

УДК 514.8:620.191.35(043.2)

**EXPERIMENTAL COMPARISON OF DIFFERENTIAL-PHASE METHOD
AND METHOD OF DYNAMIC FOCUSING IN DEFINING
OF ROUGHNESS PARAMETERS OF SURFACES***Kunze Klaus*, PhD, *Modler Niels*, PhD
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У цій статті пропонується інформація про метод відмінної фази і метод з автоматичним фокусуванням, які використовуються на лазері відмінної фази, хто розглядає профілограф-профілометр (ДЕДАЛ-ЛСПП) і мікроскоп «MICROSCAN» відповідним чином. Також вважається експериментальним порівняння визначення тривимірних мікро- і наногіометричних поверхневих умов і стандартизовані параметри брутальності поверхні за допомогою таких методів.

Ключові слова: грубость, поверхня, мікроскоп, лазер, перегляд, тривимірне представлення.

In this work you can find information about differential-phase method and method of autofocusing, which are used on differential-phase laser scanning profilograph-profilometer (DFLSP) and microscope «MICROSCAN» correspondently. Also is considered experimental comparison of defining of 3D micro- and nano-geometrical surface conditions and standardized roughness parameters of surface with the help of those methods.

Keywords: roughness, surface, microscope, laser, scanning, 3D-view.

Almost all modern machines and mechanisms consist of friction nodes, which realize contact interaction of details with working surfaces in relative motion between each other. From tribology of boundary greasing it is known that there is great influence of surface roughness on tribological properties of rolling or sliding tribosystems. Due to this fact during production of details different quantitative methods for determination of roughness parameters are widely used (such as profilograph-profilometer CALIBR-201, “TEYLOR HOBSON”, “SURTRONIC-10”). Contact methods allow describing micro-geometrical surface structure only according to single profiles and they can't give information about volumetric surface condition, which is very important during friction in dependence of direction of exploitation and influence on wear resistance of tribosystem.

Nowadays contactless optical methods and equipment such as laser contactless differential-phase method and method of dynamic focusing (in DFLSPP of Ukrainian production [2] and microscope “*µscan*” of German production correspondently) are used instead of contact, less informative and destroying methods. This new equipment and methods can give essentially new, qualitative and quantitative information about volumetric 3D micro- and nanometric geometrical surface condition. In this work are presented results of experimental investigations of rough surfaces done with a help of DFLSPP and “*µscan*”. Today for controlling of working surface roughness of details with friction nodes contact methods still are used.

In contact method needle with a circular diameter 2...4 µm slides on a surface of sample in a linear direction. This method can be used for determination of wear traces after tribotechnical tests.

After experiments done on friction machine with a constant linear contact radial deviations are more than 1 micrometer, axial — 0,1 micrometer.

That is why we can say that one of the main factors, which influence on results of tribological experiments of lubricating materials, is external structure of working surface of samples after friction.

But usage of contact method can provide us with necessary information about structure of surface, and can't give full information about surface, such as roughness in a direction of sliding.

This information have influence on character and value of wear [1].

Moreover, equipment which is based on contact method can scan surface only in one linear direction. In such conditions it is very hard to make volumetric estimation of surface structure. Indenter (needle) which is used for estimation of friction surface have circular radius (approximately 2 micrometers). That is connected with technological features and design of equipment and sensitive elements, which realize this contact method. Because of that we have such consequences like that hardware can't fix geometrical character of surface if it has roughness less than diameter of needle.

That is why only contactless optical method can provide us with full information about 3D volumetric surface structure.

DFLSPP of Ukrainian production was created for reception of true information about surface structure and reception of differential-phase picture.

Principle of action of this equipment is based on acoustic-optical scanning of object with the help of laser beam, which is divided in two orthogonal directions in crystal of paratellyrite.

During scanning this beams are reflected from surface creating 3D differential-phase picture (fig. 1).

For investigation of phase changing from reflected light waves in surrounding is used differential-phase method.

This method allows creating optical scheme tolerant to vibrations. Method is based on reception information about local difference of phases of two beams (basic and alarm), from which we can receive information about local curvature of wave front surface by scanning and integrating of defined values [3]. METHOD OF DYNAMIC FOCUSING Micro-scope μ scan of German production by firm NanoFocus [4] was created for the same purposes as DFLSPP. But principle of action of this microscope is not the same. It has focusing sensor and movable lens, which provide auto-focusing by moving of lens along measurement scale (fig. 2).

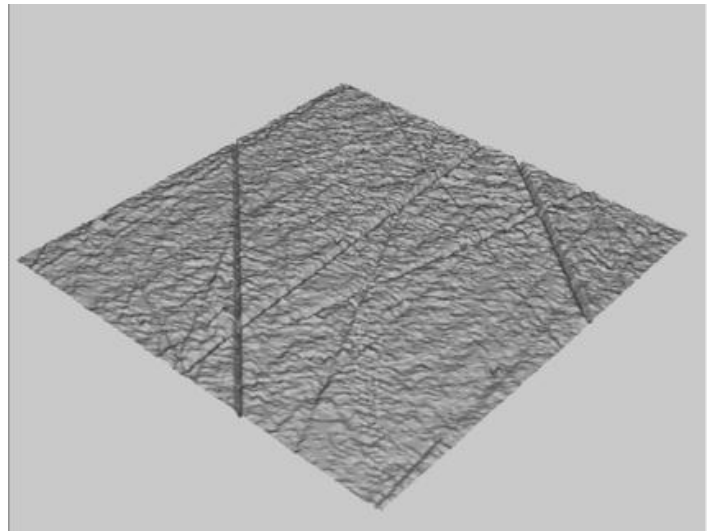
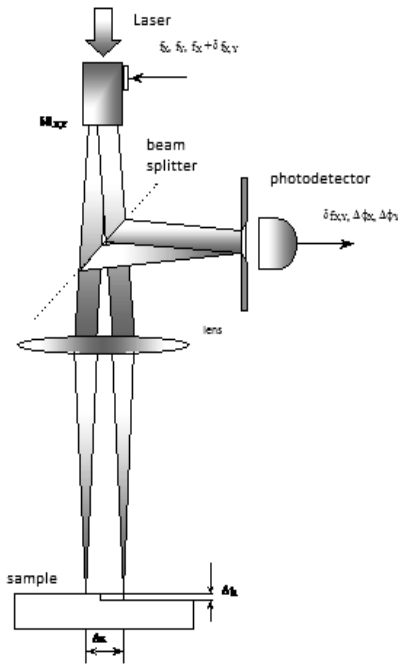


Fig. 1. Laser contactless differential-phase method

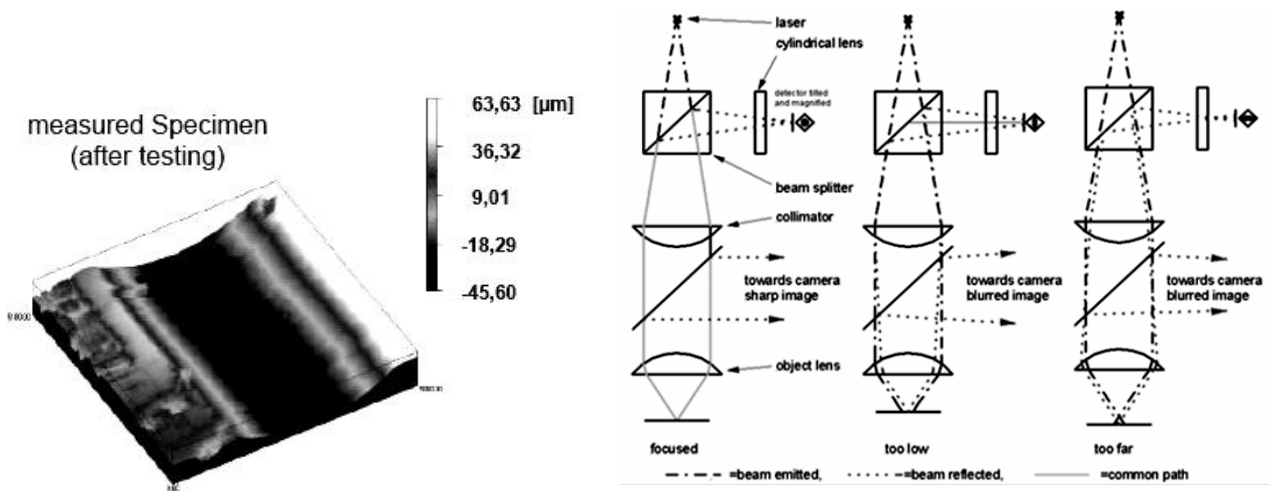


Fig. 2. Dynamic focusing method

Investigated object moves under laser beam with the set speed and information about moving of movable lens in dependence of height of surface relief goes to computer. The more focused points we will have the better picture will be received. The maximal investigated area is $10 \times 10 \text{ cm}^2$.

EXPERIMENTAL DEFINITION OF POSSIBILITIES OF DFLSPP AND "MICROSCAN"

Important peculiarity of DFLSPP and microscope μscan is possibility to define and calculate volumetric structure of rough surfaces. Software of that equipment allows defining main roughness parameters of investigated surfaces of samples. Both microscopes have different methods of calculation, that is why they also have different technical characteristics.

Thus on DFLSPP can be calculated standardized roughness parameters of samples in a range $0,005 \dots 0,320$ micrometers and on μscan in a range $0,025 \dots 1250$ micrometers (see Table). But on microscope μscan this calculated roughness parameters are also compared with international standards ISO, which can be chosen for different materials.

Also it has to be mentioned, that very important parameter during investigations of the sample is its reflection ability.

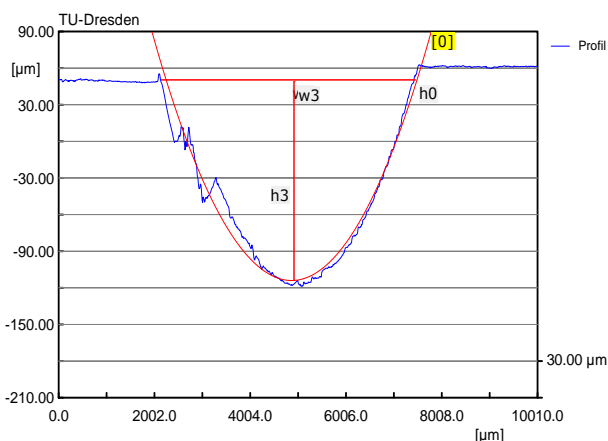
For DFLSPP can be also investigated objects with reflection ability less then 50 %, but in this case lenses on profilograph-profilometer should be changed.

Technical characteristic of microscopes

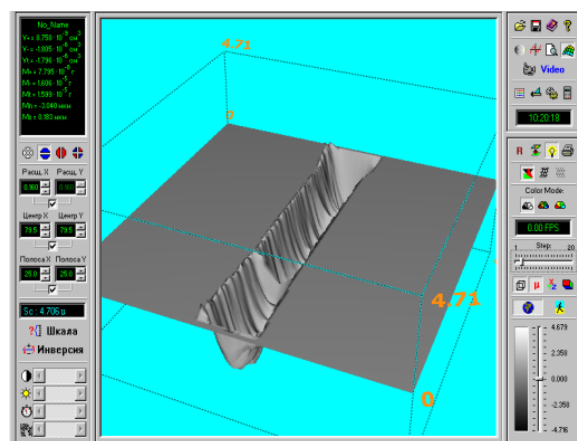
Technical parameters	Microscope			
	DFLSPP		μscan	
	Type of objective lens			
	PLAN, F=6,3, A=0,65	PLAN, F=16, A=0,3	autofocus	
AF2			AF5	
Max. scanning area, mm	2,5×2,5 0,8×0,8	5×5 3×3	100×100	
X, Y- resolution, μm	0,8	0,6	1	1
Curvature of surface, degree/ μm	20	8	26	19
Reflection coefficient of the surface, %	≥ 50		0...100	
Height of measured step of relief, μm	$\leq 0,32$		≤ 1500	
Resolution for relief, nm	≤ 10		≥ 25	
Type of scanning	Acousto-optical		mechanical	

Microscopes NanoFocus and LDFSPP are used for definition size of deterioration of modeling bearings of sliding after friction in laboratory conditions.

On the fig. 3 are presented profile of track after friction, received on a microscope NanoFocus in the laboratories of the Tribotechniques of ILK TU Dresden and 3D image of a track after friction received on LDFSPP in laboratories Nanotribo-technology NAU Kiev.



a



b

Fig. 3. Profile of track after friction by NANOFOCUS (a) and 3D view of track after friction by DFLSPP (b)

CONCLUSION

Choosing equipment for estimation roughness parameters consumer need technical and economical comparison of this equipment to decide which one is better for purchase. Comparison of technical abilities had shown that differential-phase method has next advantages:

- Is insensitive to vibrations;
- Microscope can provide measurements of surface parameters to 1 nm on height of relief;
- Investigated object is immovable;
- Object with any size can be investigated.

But in this method we don't have autofocus and have not so big working range (height of relief can be measured in range 1...320 nm). Disadvantages of differential-phase method are realized in method of autofocus. And we can name its advantages:

- Wide measurement range;
- Autofocus;
- Sample with surface with any reflection coefficient can be investigated.

In method of dynamic focusing we have next disadvantages:

- Sensitivity on height of relief is smaller then in DFLSPP;

- Mechanical scanning, which lead to vibrations and decrease sensitivity of microscope.

Comparison of all this advantages and disadvantages, general technical characteristics and price of this equipment show that such investigations are very important for consumers for making of an optimal choice of microscope for work in definite conditions.

LITERATURE

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Стаття надійшла до редакції 04.02.2011.