Advanced Condition Monitoring of Micropitting Using Multiple Sensing

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Rolling element bearings perform under most operating conditions without any problems, but there are certain conditions where micropitting appears. Although considerable work has been conducted on investigating drivers of micropitting, micropitting evolution has been poorly captured by traditional condition monitoring. In this study, micropitting evolution was detected by acoustic emission (AE) and electrostatic (ES) sensing and the wear mechanisms were identified using physical inspections. Results showed AE sensing was sensitive to asperity contact conditions and crack/pit propagation, and ES sensing was capable of detecting microstructure alterations, tribofilms, cracks and pits.

Keywords: rolling element bearing, micropitting, acoustic emission sensing, electrostatic sensing

1. Introduction

Micropitting is a type of surface-initiated rolling contact fatigue (RCF) that occurs in rolling and sliding contacts operating under mixed or boundary lubrication. Considerable work has been conducted on investigating influencing factors of micropitting based on post-test inspections of contact surfaces [1, 2]. However, due to weak signals generated, micropitting evolution has been poorly monitored by traditional online sensing techniques. Therefore, the mechanisms for initiation and evolution of micropitting evolution are still not fully understood. Referring to previous studies where AE and ES sensing has been applied in RCF tests [3, 4], these two techniques are expected to detect features of micropitting evolution. This work aims to develop a better understanding of the micropitting evolution mechanism using AE and ES sensing and advanced signal processing techniques corroborated by physical inspections.

2. Methods

Micropitting tests were performed on a Phoenix Tribology Ltd. TE74 Two Roller test machine. Bearing steel (AISI 52100) rollers were used to simulate the rolling and sliding contact. The oil used was Durasyn 168 mixed with 2% secondary ZDDP with the inlet temperature of 100 °C. The maximum Hertzian contact pressure was controlled at 2 GPa and the slide-roll ratio was -6%. The lambda ratio was controlled at 0.3 to ensure the tests were run under boundary lubrication conditions. Vibration, AE and ES data were recorded during testing. Time-frequency domain and signal averaging analyses of the data were employed to extract features generated during micropitting evolution. Tachometers were incorporated to monitor the rotation of rollers and identify positions of micropitting. After testing, optical and electron microscopes were used to examine the worn surfaces and sub-surface damage to determine the mechanisms involved to interpret online data.

3. Results and Discussion

The micropits generated were formed by interactions between fatigue cracks. These cracks initiated and propagated in the near-surface region where plastic deformation occurred.

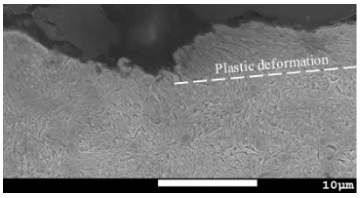

Figure 1: Cross-section of cracks and micropits.

AE data analyses indicated AE time-domain features were dependent on the amount of asperity contact and revealed generation of cracks and pits. The damage resulted in peaks in power spectrum density at frequencies between 0.3 to 0.7 MHz. Signal averaging and frequency analyses of ES identified plastic deformation, tribofilms, cracks and pits.

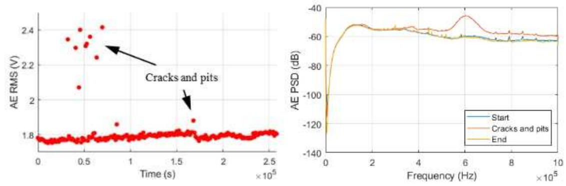

Figure 2: Cracks and pits revealed in AE.

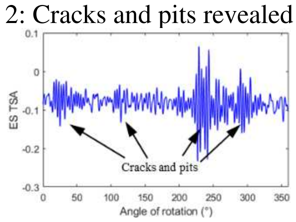

Figure 3: Cracks and pits revealed in ES.

4. References

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