SURFACE TOPOGRAPHY OF NON-OPERATED SLIDE JOURNAL MICRO-BEARINGS

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Abstract

In this paper authors present results of measurements of slide journal bearings surface topography measured with an atomic force microscope (AFM). The results of measurements of surface topography were presented in the form of surface topography maps, three-dimensional graphs and some examples of selected cross-sections of investigated surface in the form of profile graphs.

Measurements of surface topography were made for journals and sleeves of slide journal micro-bearings from personal computers' hard drives and fans, with the Atomic Force Microscope NT-206 produced in MTM in Minsk, Republic of Belarus.

The values of profile roughness parameters R_a and R_q and the distance between maximum peak height and maximum valley depth are presented as well.

The application SurfaceXplorer® was used for processing and visualization of the data obtained from AFM NT-206, which besides from generating 2D, 3D and profile diagrams, was used to calculate and draw graph of height distribution.

Surface pictures of investigated bearings sleeves were made with the optical microscope Zeiss Axiovert 25+. That measurements give information about micro-grooves dimensions and location.

On the surfaces of studied micro-bearings some micro-grooves can be found in form of herringbone, with depth about 1.5μm and width 150μm. Received information about micro-grooves geometry will allow to develop proper theory of hydrodynamic lubrication for micro-bearings with micro-grooves.

Topography of surfaces of investigated journal micro-bearings will be reconsidered after exploiting them proper amount of time.

Keywords: *atomic force microscope, surface topography, micro-grooves, herringbone grooves, micro-bearing*

1. Introduction

Surface roughness values of bearing journal and sleeve has an important impact on the gap height value in slide journal micro-bearings. It's due to the fact, that radial clearance in slide micro-bearings has significantly lower value than in macro slide bearings, thus it's necessary to take into account influence of roughness on the gap height value. In articles [3, 5] there can be found stochastic theory about influence of roughness on the gap height value. Non-classical surfaces with micro-grooves and their influence on lubrication are also object of interest of some scientists [1, 2, 4, 6, 7].

Measurements of surface roughness in micro and nanoscale can be executed with atomic force microscope. In researches authors of this paper use Atomic Force Microscope NT-206 produced in MTM in Minsk, Republic of Belarus.

Atomic Force Microscope NT-206 provides findings for samples with maximum roughness value ± 1μm. Max. field in one scanning process is up to 32μm x 32μm. Scanning process can be done in three various modes, which can be changed depending on sample type and measurement conditions:

- static (contact) mode,

- dynamic (non - contact) mode,
- intermittent mode.

Measurements were proceeded with resolution 256x256 points.

Authors investigate surface topography of four new (non-used) slide journal micro-bearings: two from computers hard drives and other two from computers fans.

For studies authors chose micro-bearings with micro-grooves in the form of herringbone from: 2.5” HDD Samsung HM160HI 5400rpm and 3.5” HDD Seagate Barracuda 7200.10 ST380815AS 7200 rpm.

Other devices with slide journal micro-bearings with smooth or grooved surfaces are computers fans. Authors made measurements of surface topography of bearings from: Kama Flow SP0825FDB12H fan (diameter d=80 mm) with grooved surface of bearing sleeve and Xilence Case fan (diameter d=92 mm) with sleeve surface without grooves.

Two identical sets of two HDD's and two fan's are functioning with nominal rotation speed: first set in a continuous mode, without break, second in intermittent mode: 15 minutes of running and next 15 minutes of break, and so on (Fig. 1).

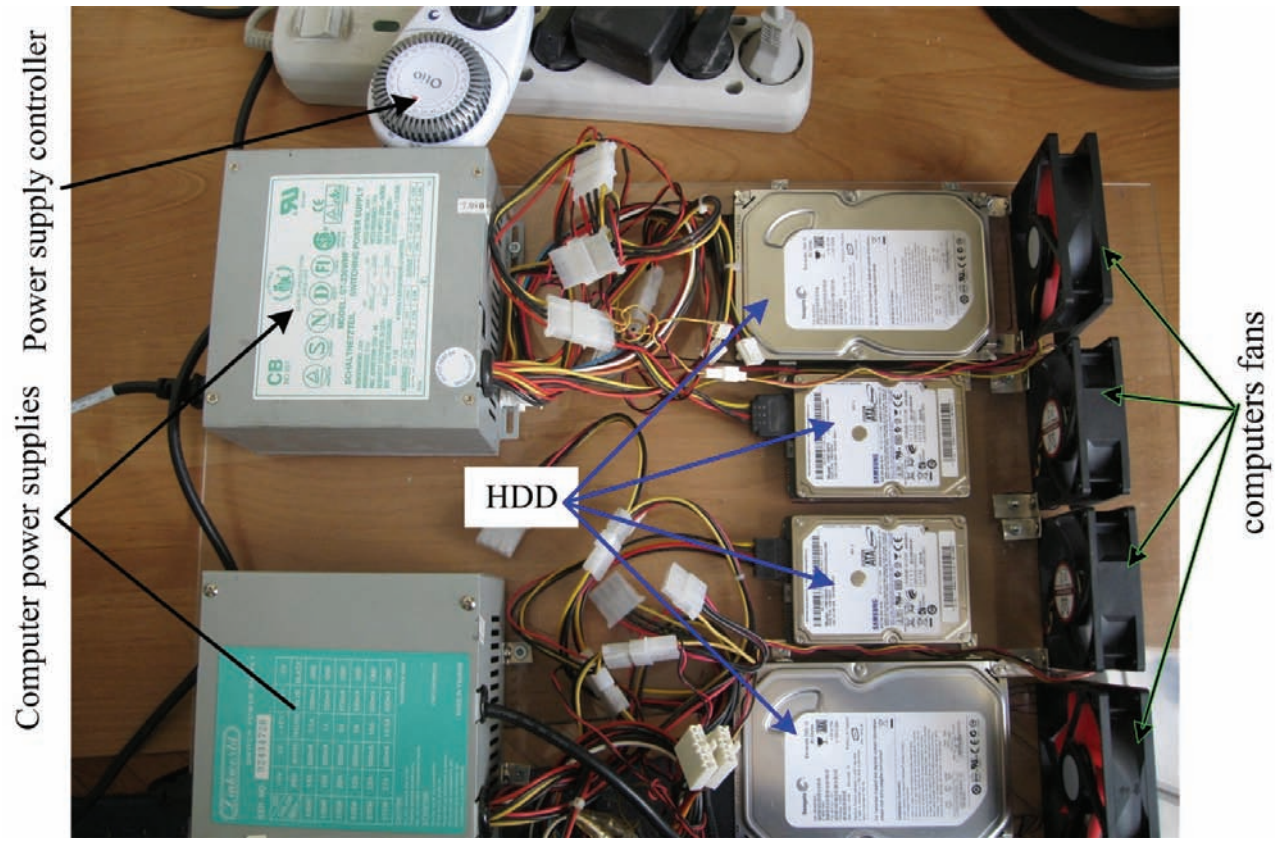

Fig. 1. Working sets of computers hard disk drives and fans

Results of measurements of the samples of investigated micro-bearings sleeves, made with the optical Zeiss Axiovert 25+, (zoom 5x, 10x, 20x, 50x) are presented in Fig. 2-5.

Figure 2 shows the sample of micro-bearing sleeve with micro-grooves applied in 2.5” HDD Samsung HM160HI device.

Width of grooves presented in Fig. 2 is about 140μm, while width of grooves shown in Fig. 3 is about 150μm. Fig. 3 presents bearing sleeve with micro-grooves from slide journal micro-bearing applied in HDD 3.5” Seagate Barracuda ST380815AS.

Bearing sleeve from journal slide micro-bearing applied in Kama Flow SP0825FDB12H fan, is covered with micro-grooves, which width is nearly 80μm (see Fig. 4).

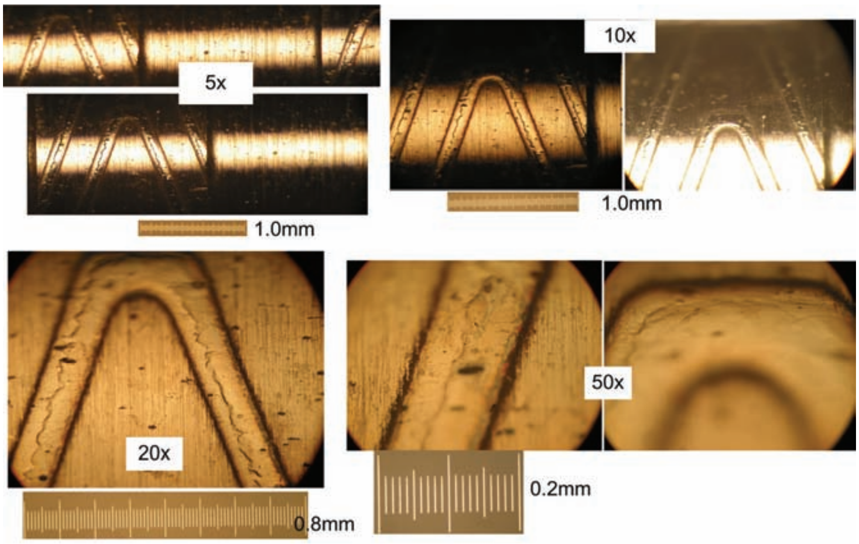

Fig. 2. Bearing sleeve surface with micro-grooves - bearing from 2.5” HDD Samsung HM 160 HI

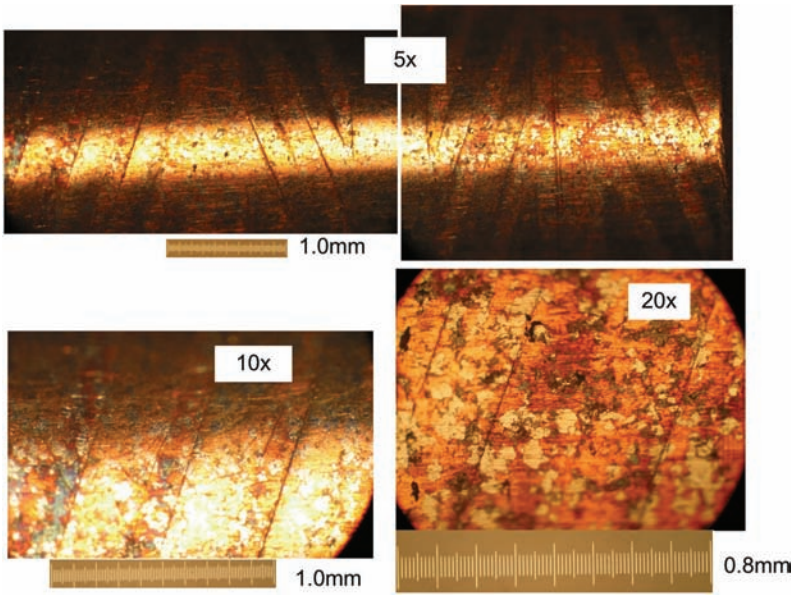

Fig. 3. Bearing sleeve surface with micro-grooves - bearing from 3.5” HDD Seagate Barracuda ST380815AS

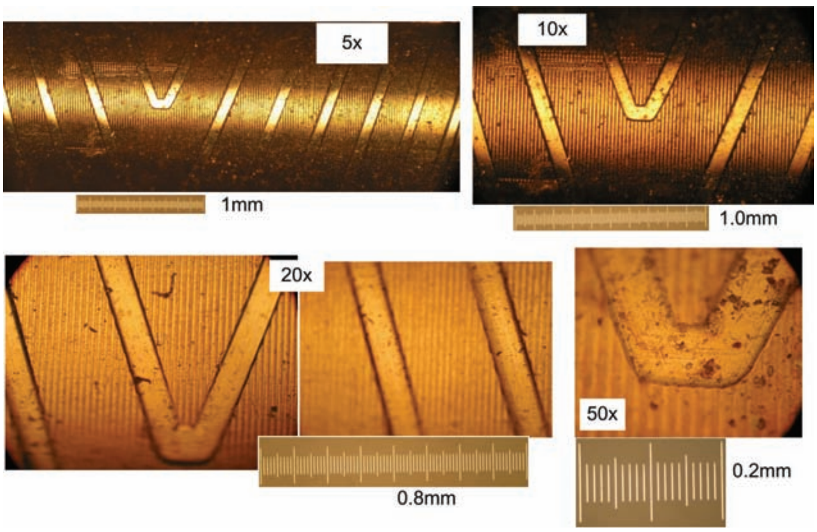

Fig. 4. Bearing sleeve's surface with micro-grooves - bearing from Kama Flow SP0825FDB12H

Figure 5 presents pictures of the sample cut from porous sleeve (without micro-grooves) from slide journal micro-bearing applied in ordinary computers fans.

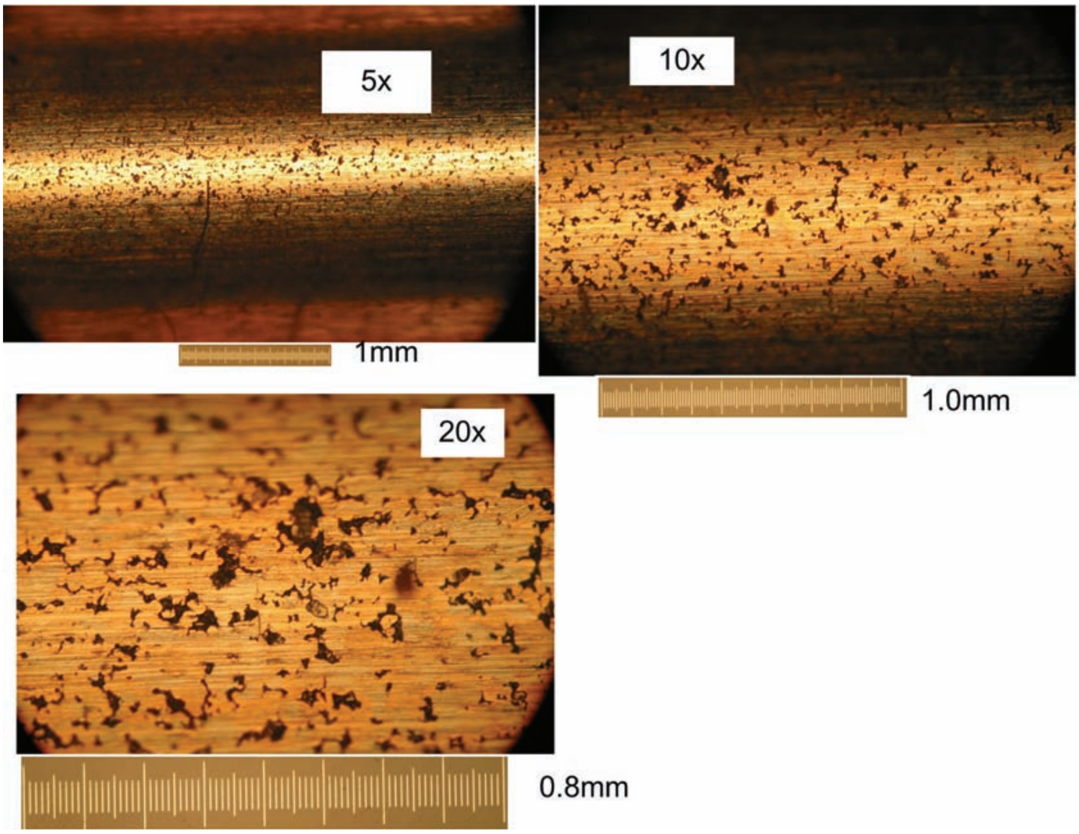

Fig. 5. Bearing sleeve porous surface - bearing from Xilence Case Fan 92mm

2. Measurements of surface topography

Surface topography of investigated slide journal micro-bearings sleeves was measured with the atomic force microscope NT -206 in the contact (static) mode.

In Fig. 6-9 there are presented three-dimensional graphs of surface topography, cross-section diagrams and plots of peaks and valleys height distribution of measured samples.

Surface topography of slide journal micro-bearing sleeve from 2.5” HDD HM 160 HI Samsung hard disc drive is shown in Fig. 6. Line in Fig 6a. shows which cross-section of the sample is presented in Fig. 6b. Fig. 6c presents graph of peaks and valleys height distribution, tilts orientation and tilts angles distribution in the investigated sample.

Surface topography of slide journal micro-bearing sleeve applied in 3.5” HDD Seagate Barracuda ST380815AS hard disc drive is presented in Fig. 7, while in Fig. 8 i 9 authors present topography of the surface of journal sleeve from slide journal micro-bearing applied in Kama Flow SP0825FDB12H and Xilence Case Fan 92mm fans.

From received data, presented in Fig. 6-9, it can be observed, that the surface roughness values are from few nanometers, of micro-bearing surface from HDD Samsung, to tens nanometers of other micro-bearings surfaces. Surface roughness values of micro-bearings from Kama Flow and Xilence Case fans are greater than others. It's caused by the different type of physical processing of journal sleeve surface, furthermore those surfaces are porous (see Fig. 4 and 5).

Also in Fig. 2 and 5 is shown surface unevenness caused by physical processing of slide journal micro-bearing.

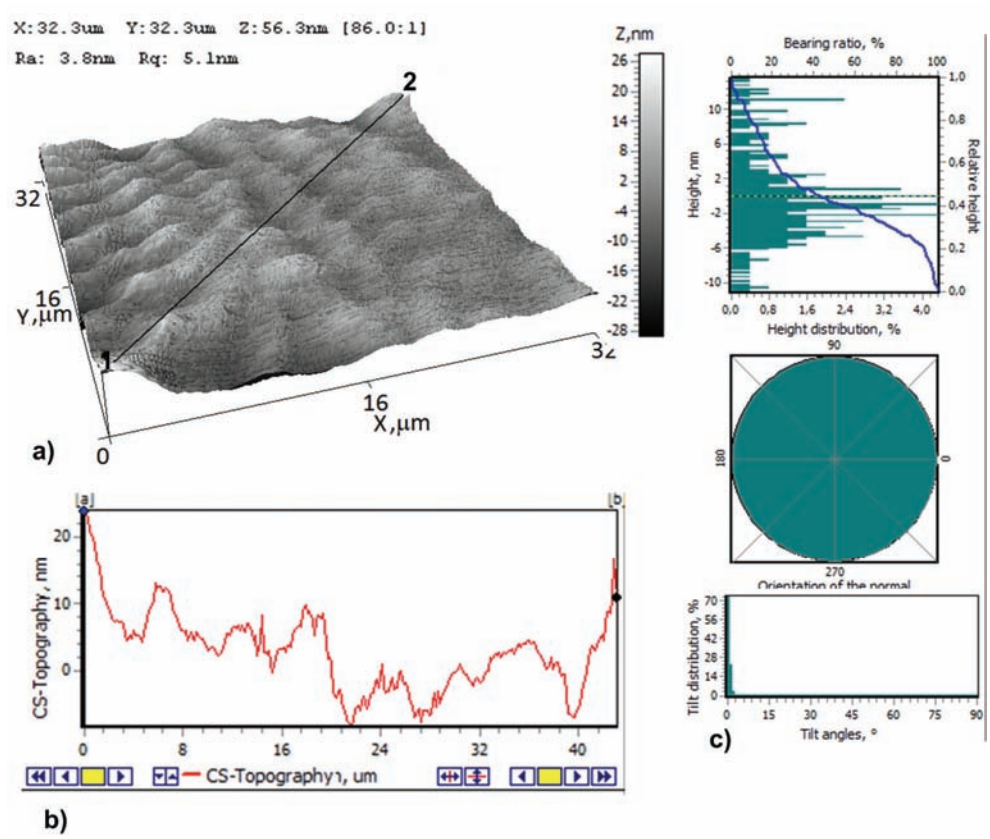

Fig. 6. Surface topography of slide journal micro-bearing sleeve from 2.5” HDD Samsung HM 160 HI: a) 3D view, b) cross-section 1-2, c) roughness height distribution, tilts orientation, tilts angles distribution

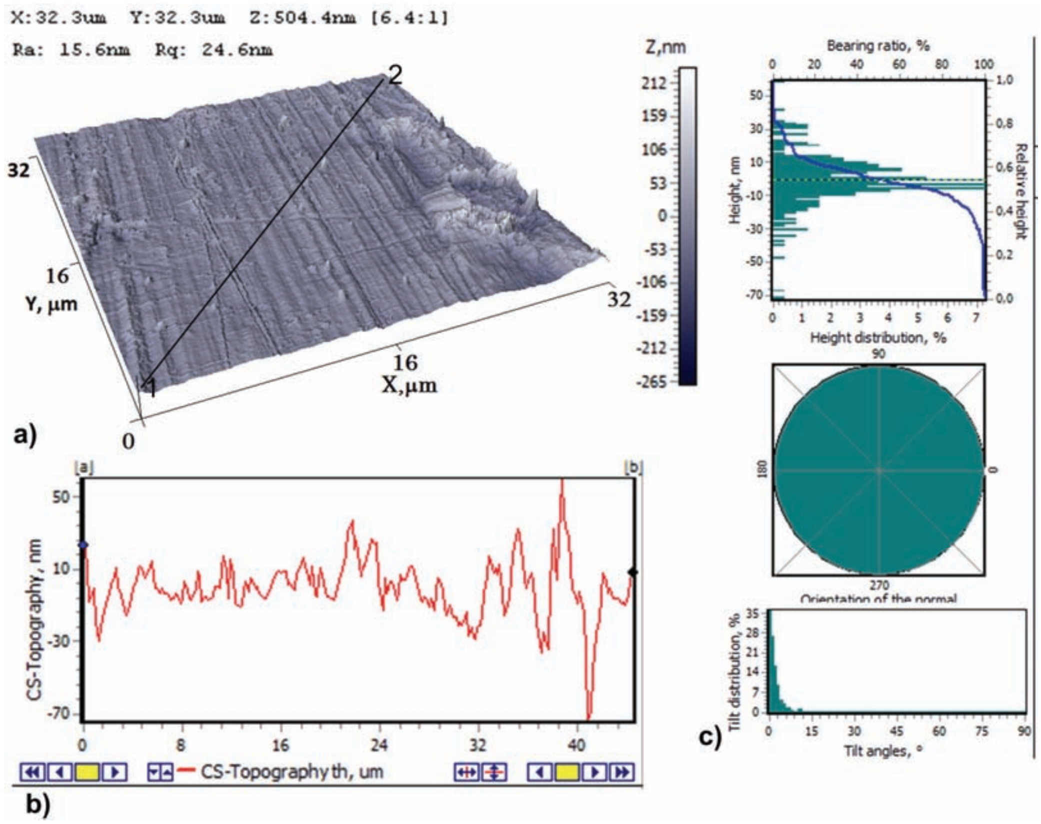

Fig. 7. Surface topography of slide journal micro-bearing sleeve from HDD Seagate Barracuda ST380815AS: a) 3D view, b) cross-section 1-2, c) roughness height distribution, tilts orientation, tilts angles distribution

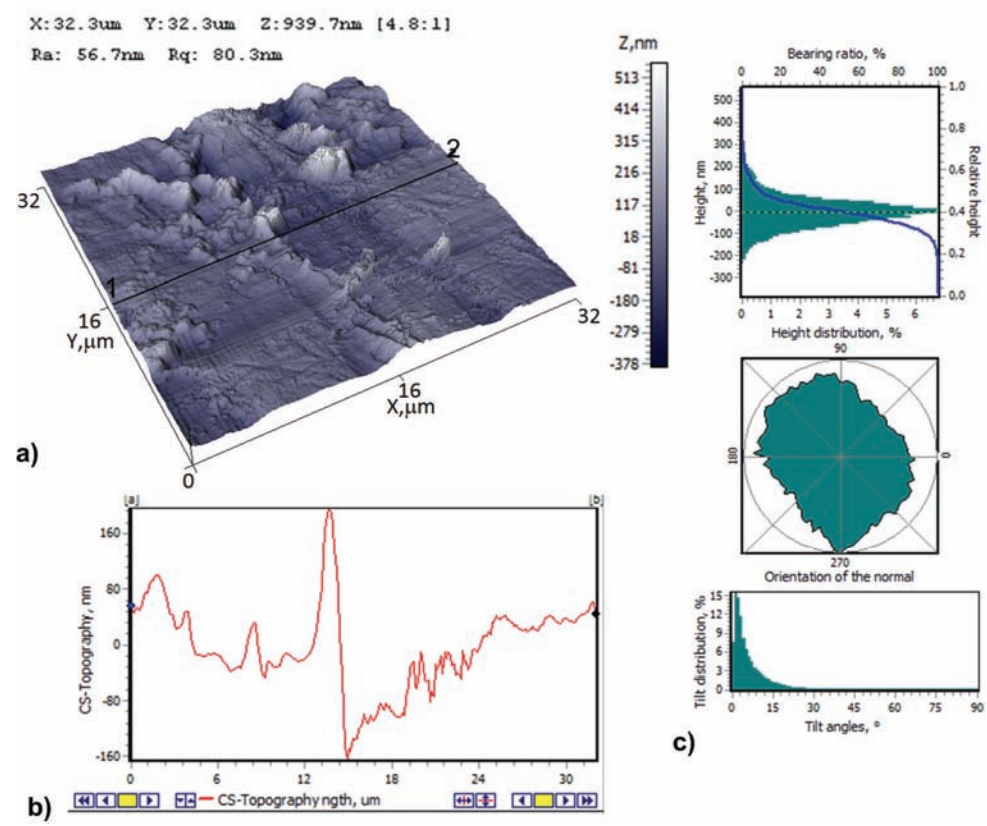

Fig. 8. Surface topography of slide journal micro-bearing sleeve from Kama Flow SP0825FDB12H fan: a) 3D view, b) cross-section 1-2, c) roughness height distribution, tilts orientation, tilts angles distribution

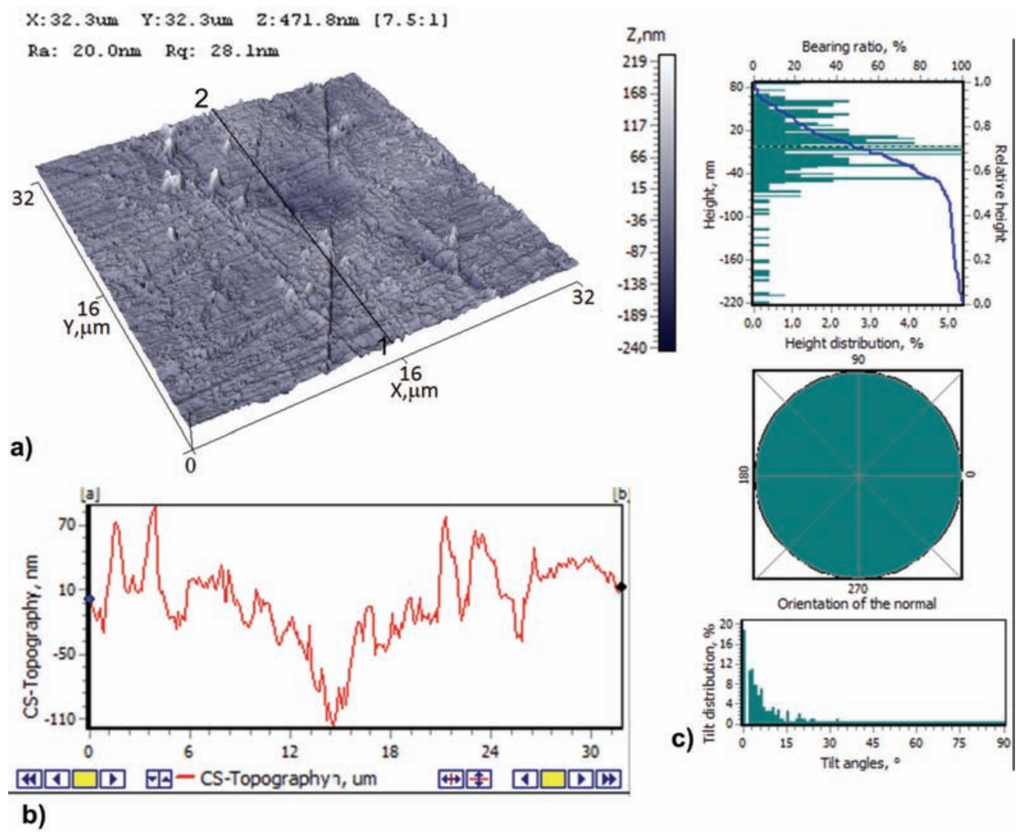

Fig. 9. Surface topography of slide journal micro-bearing sleeve from Xilence Case fan: a) 3D view, b) cross-section 1-2, c) roughness height distribution, tilts orientation, tilts angles distribution

3. Conclusions

The knowledge about roughness values of the operating surfaces of bearing journal and sleeve, and also about micro-grooves dimensions, allows to create a efficient theory of hydrodynamic lubrication for slide journal macro and micro-bearings.

The same slide micro-bearings surfaces will be measured and reconsidered after operating them proper amount of time.

The comparison of received data will allow to verify type and amount of surface wear of discussed journal micro-bearings parts and will help to design surface layers with improved tribological properties.

References

[1] Asada, T., Saito, H., Asaida, Y., Itoh, K., *Design of hydrodynamic bearing for height-speed HDD*. Microsystem Technologies, 8, pp. 220-226, 2002.

[2] Chizhik, S., Khudoley, A., Kuznetsova, T., Wierzcholski, K., Miszczak, A., *Micro and Nanoscale Wear Studies of HDD Slide Bearings By Atomic Force Microscopy*. Proceedings of Methodological Aspects of Scanning Probe Microscopy, Heat and Mass Transfer Institute of NAS, pp. 247-252, Minsk 2010.

[3] Gururajan, K., Prakash, J., *Surface Roughness Effects in Infinitely Long Porous Journal Bearings*. Transactions of the ASME, Journal of Tribology, Vol. 121, pp. 139-147, 1999.

[4] Jang, G. H., Lee, S. H., Kim, H. W., Kim, C.S., *Dynamic analysis of a HDD spindle system with FDBs due to the bearing width and asymmetric grooves of journal bearing*, Microsystems Technologies, 11, pp. 499-505, 2005.

[5] Jang, G. H., Seo, C. H., Ho Scong Lee, *Finite element model analysis of an HDD considering the flexibility of spinning disc-spindle, head-suspension-actuator and supporting structure*, Microsystem Technologies, 13, pp. 837-847, 2007.

[6] Miszczak, A., *Analiza hydrodynamicznego smarowania ferrocieczą poprzecznych łożysk ślizgowych*. Monografia. Fundacja Rozwoju Akademii Morskiej, Gdynia 2006.

[7] Wierzcholski, K, Miszczak, A., *Adhesion Influence on the Oil Velocity and Friction Forces in Cylindrical Microbearing Gap*. Scientific Problems of Machines Operation and Maintenance, Polish Academy of Sciences, z. 1(161), Vol.45, pp. 71-79, 2010.