MEASUREMENT OF NON USED MICROBEARING OCCURRING IN COMPUTER HDD SEAGATE BARRACUDA

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Abstract

The advent of new techniques, to measure surfaces topography, adhesion, micro-bearing lubrication has led development of a micro-tribology and nano-tribology.

Mentioned researches are connected with experimental measurements and theoretical considerations. Taking into account the proper nano-grooves in cooperating surfaces in contemporary HDD micro-bearing design methods we attain the bubble prevention effects at the rotation speed in the vicinity of 10 000 rpm. This paper presents results of measurements of two new non-used cooperating micro-bearing surfaces occurring in computer Hard Disc Driver 3.5" Seagate Barracuda, 7200.10 ST380815AS, 7200rpm. Elaborated measurements concern: Scanning Electron Microscope (SEM) images of journal roughness and sleeve work surfaces with grooves, AFM-NT-206 (Micromachines Ltd, Belarus) roughness tests with 3D images of journal and sleeve work surfaces and profiles of their cross sections. Furthermore are performed Vickers micro-hardness value studies for journal and sleeve surface utilizing Micro-hardness Tester PMT-3M-LOMO-Russia. The measurements are performed for a new non used journal and sleeve surface utilizing the Atomic Force Microscope and SEM & Micro-X-Ray analysis.

Keywords: *HDD-microbearing, nano- grooves, nano-profiles of work surfaces*

1. Introduction

The geometry of nano- or micro-grooves on the two cooperating surfaces of HDD micro-bearings has important influence on the bubble forming, bearing stiffness, friction forces, load carrying capacity and wear [4]. For example when the groove angle is 30-60°, the gas-liquid interface may be turbulent and air bubbles may be formed. If the groove angle is 15° these problems do not arise [1-3].

In this paper have been achieved measurements of working cylindrical surfaces occurring in non used micro-bearing Hard Disc Driver 3.5" Seagate Barracuda, 7200.10 ST380815AS, 7200rpm. Diameter of the journal has 4mm, radial clearance 3.15 μm, groove angle about 15°. Measured sample concerning journal and sleeve in a new non used microbearing surfaces is presented in Fig. 1.

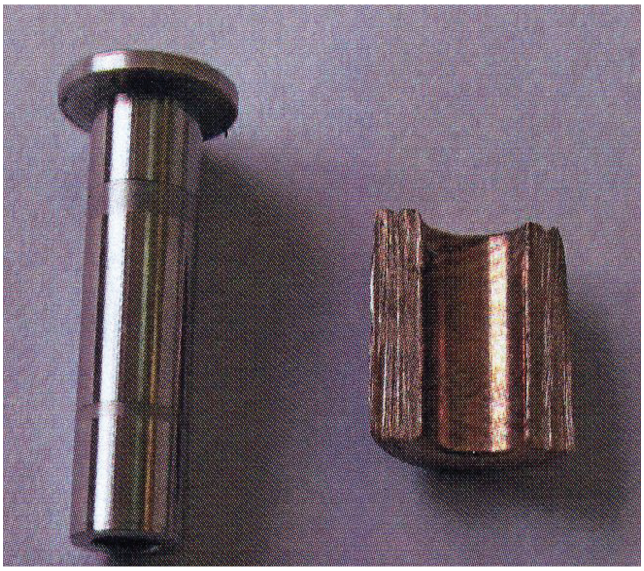


Fig. 1. The view of measured non used surfaces with nano-ridges and grooves in cylindrical slide microbearing journal and sleeve, for computer HDD, 3,5", Seagate Barracuda, 7200.10 ST 380815AS, 7200rpm

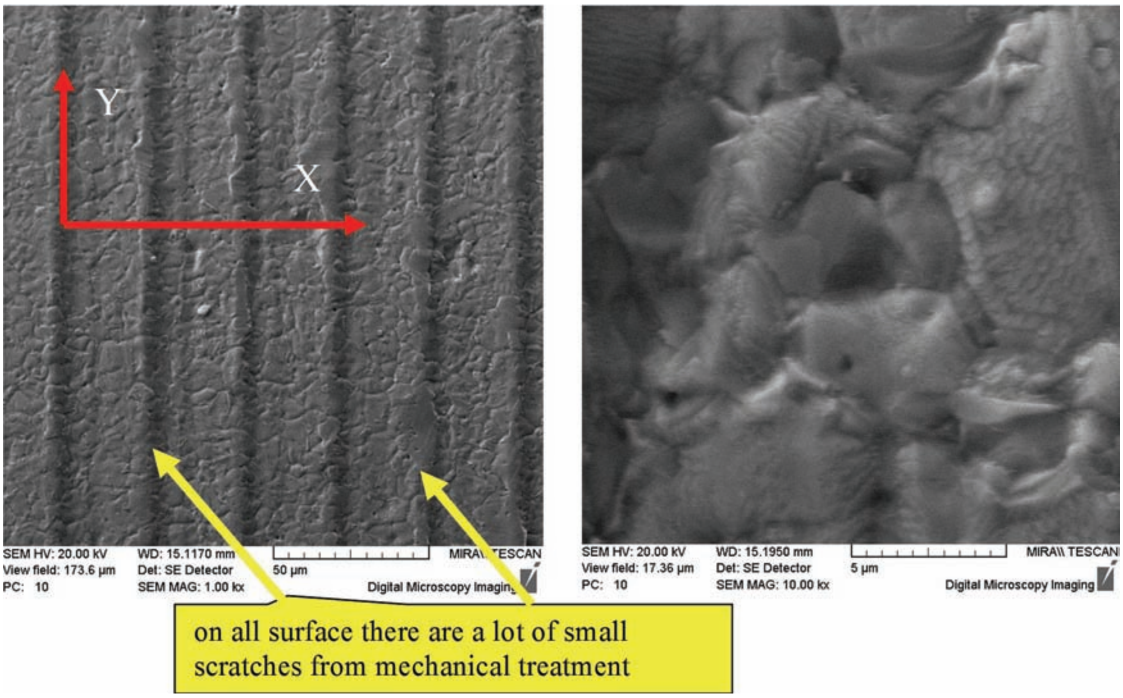
2. SEM & micro x-ray analysis of the journal work surface

The journal is made from Steel X20Cr13 EN10250-4. Bearing material consists from following roots: silicon (Si), chromium (Cr), manganese (Mn), iron (Fe). Percentage values of mentioned ingredients are given in Tab. 1. The values are measured three times for three spectrums. The standard deviation values are calculated and indicated in presented table. Moreover the average values of roots composition in journal material are determined.

Tab. 1. X-Ray analysis results of percent values of ingredients occurring in journal bearing material

Ingredients	Si	Cr	Mn	Fe	Total
Spectrum 1	0.52	14.60	0.83	84.05	100.00
Spectrum 2	0.53	14.36	0.73	84.39	100.00
Sspectrum 3	0.46	14.49	0.60	84.45	100.00
Average	0.50	14.48	0.72	84.29	100.00
Standard Deviation	0.04	0.12	0.11	0.22	
Maximum value	0.53	14.60	0.83	84.45	
Minimum value	0.46	14.36	0.60	84.05	

Figure 2 illustrates the image of the journal work surface in two enlarged scales, using the Digital Microscopy Imaging. Fig. 2a presents the surface 173.60μm×173.60μm and enlargement picture showed in Fig. 2b describes the region twenty times enlarged namely 8.680μm×8.680μm. Fig. 2a shows some kind of the surface technological treatment. It looks like the result of a plastic deformation. Fig. 2b shows that the wide of the ditches caused by the dressing has about values from 1 to 5μm.



a) b)

Fig. 2. SEM image of work surface of the journal with the draw marks of treatment: a) view field 173.60μm×173.60μm, b) view field: 8.680μm×8.680μm

3. SEM & micro x-ray analysis of the sleeve work surface

The sleeve is made from sintered 53.5Cu45Fe1.5Sn powder composition. Such sintered metal consists from following roots: silicon (Si), iron (Fe), cupper (Cu), tin (Sn). Percentage values of mentioned ingredients are given in Tab. 2. The values are measured only one time for one spectrum.

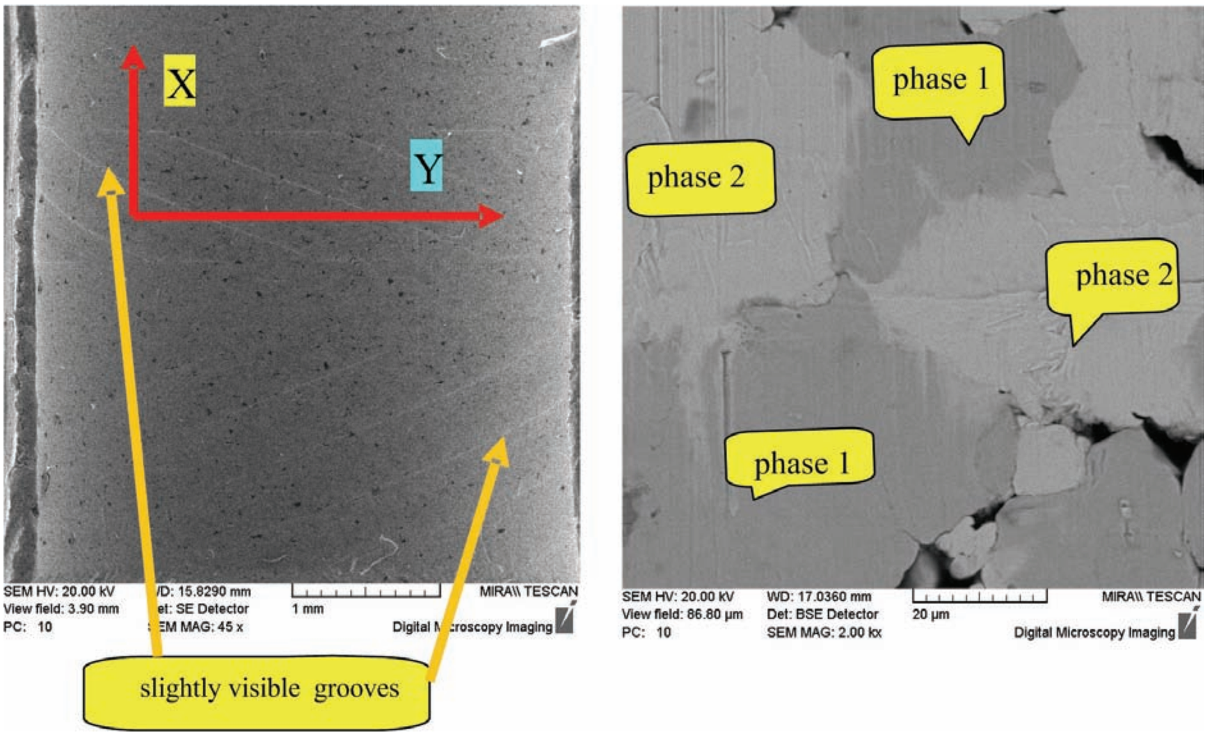
Tab. 2. X-Ray analysis results of percent values of ingredients occurring in on the sleeve work surface

Ingredients	**Si**	**Fe**	**Cu**	**Sn**	**Total**
Spectrum 1	0.10	44.60	51.74	1.40	100.00
Average	0.10	44.60	51.74	1.40	100.00
Standard deviation	0.00	0.00	0.00	0.00	
Maximum value	0.10	44.60	51.74	1.40	
Minimum value	0.10	44.60	51.74	1.40	

Figure 3 illustrates the image of the sleeve work surface in two successive enlarged scales, using the Digital Microscopy Imaging. The material presented in Fig. 3 is heterogeneous and has huge porosities.

Fig. 4a presents the square surface 3.90mm×3.90mm, and about forty fife time enlargement pictures showed in Fig. 4b illustrates the square regions 86.80μm×86.80μm.

Sleeve surface presented in Fig. 4a shows slightly visible herringbone grooves. We can not find them by AFM (see Fig. 6). Fig. 4b illustrates the most enlarged region where two phases of material are indicated.



a) **b)**

Fig 3. SEM image of work surface of the sleeve: a) view field 3900μm $\times$3900μm, b) view field: 86.80μm$\times$86.80μm

4. AFM roughness test for journal surface

Roughness of the journal working surface is measured in 3D space by the Atomic Force Microscope in the view field 20 000nm×20 000nm×358.3nm for calculated: average roughness Ra=40.0nm, and the root mean square of the roughness Rq=50.9nm. The results are presented in Fig. 4.

The cross section along the sample presented in Fig. 4 illustrates the height roughness profile of the journal surface in Fig. 5.

It is easy to see in Fig. 4 and 5 that roughness of the journal surface attain the height about 30nm and the ditches is about 170 nm deep and 700 nm wide.

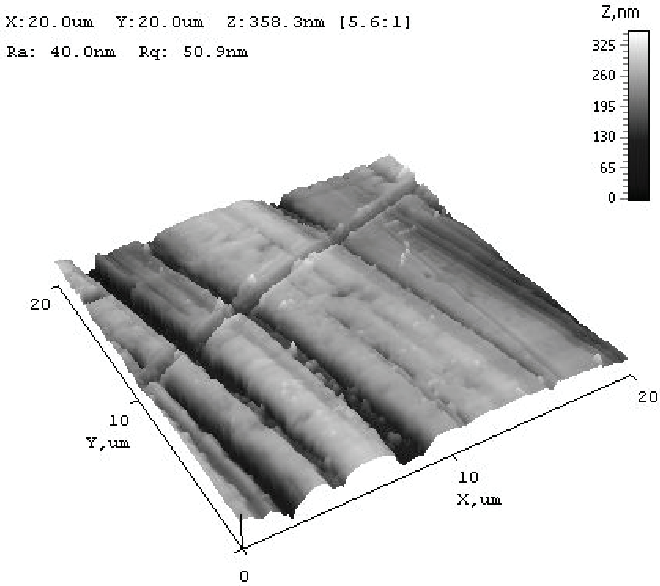


Fig. 4. 3D AFM image of work surface of the journal (Ra = 40.0 nm)

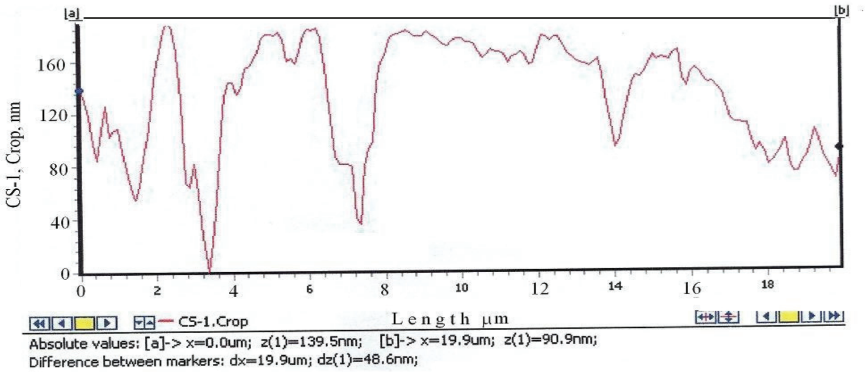


Fig. 5. Profile of work surface of the journal presenting roughness height in nano-meters versus sample length in micrometers

5. AFM roughness test for sleeve surface

Roughness of the sleeve working surface and groove profile are measured in 3D space by the Atomic Force Microscope in the view field 9400nm×9400nm×425.1nm for parameters: Ra=21.3nm, Rq=33.3nm. The results are presented in Fig. 6.

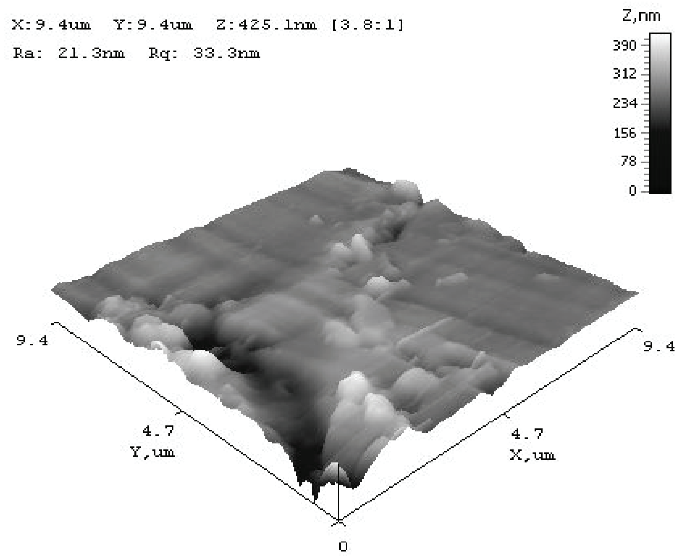


Fig. 6. 3D AFM image of work surface of the sleeve (Ra = 21.3 nm)

The cross section along the sample presented in Fig.6 illustrates the height roughness profile of the sleeve surface in Fig. 7.

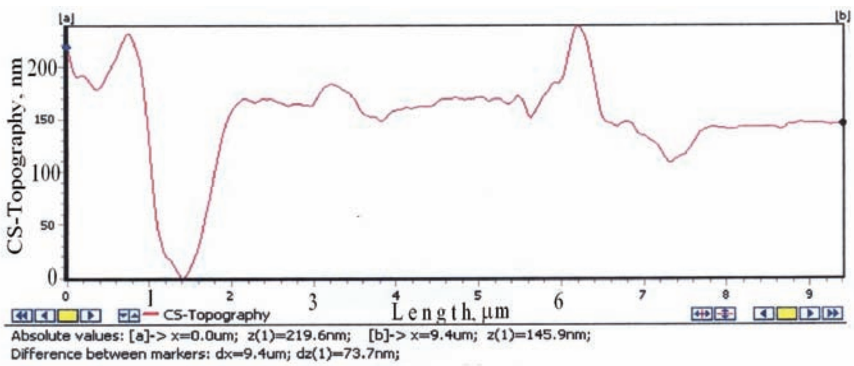


Fig. 7. Profile of work surface of the sleeve presenting roughness and groove height in nano-meters versus sample length in micrometers

From Fig. 6 and Fig. 7 follows, that the roughness on the sleeve surface attains value about 50 nm height, and the ditches is a 170 nm deep and 800 nm wide. The ditches have approximately the triangular shape where lateral slopes are very steep.

6. Microhardness and modulus of elasticity studies

Vickers hardness test was performed by indentation of diamond pyramid into sample material with load 100 gram. Average values of Vickers Microhardness are obtained for journal 8570 MPa and for sleeve 2010 MPa for yellow phase and 1750 for white phase. The Vickers diamond Pyramid indenter is ground in the form of a squared pyramid with an angle 136° between faces. The depth of indentation is about 1/7 of the diagonal length. In presented measurements the Vickers hardness test was performed by indentation of diamond pyramid into sample material with load 10 gram. The standard technique – Microhardness Tester “PMT-3M” (LOMO, Russia) - was utilized for the indentation.

Modulus of Elasticity measurements were performed utilizing AFM by indentation of diamond probe with 100 nm radius of tip. References material for measurements was diamond.

7. Conclusions

The measurements performed in micro and nano scale of journal with (4mm diameter) and sleeve surfaces occurring in computer HDD 3.5” Seagate Barracuda, 7200.10 ST380815AS, enable to derive the proper model of analytical and numerical calculations and elaboration of real exploitation parameters for various HDD micro-bearing lubrication.

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