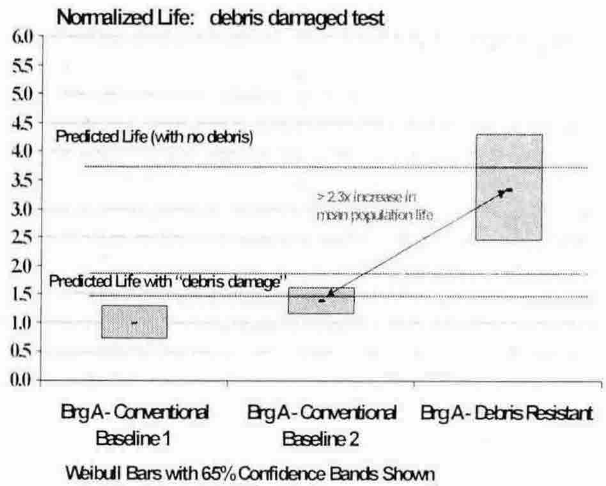

Figure 3 Life test comparison of one manufacturer's "debris resistant bearing" versus conventional baseline process, bearing O.D. 248 mm.

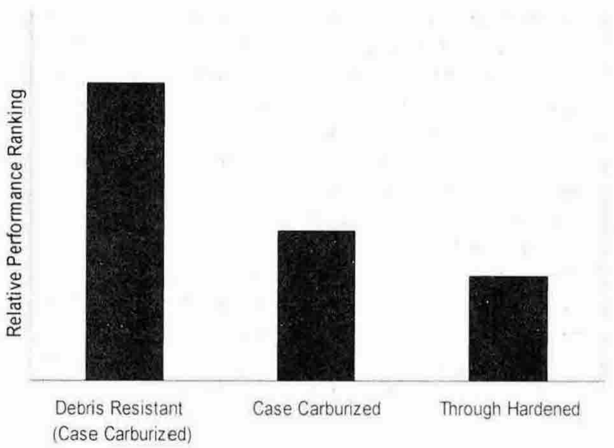

Figure 4 – Relative debris life factor for bearing materials.