SURFACE TOPOGRAPHY OF SLIDE JOURNAL BEARINGS

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Abstract

In this article the measurements results of surface topography of different types of slide bearings sleeves have been presented. The research has been conducted with the use of 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 thin-walled sleeves of slide journal bearings covered with PTFE, POM, bronze and white metal layers. Operated and new sleeves have been considered with the use of Atomic Force Microscope NT-206 produced in MTM in Minsk, Republic of Belarus [2].

Atomic Force Microscope NT-206 provides information for samples with maximum roughness value ± 1μm. Max. field in one scanning process is up to 32μm x 32μm. Measurements were preceded with resolution 256x256 points.

Presented in the work results of surface topography measurements also include the calculated values of average deviation profile Ra and Rq and the value of fixed distance between the lowest and highest inequality.

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.

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

***Keywords**: atomic force microscope, surface topography, journal bearing,*

1. Introduction

Require constructing improved slide bearing with capability of adjustment and adaptation to operating conditions and needed parameters is a motivation for scientists and constructors for developing new research fields associated with theory of non-classical lubrication of slide bearings.

The issue of non-classical lubrication of slide bearings can be considered on the following aspects:

- non-classical lubricants and lubrication systems,
- non-classical geometry of slide bearing,
- new sleeves materials.

The aim of a scientists and constructors is to:

- improve lubricity and viscosity of lubricants,
- create possibility to control viscosity of a lubricant and capacity of a bearing,
- invent protection system for the bearing against undesirable and dangerous operating conditions (oscillations, underload, mixed friction, etc.),
- obtain improved bearings materials,
- increase capacity of the bearings and decrease the wear.

Present bearing materials applied as operating surfaces of the sleeves can be specified as a:

a) metals:
   - homogenous,

- composites,
- porous,

bronze, sintered bronze, alloys of lead, alloys of tin, et al.

b) intermetallics,
c) polymers:
- homogenous,
- composites,

(PA, PE, PTFE, POM, UHMWPE)

d) ceramics: Al_2O_3, ZrO_2, Bioceramics;
e) et al.

The sleeves operating surfaces made of mentioned bearing materials have different values of roughness, which can be explained trough an outcome of a various production process methods or surface treatment process of several layers.

In this paper authors present their researches about surface topography of selected bearings sleeves. For studies authors used bearing sleeves, which operating surface was made of: bronze, white metal, PTFE (polytetrafluoroethylene) and POM (polyoxymethylene). In these investigations new and used journal sleeves were taken into consideration.

Investigated samples are presented in Fig. 1.

Bronze POM PTFE white metal - new white metal - used

Fig. 1. Pictures of investigated samples

Roughness of bearing sleeve and journal operating surfaces has important impact on the gap height size in slide journal bearings, so it is very essential to take into account the influence of surface roughness on that value. It can be done by use of stochastic methods described in [1, 3-6]. Non-classical surfaces with indentations, which basically influents on lubrication, are also object of interest of various researches [2, 7].

Measurements of surface roughness in micro and nanoscale can be executed with atomic force microscope (AFM).

2. Measurements of surface topography

Surface topography of investigated bearings sleeves was measured with the atomic force microscope NT -206 produced in MTM in Minsk, Republic of Belarus, using the contact (static) mode.

In Fig. 2-6 there are presented three dimensional graphs of surface topography, cross-section diagrams and plots of peaks and valleys height distribution and tilt angles distribution of measured samples.

Figure 2a presents surface topography on non-used journal sleeve made of white metal while in Fig. 2b there is presented another similar journal sleeve, made of the same material, but after usage.

Surface roughness graph of non-used journal sleeve made of PTFE is shown in Fig. 3. Fig. 3b shows surface topography of used PTFE bearing sleeve.

Following graphs present surface topography of new and used bearing sleeves made of POM (see Fig. 4a and 4b). Surface topography of bronze bearing sleeve is presented in Fig. 5a and 5b.

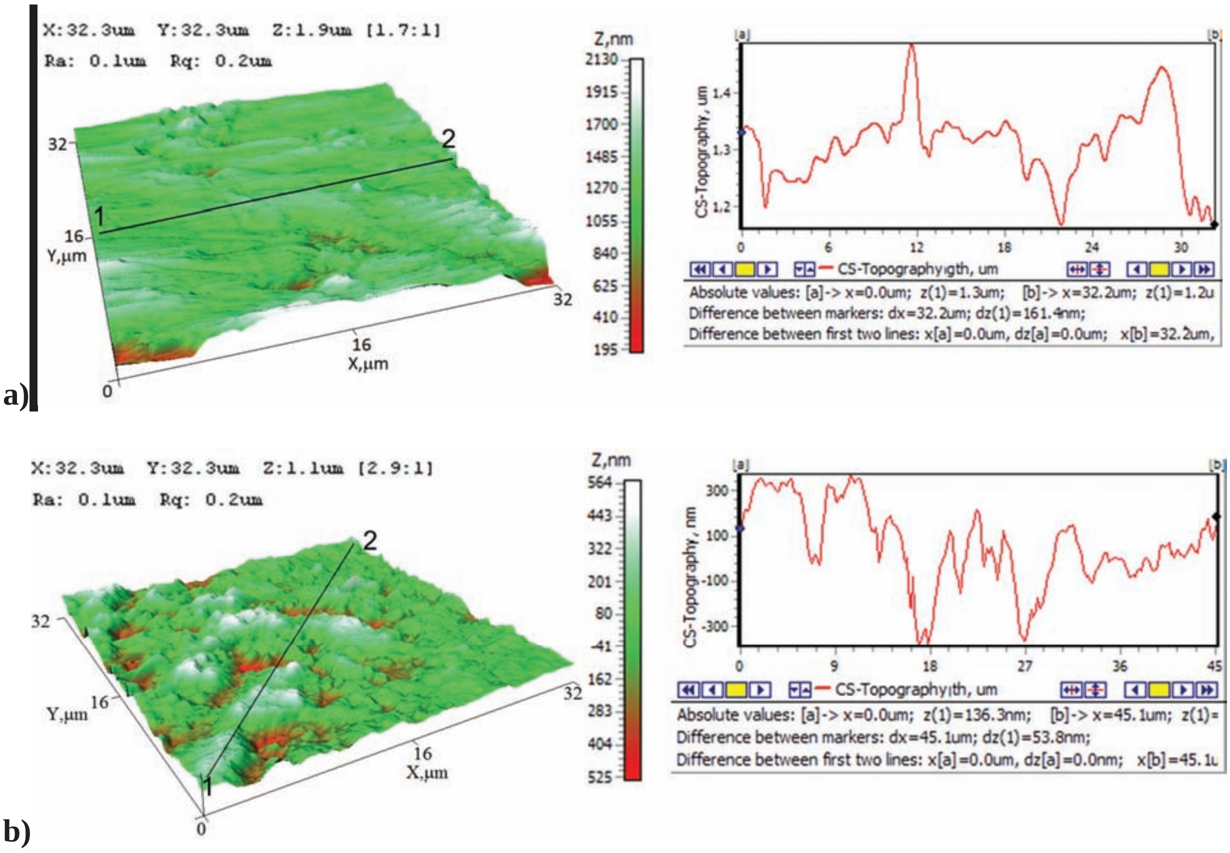

Fig. 2. Surface topography of bearing sleeve made of white metal. 3D view and cross-section, for: a) non-used bearing sleeve b) used bearing sleeve

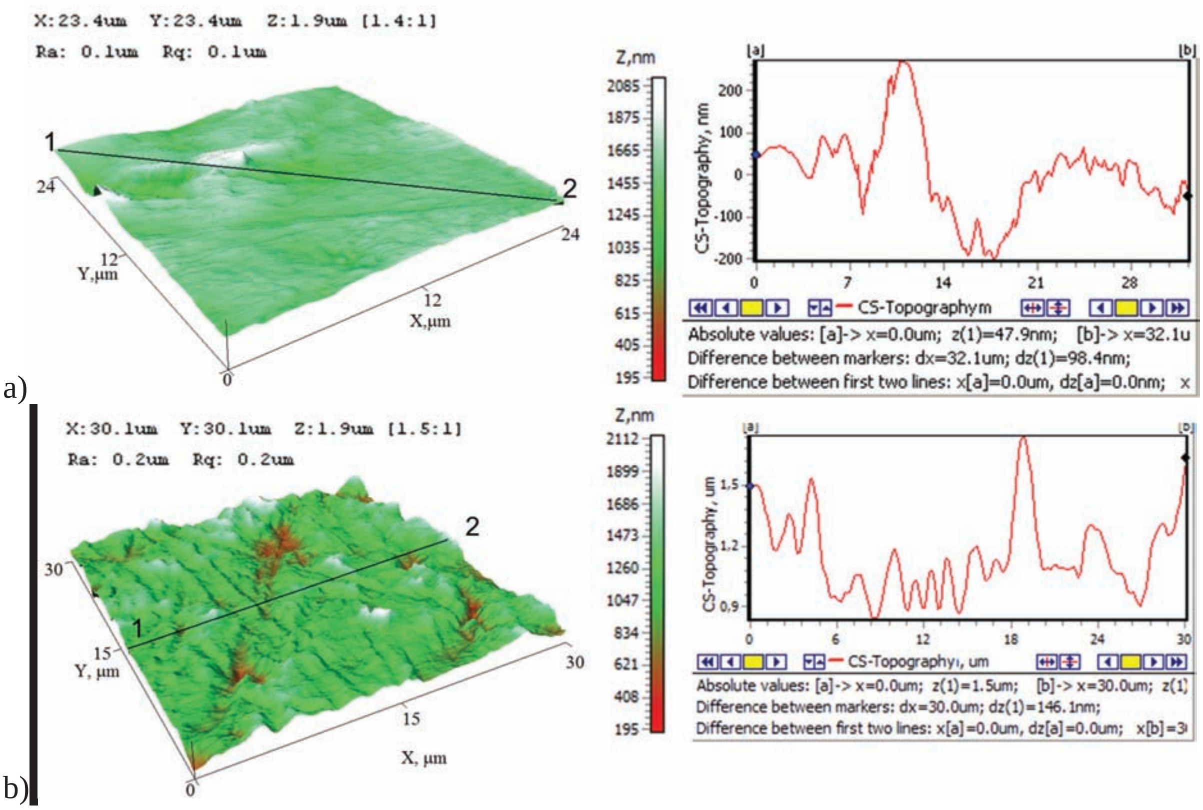

Fig. 3. Surface topography of bearing sleeve made of PTFE. 3D view and cross-section, for: a) non-used bearing sleeve b) used bearing sleeve

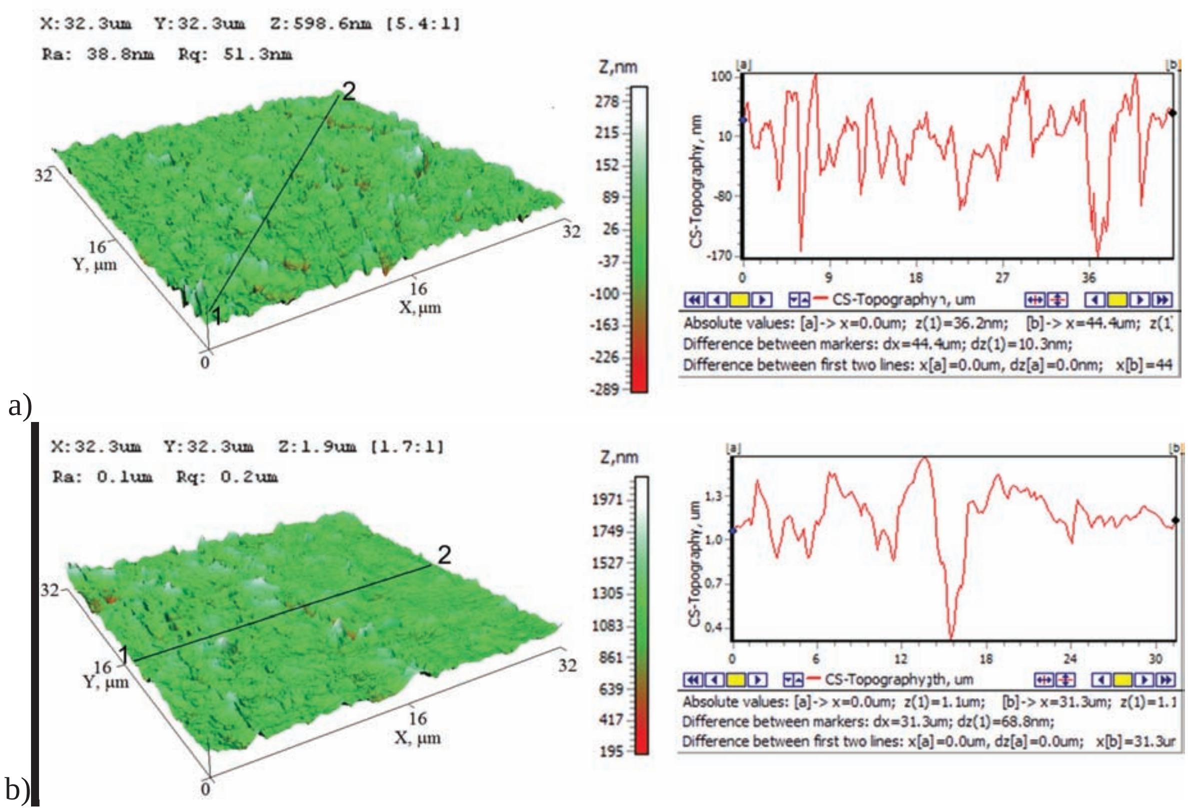

Fig. 4. Surface topography of bearing sleeve made of POM. 3D view and cross-section, for: a) non-used bearing sleeve b) used bearing sleeve

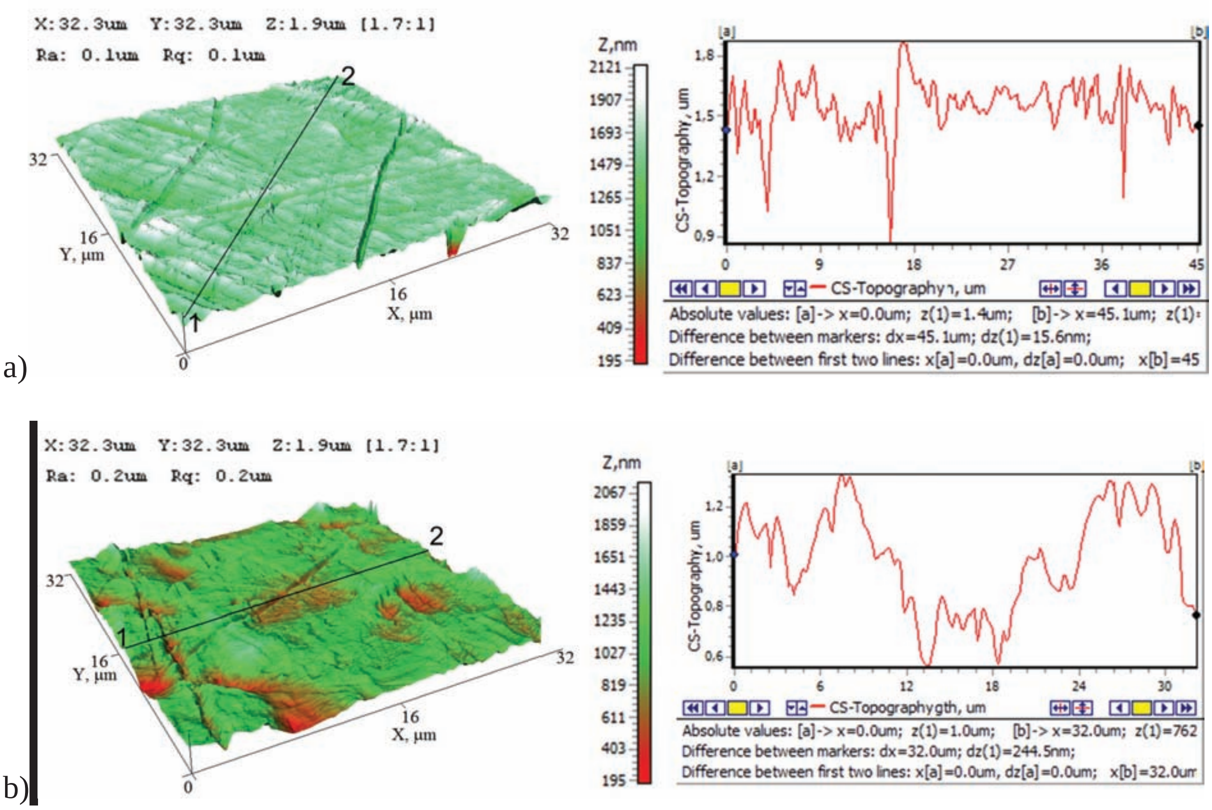

Fig. 5. Surface topography (with indentations) of bearing sleeve made of bronze. 3D view and cross-section, for: a) non-used bearing sleeve b) used bearing sleeve

Surface roughness of non-used smooth thick-walled bearing sleeve made of bronze is presented in Fig. 6a, while Fig. 6b presents similar bearing sleeve but from used bearing.

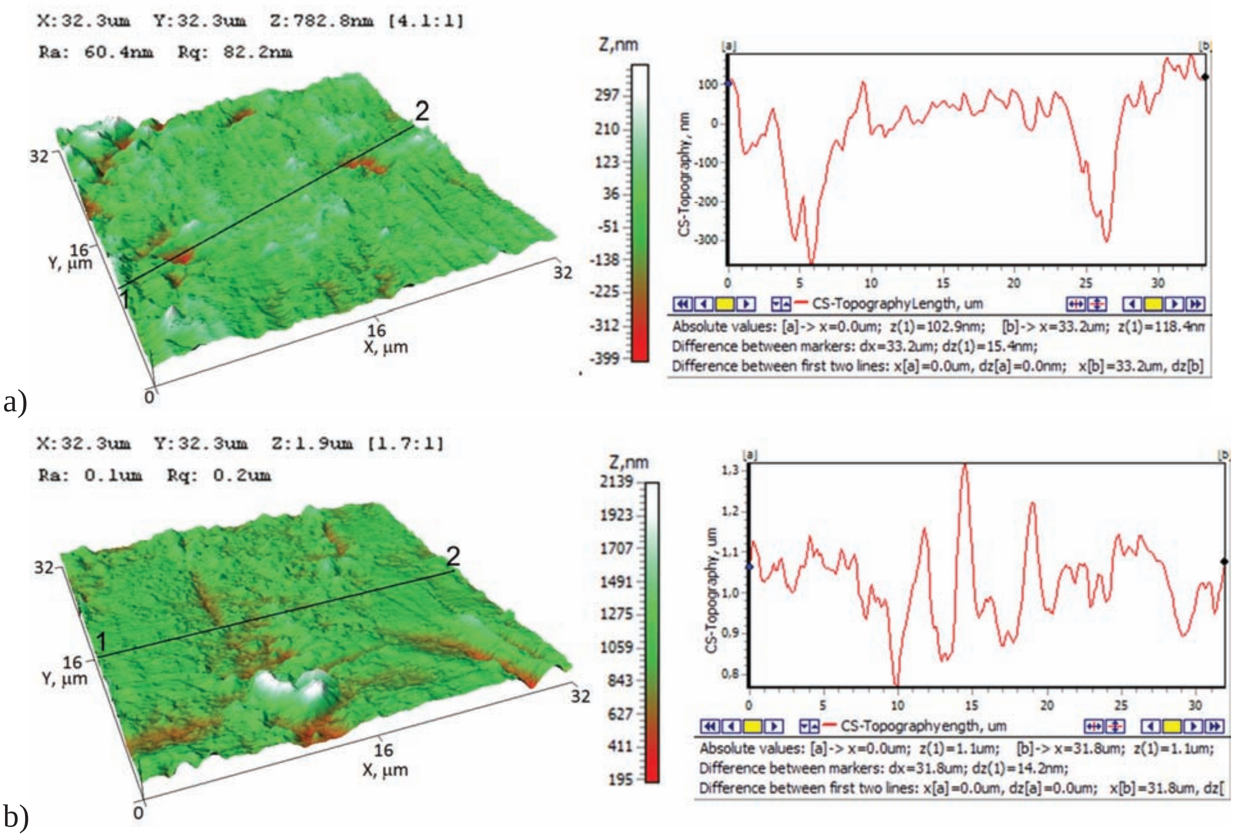

Fig. 6. Surface topography of thick-walled, smooth bronze bearing sleeve. 3D view and cross-section, for: a) non-used bearing sleeve b) used bearing sleeve

From results, presented in Fig. 2-6, it can be observed, that non-used bearing sleeves roughness has slightly lower value than roughness of used bearing sleeves. The greatest values of roughness is for used bearing sleeve made of PTFE - the R_a parameter (arithmetic average of roughness) is about 0.2μm, while the lowest value is for bearing sleeve made of POM - R_a is about 38.8 nm.

Visible scratches on surfaces are significantly increasing value of R_a parameter. That scratches are the effect of wear of bearing sleeve surface related to operating in inappropriate conditions, such as mixed friction, boundary friction or can be caused by foreign substances, which occur in lubricant - oil used in studied bearings as a lubricant ,,worked” without filtration.

Authors used SurfaceXplorer® 1.3 application for processing and visualization data received from measurements. Cross-sections presented on the right-hand side in Fig. 2-6 are marked as 1-2 line in related figures on left-hand side. Peaks height and tilt angles distributions was also executed with application SurfaceXplorer®.

Examples of peaks and valleys height and tilt angles distributions show Fig. 7. Due to that information, it will be possible to determine coefficients of mathematical expectation operator applicable for calculating hydrodynamic pressure with use of Reynolds' equations [2-4].

3. Conclusions

Obtained information about bearings sleeves surface roughness and about inequality height and tilt angles distributions gives fundamentals for developing valid and successful theory of hydrodynamic lubrication, which includes influence of bearings sleeves surface roughness on lubricant gap height and other operating parameters, also depending on type of material.

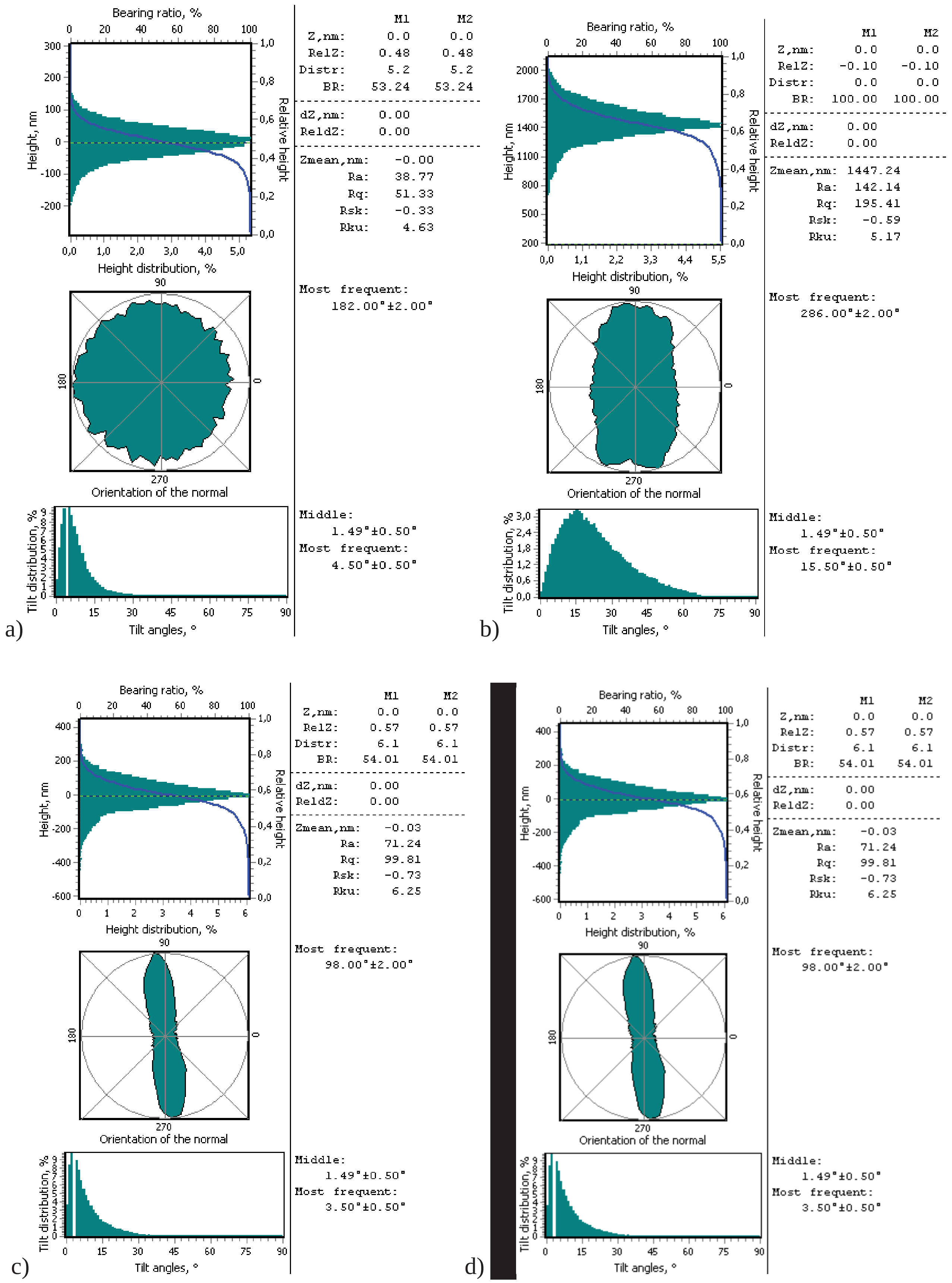

Fig. 7. Peaks and valleys height distribution, tilt orientation and angles: a) POM bearing sleeve, b) PTFE bearing sleeve, c) thin-walled bronze bearing sleeve, d) white metal bearing sleeve

Furthermore, it allows determining relationships needed to find bearing operating parameters with stochastic methods.

The knowledge about roughness values of the operating surfaces of bearing journal and sleeve will allow to design and construct bearings with better tribological properties, so also life expectancy of bearing journals and sleeves will be improved.

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