

SURFACE TOPOGRAPHY OF OPERATED SLIDE JOURNAL MICRO-BEARINGS USED IN COMPUTER FANS

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Abstract

In this paper authors present results of measurements of slide journal bearings surface topography measured with a profilometer and an atomic force microscope (AFM).

Surface topography of investigated bearings (i.e. journals and sleeves) was measured using the Hommeltester T8000-R60 profilometer. The results of these measurements give information about micro-grooves dimensions and location.

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

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 surfaces in the form of profile graphs.

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 graphs of height distribution.

In this research authors used two identical sets of micro-bearings. The investigated bearings are:

- a) Kama Flow SP0825FDB12H fan with grooved surface of bearing sleeve,*
- b) Xilence Case fan which sleeve surface was without grooves.*

First set of that micro-bearings functioned for a year at rated RPM continuously (i.e. 24 hours a day). Second set of the same micro-bearings also functioned for a year at rated RPM, but in intermittent mode (i.e. 15 minutes on, 15 minutes off).

On the surfaces of studied micro-bearings some microgrooves can be found in form of herringbone, with depth about 1-2 μ m and width 100-150 μ m. Received information about microgrooves geometry will help to develop proper theory of hydrodynamic lubrication for micro-bearings with microgrooves and allows determining how the mode of operating affects on the wear of co-operating surfaces.

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

1. Introduction

Surface roughness values of bearing journal and sleeve have an important impact on the gap height value in slide journal micro-bearings. It is due to the fact, that radial clearance in slide micro-bearings has significantly lower value than in macro slide bearings, thus it is necessary to take into account the influence of roughness on the gap height value [1, 5, 8, 11]. In articles [2, 6, 7, 9] there can be found a stochastic theory about influence of roughness on the gap height value. Non-classical surfaces with microgrooves and their impact on lubrication are also an object of interest of some scientists [2-4, 6, 7, 9-11].

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

The Atomic Force Microscope NT-206 provides findings for samples with maximum roughness value $\pm 1\mu$ m. Maximum scan area of measurement is 32 μ m x 32 μ m. Measurements were proceeded with resolution 256x256 points in static (contact) mode.

The investigations concern surface topography measurements of four used slide micro-bearings journals and sleeves, which were operated in computers cooling fans. Two identical sets of micro-bearings were taken into account: Kama Flow SP0825FDB12H fan (diameter $d=80$ mm, 2900 rpm) with grooved surface of bearing sleeve with grooved (herringbone grooves) surface of bearing sleeve and Xilence Case fan (diameter $d=92$ mm, 1500 rpm) with sleeve surface without grooves. The first set of that micro-bearings functioned for a year at rated RPM continuously (i.e. 24 hours a day). The second set of the same micro-bearings also functioned for a year at rated RPM, but in intermittent mode (i.e. 15 minutes on, 15 minutes off). In our prior paper, we described the surface topography measurements of the same, but not operated micro-bearings [4].

Figure 1 shows the working sets (first set - continuously, second set - intermittently) of computer hard disk drives and cooling fans.

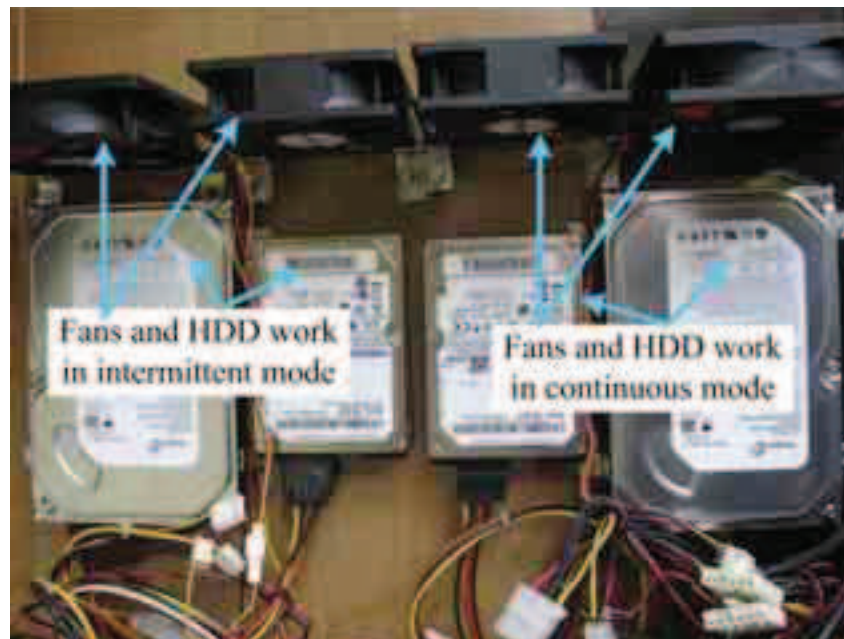


Fig. 1. Working sets of computers hard disk drives and fans

The surface topography measurements in macro scale were made with the Hommeltester T8000-R60 profilometer. As a result, we obtained the information about location and arrangement of microgrooves. Dimensions of scan area were as follows: 3-4 mm of length and 250-300 μm of width.

2. Measurements of surface topography

The results of surface topography measurements of Kama Flow SP0825FDB12H fan micro-bearing *sleeve*, which was operated in continuous mode, are illustrated in Fig. 2. Fig. 3 shows the surface topography of Kama Flow SP0825FDB12H fan micro-bearing sleeve, which was operated in intermittent mode. Fig. 2a and 3a present the topographies of investigated surfaces, acquired with the profilometer, while Fig. 2b and 3b show results gained with the atomic force microscope. The surface topography is presented in two and three-dimensional graphs. Furthermore, some selected cross-sections, roughness height distribution and orientation are introduced as well.

In Fig. 2, besides microgrooves, it can be observed the traces after turning as regular grooves with a width of about 19 μm and depth of 1 μm . The width of the fabricated microgrooves is around 100 μm , depth 5-10 μm and the distance between the grooves is about 300 μm . Treatment traces of surface, presented in Fig. 3, is less evident. It proves the wear of bearing sleeve surface, which was operated in intermittent mode, to be greater.

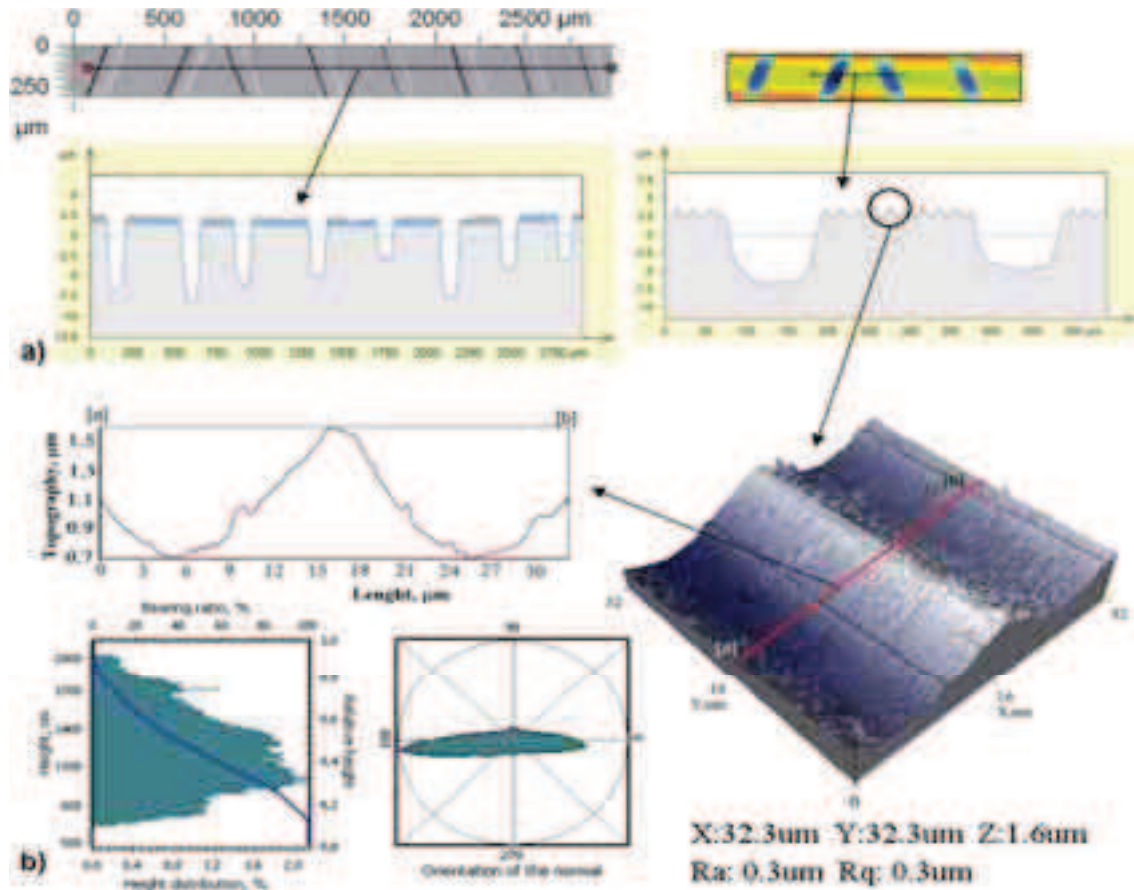


Fig. 2. Bearing sleeve surface with microgrooves - bearing from Kama Flow SP0825FDB12H – continuous mode

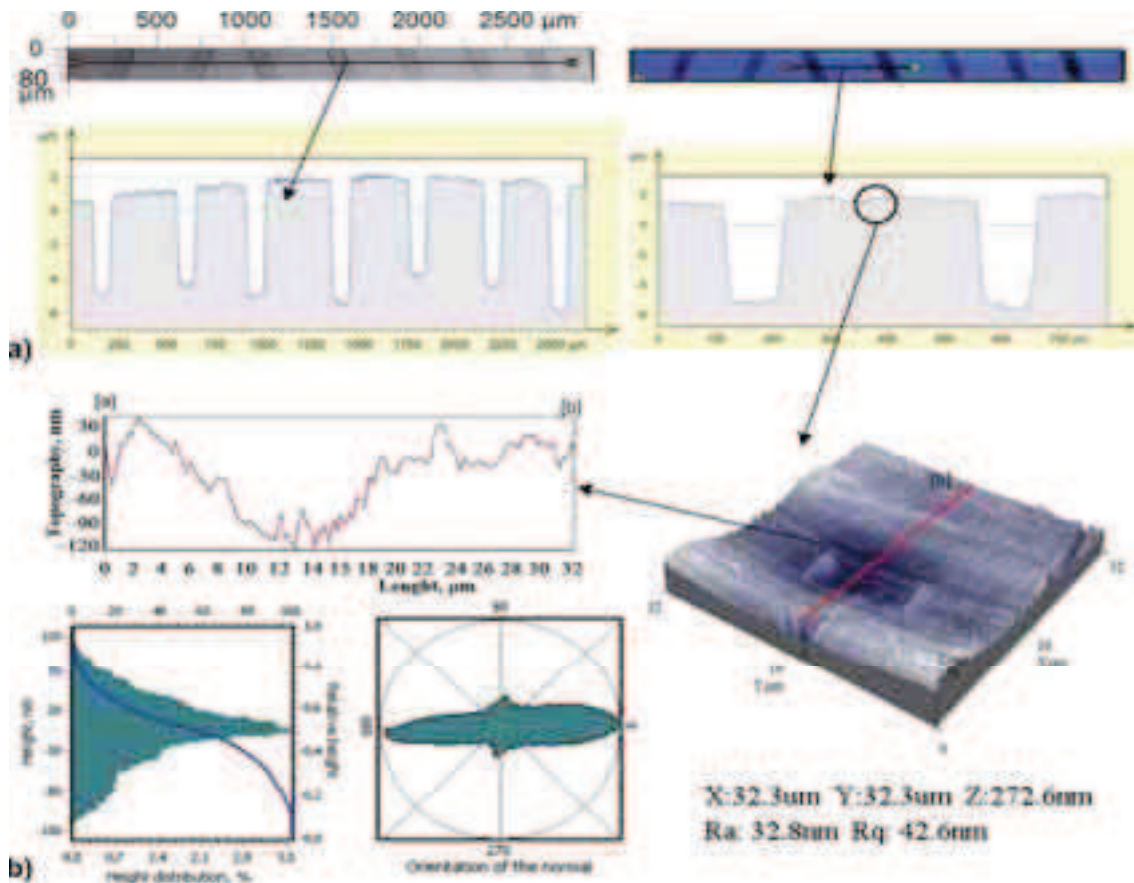


Fig. 3. Bearing sleeve surface with microgrooves - bearing from Kama Flow SP0825FDB12H – intermittent mode

The results of surface topography measurements of classical slide micro-bearing, used in Xilence *Case* computer cooling fan, which worked in continuous mode, are presented in Fig. 4. Surface topography of the same bearing, but used in intermittent mode, is presented in Fig. 5. Fig. 4a and 5a present the topographies of investigated surfaces, achieved with the profilometer, Fig. 4b and 5b with the atomic force microscope.

Xilence Case fan bearing sleeve is made of porous and sintered material. It can be seen in Fig. 4b and Fig. 5b as significant irregular cavities on bearing surface.

Surface topographies of investigated micro-bearings journals are presented in Fig. 6 and 7. Fig. 6 shows results received for Kama Flow SP0825FDB12H fan bearing journal, Fig. 7 presents results for Xilence Case fan bearing journal.

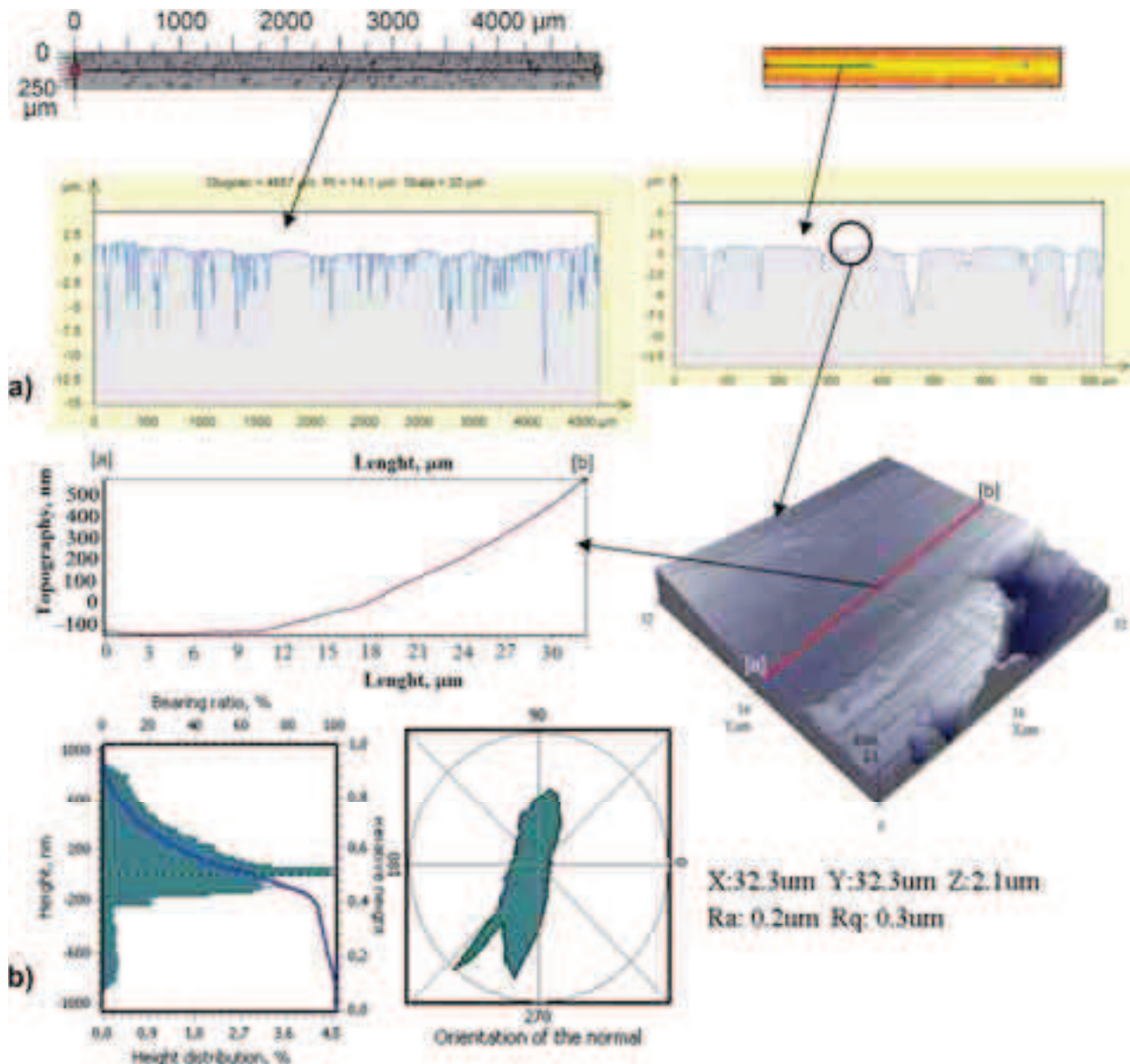


Fig. 4. Bearing sleeve surface without microgrooves - bearing from Xilence Case – continuous mode

The roughness values of surfaces presented in Fig. 4b and 5b are much higher, in comparison with roughness of other investigated surfaces. It is due to the fact that sleeve material is porous.

In Fig. 6a, 7a and 7b visible signs of wear of bearing journal (in the form of material loss or scratching) occur. It can be caused by hard inclusions that exist in slide bearing lubricating gap or may be a result of boundary friction between cooperating surfaces of slide micro-bearing.

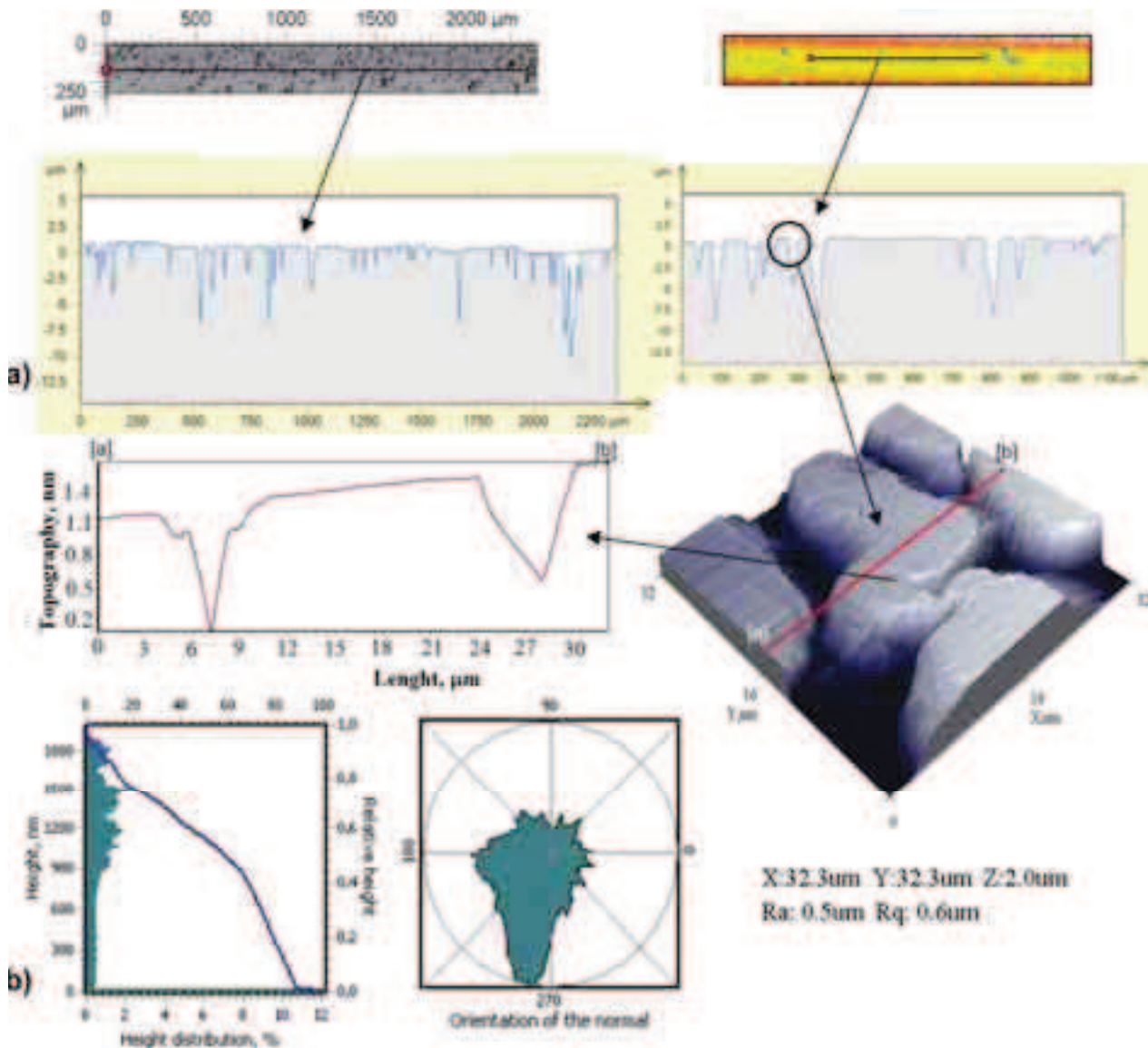


Fig. 5. Bearing sleeve surface without microgrooves - bearing from Xilence Case – intermittent mode

3. Observations and conclusions

The surface topographies shown in Fig. 2-7 were selected from dozens of measurements results, which were made with the AFM. In this paper, only some chosen results are presented, but conclusions concern all of investigated areas of the bearing surfaces.

Operation in intermittent mode of slide micro-bearing causes faster wear of its sleeve and journal surfaces, due to the fact, that bearing periodically was operated under unstable conditions and boundary friction was occurring.

Measurements made with the profilometer, were used to determine the widths and depths of microgrooves and also the distances between them. The data gained in this experiment allow performing numerical calculations and simulating with high accuracy a hydrodynamic pressure distribution in lubrication gap of a slide micro-bearing with grooved cooperating surfaces.

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

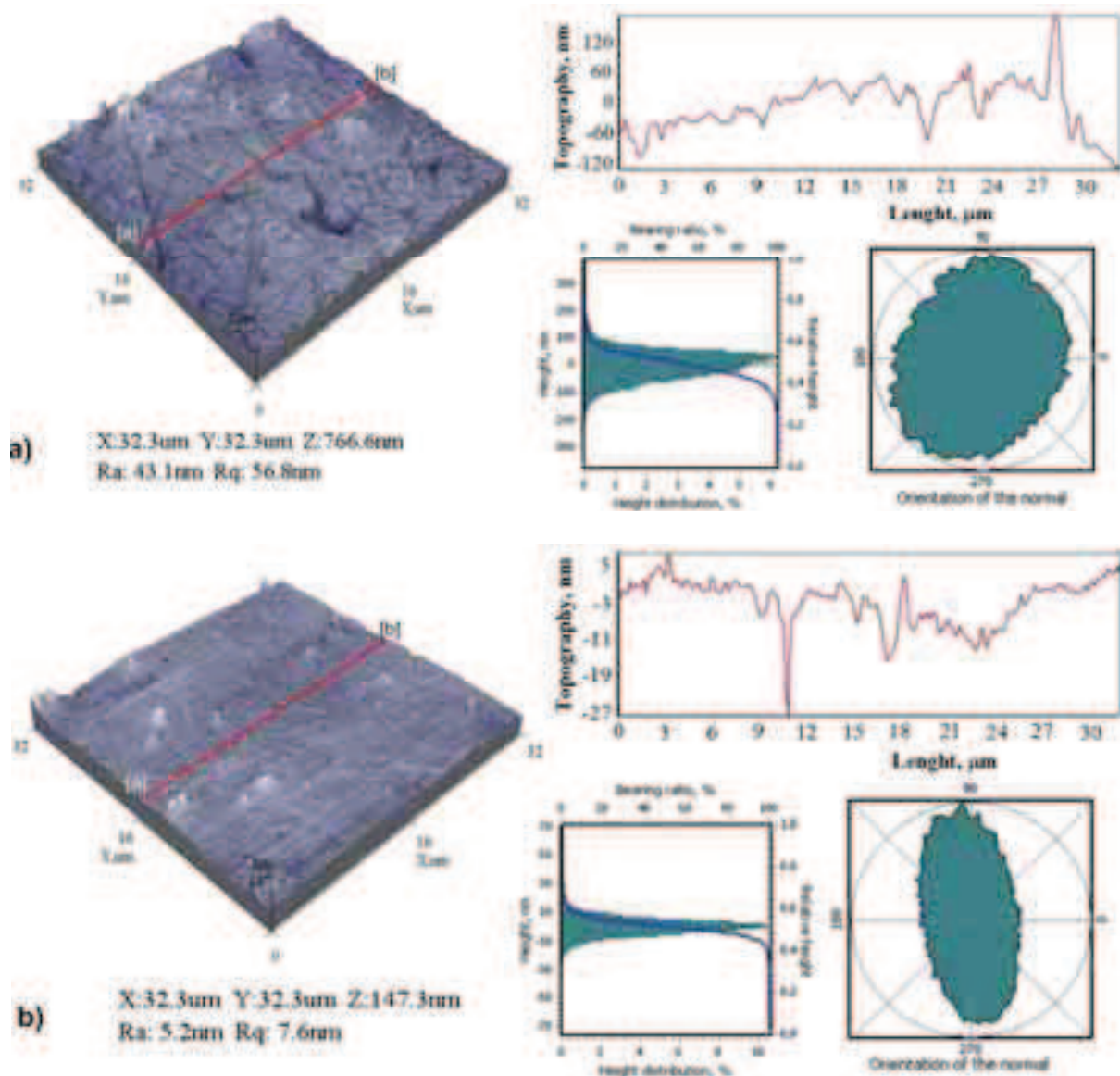


Fig. 6. Bearing journal surface topography - bearing from Kama Flow SP0825FDB12H: a) continuous mode, b) intermittent mode

References

- [1] Andharia, P. I., Deheri, G. M., Gupta, J. L., *Effect of Longitudinal surface Roughness on the Behaviour of Squeeze Film in a Spherical Bearing*, International Journal of Applied Mechanics and Engineering, Vol. 6, No. 4, pp. 885-897, 2001.
- [2] Asada, T., Saito, H., Asaida, Y., Itoh, K., *Design of hydrodynamic bearing for high-speed HDD*, Microsystem Technologies, 8, pp. 220-226, 2002.
- [3] 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.
- [4] Czaban, A., Miszczak, A., *Surface Topography on Non-Operated Slide Journal Micro-Bearings*, Journal of KONES Powertrain and Transport, Vol. 18, No. 2, pp. 109-115, 2011.
- [5] 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.

- [6] 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.
- [7] 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.
- [8] Miszczak, A., *Analiza hydrodynamicznego smarowania ferrocieczą poprzecznych łożysk ślizgowych*, Monografia, Fundacja Rozwoju Akademii Morskiej, Gdynia 2006.
- [9] 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, Radom 2010.
- [10] Wierzcholski, K., Miszczak, A., Khudoley, A., *Characterization of nano-grooved superficial layer of computer microbearings*, Tribologia, 6, pp. 257-267, Radom 2011.
- [11] Wierzcholski, K., Miszczak, A., *Load carrying capacity of microbearing with parabolic journal*, Solid State Phenomena, Trans Tech Publications, Vols. 147-149, pp. 542-547, Switzerland, UK, USA 2009.

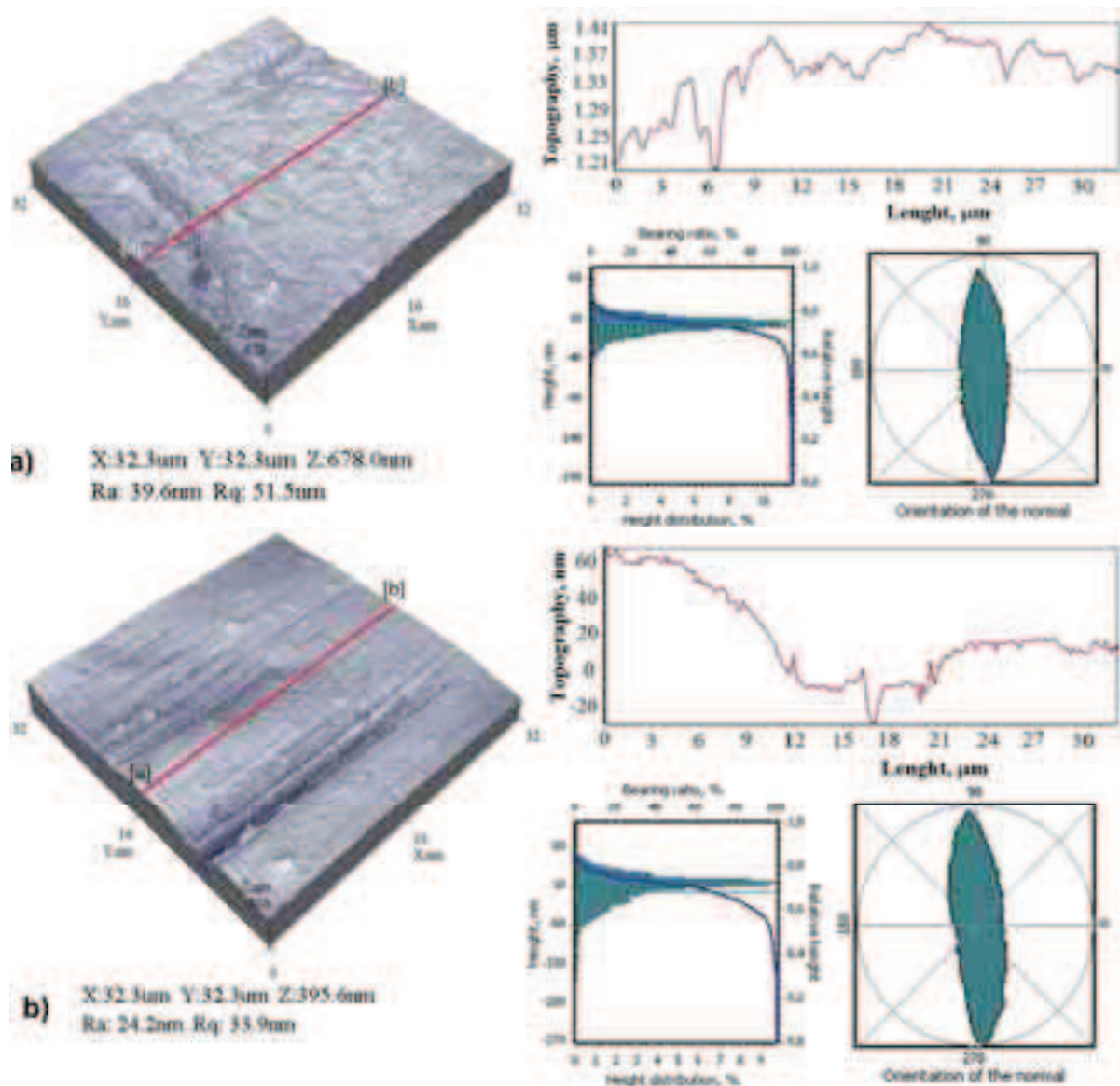


Fig. 7. Bearing journal surface topography - bearing from Xilence Case Fan – continuous mode, a) continuous mode, b) intermittent mode