Effect of Ultrasonic Nanocrystal Surface Modification on Fretting Wear of AISI 52100 Bearing Steel

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In this study, the effects of ultrasonic nanocrystal surface modification (UNSM) on fretting wear of AISI 52100 bearing steel were experimentally investigated. A nanocrystal structure was generated by UNSM with a deformed layer of 220 µm that exhibited a high dislocation density, where top layer in 30 µm transformed to a nanostructure of the grain size in 20 nm and mechanical twins were observed. Fretting wear loss rate of the UNSM-treated samples at 800,000 cycles was reduced by approximately 40% in comparison with that of the untreated sample.

Keywords: AISI 52100 bearing steel, fretting wear, nano-grain, UNSM

1. Introduction

Most often the high-frequency oscillations are not desired, in some applications, however, they are required for correct operation of the system [1]. In piezoelectric ultrasonic motors, the high-frequency frictional contact between stator and rotor is essential for the generation of the driving force. In this study, an ultrasonic fretting wear tester at a frequency of 20 kHz was developed, in which the fretting slip amplitude can be changed individually without changing the fretting pads. Experiments were performed on untreated and UNSM-treated AISI 52100 bearing steel and the results were comprehensively discussed.

2. Methods

UNSM was applied to AISI 52100 bearing steel plate samples with dimensions of 70 × 70 × 50 mm^3 under the parameters listed in Table 1. The fretting wear was investigated using a newly developed ball-on-flat fretting wear tester at a frequency of 20 kHz, an amplitude of 30 µm and at a load of 5 N.

Table 1: UNSM parameters.

Frequency [kHz]	20
Amplitude [µm]	30
Static load [N]	60
Ball diameter [mm]	2.38
Ball material	WC

2.1. Results

Fretting wear scars formed on the surface of the untreated and UNSM-treated AISI 52100 bearing steel samples are shown in Figure 1. It can be seen that the fretting wear scars formed on the surface of the UNSM-treated samples were found to be smaller than those of the fretting wear scars formed on the surface of the untreated samples. Fretting wear loss rate of the UNSM-treated samples at 800,000 cycles was reduced by approximately 40% in comparison with that of the untreated sample.

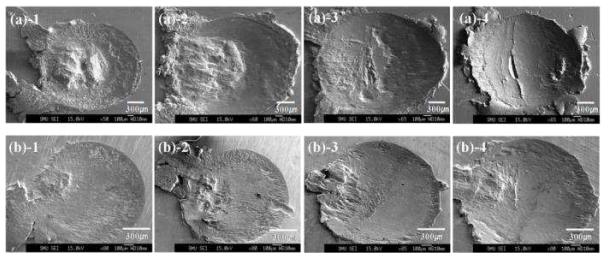

Figure 1: Fretting wear scar of the untreated and UNSM-treated AISI 52100 bearing steel samples.

3. Discussion

A UNSM demonstrated a beneficial effect on the enhancement of fretting wear of AISI 52100 bearing steel (see Figure 1) due to the formation of nanostructured layer after UNSM, which had a higher hardness than that of the untreated sample [2]. The increase in hardness after UNSM is due to the formation of martensitic phase, high dislocation density and grain refinement. Fretting wear resistance improved after UNSM may be attributed to the increase in hardness, work hardening and also change in surface roughness. The main influencing factors in the fretting wear process will be combined to analyze the effects of UNSM on the fretting wear.

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4. Reference

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