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TIME-DEPENDENT ANALYSES OF WEAR IN OSCILLATING BEARING APPLICATIONS

TRACK OR CATEGORY

WEAR

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INTRODUCTION

Oscillating bearings can be found in several industrial applications. The minute motion is intentional in some applications like blade bearings for wind turbines [1]. Other bearings in technical systems are unintentionally affected by vibrations due to operation or shipping.

The dominating and therefore most focused upon damage modes in oscillating bearings are false brinelling and fretting corrosion [2]. False brinelling was first mentioned by ALMEN in 1937 [3]. Figure 1 shows a false brinelling damage and the typically occurring areas due to slip. False brinelling can be found in lubricated bearings operating under small pivoting angles. The greyish color occurs due to the formation of magnetite, i.e. Fe_3O_4.

First effects of fretting wear were mentioned in 1927 by TOMLINSION [4]. The term fretting is used for damages where two contacting surfaces are subjected to relative slip [5]. The main difference between false brinelling and fretting corrosion is, that false brinelling occurs under mixed lubrication conditions, while fretting corrosion occurs under dry contact conditions. In unlubricated contacts the oxide film will be time-dependently destroyed due to the metal-metal contact. The oxide particles in the contact spot will then lead to abrasive wear. Figure 1 shows a fretting corrosion damage of a point-contact. The reddish color occurs due to the formation of hematite, i.e. alpha - Fe_2O_3 [6].

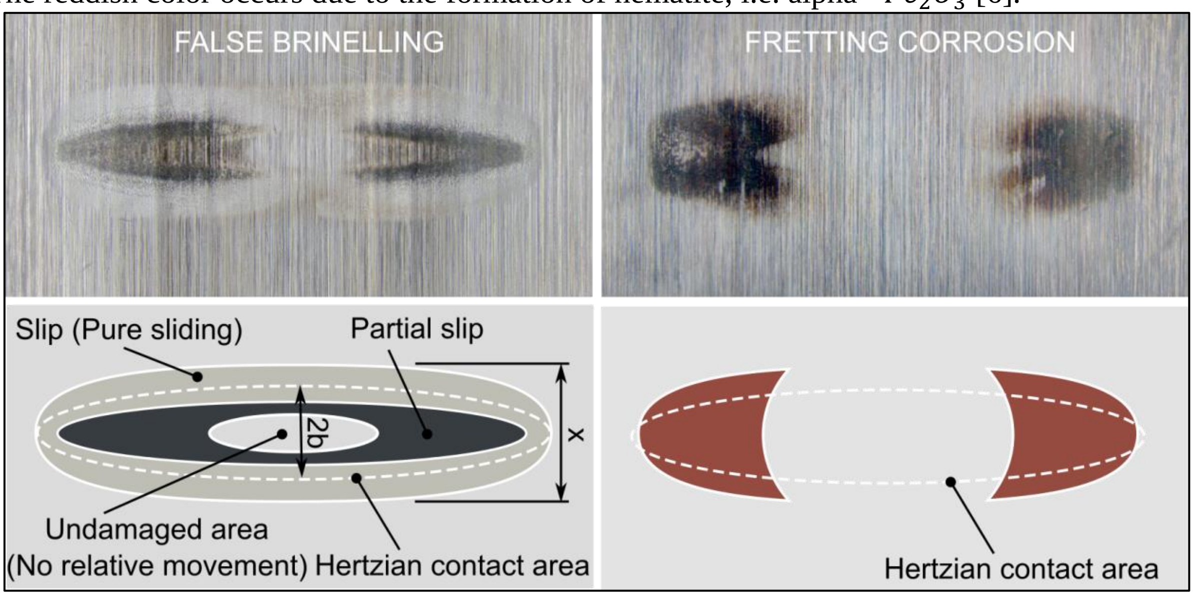

Figure 1: Different areas of false brinelling damage [7] and typical fretting corrosion damage

Under the aspect of a certain ratio of displacement to Hertz'ian contact area ($x/2b$) [8], see Figure 1, false brinelling can be described as the incubation process of fretting corrosion [9] [10]. In this case, incubation process means, that at the beginning of the oscillating motion a lubricant film is present. If so, mild wear occurs (false brinelling). Beneath a certain $x/2b$ -ratio the lubricant can be squeezed out of the contact. The metal-metal contact leads to fretting corrosion [11]. In this paper effects of the incubation process are analyzed for an angular contact ball bearing which is lubricated with mineral oil. The operating parameters (pivoting angle, oscillating frequency, load and lubrication) are constant for all experiments. The experiments were run for 10^5 up to $5 \cdot 10^6$ cycles to show the progress of wear with increasing cycles. For the analyses of the wear marks, different wear characteristics were examined according to literature.

TEST CONDITIONS

The experiments were conducted on a test rig equipped with a servo-motor. The motor allows the required oscillation motion. The bearings were loaded under pure axial load. For the experiments angular contact ball bearings of the size 7208 were used. Table 1 shows the experimental data.

Bearing	
Bearing size	7208
Inner diameter	40 mm
Outer diameter	80 mm
Number of rolling elements	14
Lubricant	
Type	Mineral oil
Kinematic viscosity (40 °C)	100 mm/s²
Experimental data	
Pivoting angle	1,2°
Oscillating frequency	5 1/s
Axial load	8500 N
No. of cycles	$10^5 - 5 \cdot 10^6$

Table 1: Experimental data

RESULTS

The test bearings were analyzed with a laser-scanning microscope (Keyence vk-x200). Each contact spot between raceway (inner and outer ring) and rolling element was analyzed. Thus, roughly 300 laser-scans were carried out. Figure 2 shows the occurring wear in seven contact spots between raceway and rolling element. Also four contact spots under dry conditions are visualized. All contact spots were subjected to a different number of cycles.

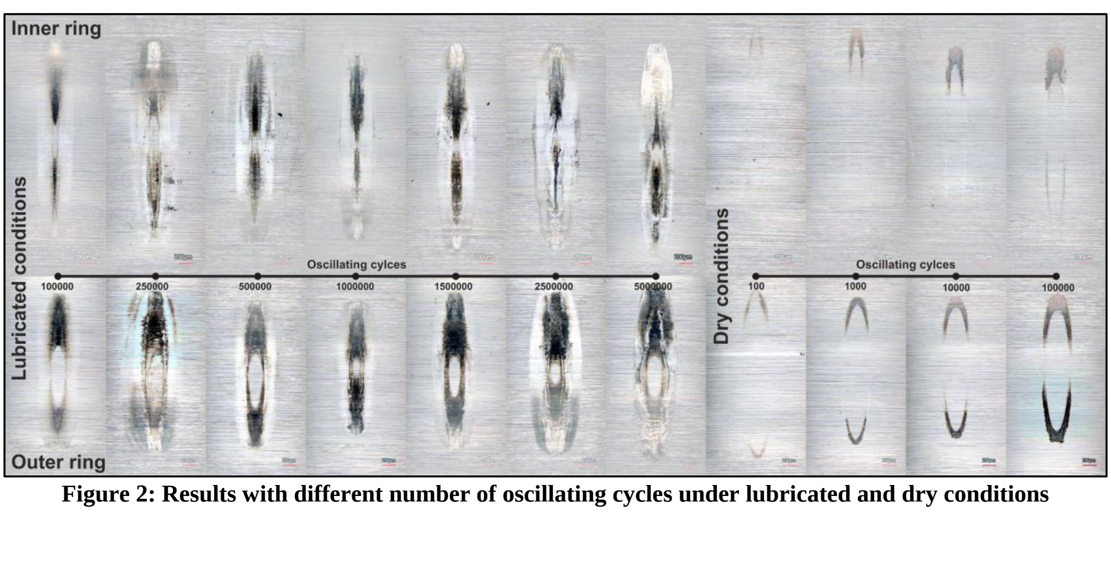

Figure 2: Results with different number of oscillating cycles under lubricated and dry conditions

Figure 3 shows some results of the experiments. Figure 3.1 shows the heavily damaged area vs. cycles on the inner and outer ring. The damaged area increases with the number of cycles. For $5 \cdot 10^6$ cycles the area on the outer race slightly decreases, which could be affected by statistical deviations. Figure 3.2 shows the distribution of undamaged, mildly damaged and heavily damaged area. This graph shows that the heavily damaged area increases with rising number of cycles. Finally Figure 3.3 and 3.4 show the hematite and magnetite portions for the inner and outer raceway. The hematite portion increases with the rising amount of cycles. Also the magnetite portion rises. In Figure 3.3 some statistical deviations can be seen at $2.5 \cdot 10^6$ cycles. With $5 \cdot 10^6$ cycles the portion of magnetite decreases while the portion of hematite rises due to covering effects and/or tribochemical reactions.
The results show, how different oscillating wear phenomena occur with increasing amount of cycles.

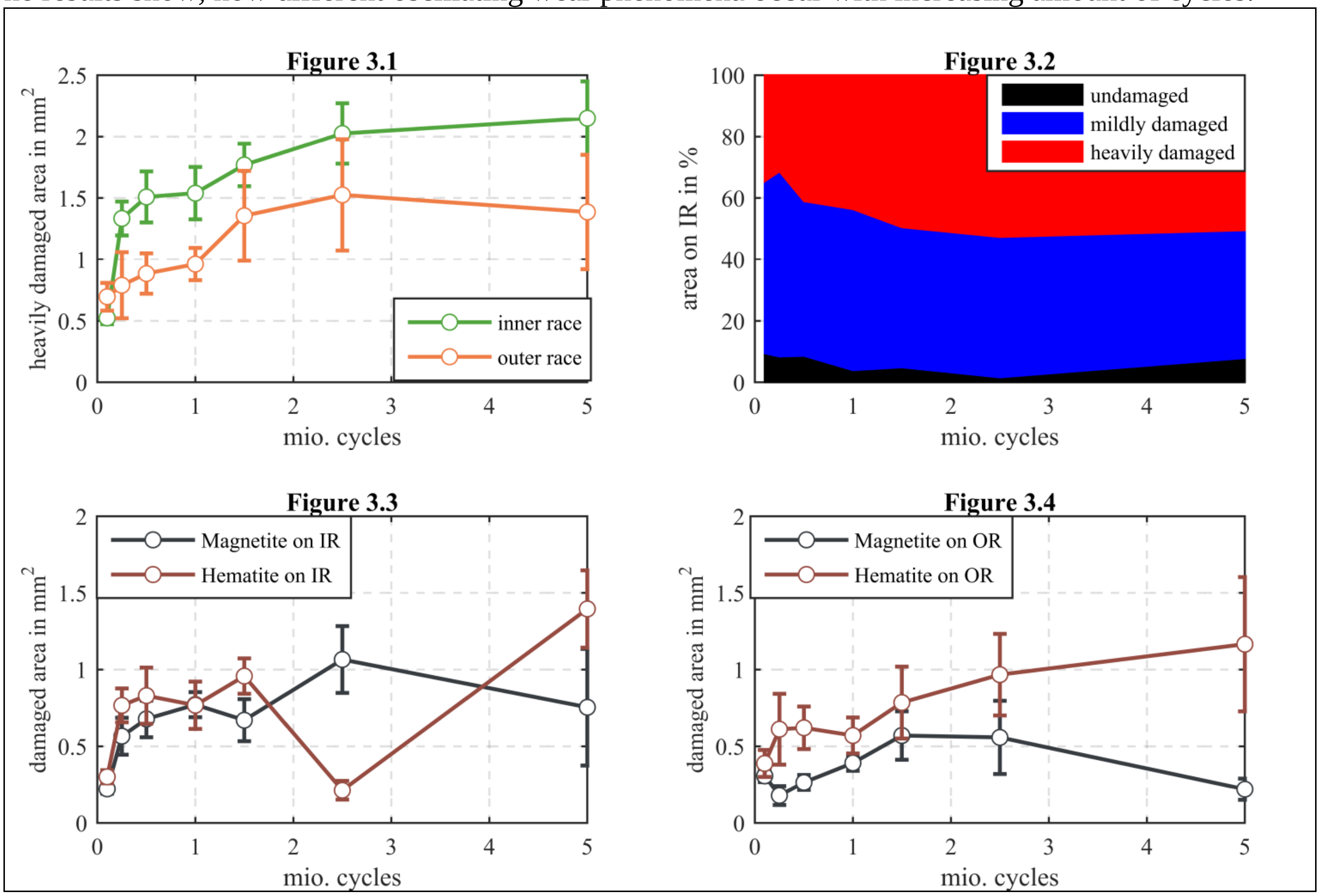

Figure 3: Overview of results

KEYWORDS
Fretting wear, false brinelling, minutely vibrating

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