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APPLICATION OF SPECTRAL ANALYSES FOR SURFACE LAYER CHANGES ESTIMATION OF CO-OPERATING UNITS WITH CONFORMAL CONTACT

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Abstract

The qualitative opinion of the surface layer condition was introduced in this paper. The usefulness of spectral analyses was analysed to the opinion of changes proceed in the surface layer of co-operating units. The functions of the power spectral density and autocorrelation which were used to analyses were self- characterized.

The structures of the surface after tribology investigations were accepted to the opinion of proceeding changes. Spectral graphs were analysed for structures without the co-operation (directly after the finishing processing) and after the various roads of the friction. The following intervals of the road of the friction were used to the qualitative opinion: 100, 200, 300, 500 metres – there are most intensive changes and 2000 metres – the stabilization of changes follows. The conditions during tribology investigations were accepted as stable. The received graphs of the power spectral density and autocorrelation function approve oneself useful in the opinion of the changes proceed of surface layer during her transformation.

Keywords: *qualitative analysis, surface layer, spectral analysis, tribology investigations, conformal contact*

1. Introduction

The properties of surface layer (SL) created as a result of the established technological process realization in the largest mark influence on the tribology profiles of the machine engines co-operating units [3, 7, 10, 12]. About the properties of surface layer generally decides the surface stereometry that is the external top section of surface layer. The stereometry form of the surface defines itself as the surface geometrical structure (SGS). The stereometry structure of the surface is the ridges set of the surface, being the realized processing traces or the results of the wear process. Describing SGS admits as basic quantities: the surface roughness, the wavy finish, the stage of surface isotropy – the directive tendency of the processing feed ridge, the deviation of shape and the surface defects [1].

The surface could have the anisotropic character in dependence from the location of SGS characteristic elements – with steered location of eminences and depressions (the surface directive tendency) or isotropic – not showing the steering location. The geometrical structure of the units of kinematic pair's surface has the essential influence on the friction processes proceeds in these pairs, and on the kinematic pair's waste intensity.

The estimation of co-operating units surface layer proceeds changes describes quantitative and qualitative values changes. The description of quantitative changes expresses quantities: the various parameters of roughness, the mass decrease, the change of linear dimensions [3, 9, 10, 11]. However the opinion of qualitative changes takes place among others on the basis of the studied surfaces photos or also basis on the spectral analyses of the surfaces [2, 6, 8]. We receive the information on the basis of the qualitative analysis about general sights of SGS and about the wear effects and also about the kind of possible damages.

In this paper to the qualitative analysis of the condition of the surface geometrical structure were accepted the spectral analyses which describe the frequencies structure of studied surfaces.

2. SGS function used for spectral analysis

The functions of power spectral density (PSD) and autocorrelation (AC) were used to the spectral analysis of surface layer changes estimation. The functions of power spectral density and autocorrelation describe the frequencies structure of the surface. These functions are very usefulness in analysing the surface topography during production and constitution of the geometrical surface, and surface waste process estimation.

During investigations, one from above mentioned functions is generally used in dependence from the aim of the tests. This results from the mutual statements between these functions, because the power spectral density function is Fourier transformation of the autocorrelation function. The power spectral density function illustrates how the surface irregularity deviation spreads together with the frequency.

In the practise of investigations the PSD function is used more often, because among others basis on this function we could estimate the influence the component strength of cutting forces or the condition of cutting edge on the surface geometrical structure. In this case the autocorrelation function is used as the opinion supplementary parameter because it reacts very sensible on any structure surface disturbances [4, 5].

In generally basis on the surface spectral analysis we could draw out following conclusions [4, 5]:

- the largest signification in the spectral analysis have component with low frequency, the high frequency component signification is insignificant,
- on the periodical surfaces in one or two perpendicular directions the power of energy focuses in the areas of proper frequency along these same senses,
- on the anisotropic surfaces the energy of the power focuses along the perpendicular sense to the directive direction (symmetrical) of the surface,
- in case of anisotropic surfaces mixed with participation of the random component with short-wave character, the decisive part keep long-wave periodical components that defining the anisotropy of the structure,
- in case of anisotropic random surfaces appear the characteristic sights of the random hum on the background of clear predominant components with low frequency beside this the surface structure keeps anisotropy and directive tendency,
- in case of random isotropic structures clearly predominates the random hum and sights of anisotropy are insignificant.

3. The analysis of the example surface structures

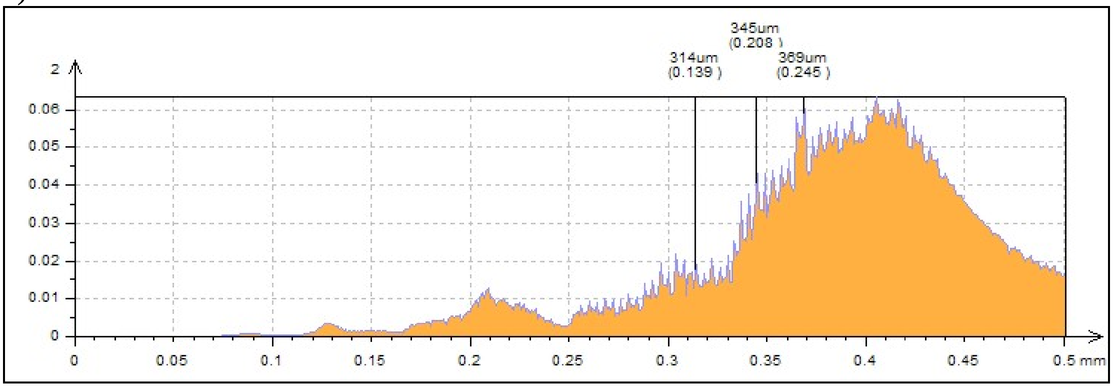
To analyse of the spectral analyses usefulness for the qualitative opinion of co-operating surfaces layer changes the experimental investigations were conducted. Studied samples were subjected tribology investigations, and the point of the contact of co-operating surfaces during investigations was conformal, i.e. he was spread on the whole co-operating surface of samples.

One of analysed structures came directly from the finishing processing, this surface was without the co-operation, but remaining structures were after tribology investigations with the various roads of the friction. The following intervals of the road of the friction were chosen to the qualitative opinion: 100, 200, 300, 500 - there are most intensive changes and 2000 metres – the stabilization of changes follows. Conditions during tribology investigations were accepted as stable.

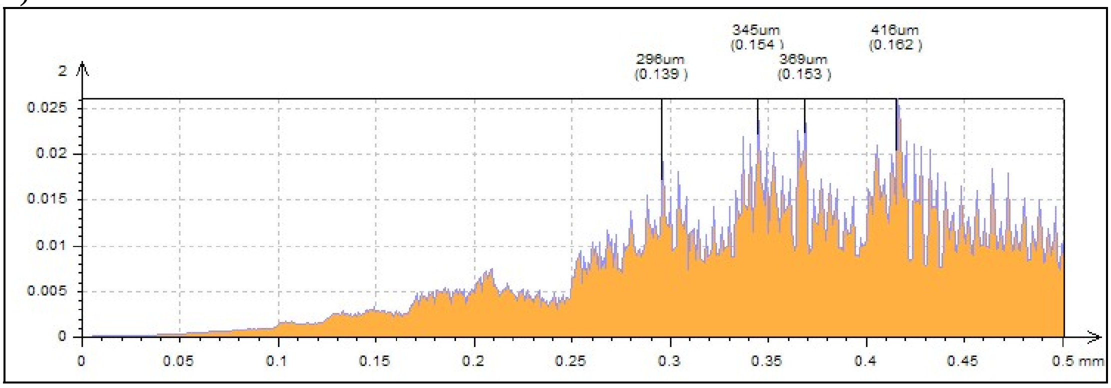
The samples with counter-sample co-operated in the centre oiling which was machine oil (L-AN 68), and values of parameters exploational were following: the speed of the relative movement: 2,9 m/min (0,05 m/s), burden 600 N (theoretical pressures in the zone of the contact point 2 MPa). The angle of co-operation between the characteristic directive tendency of samples and counter-sample was 0°. Samples were made from steel 102Cr6, counter-samples were made from steel X210Cr12. Hardness of counter-sample visibly exceed (about 50 %) the hardness of samples – the changes should proceeds firstly on the samples surface. The values of hardness were suitably 60 HRC and 40 HRC.

The graphs of the power spectral density function for put measuring points were introduced on pictures below.

a)



b)



c)

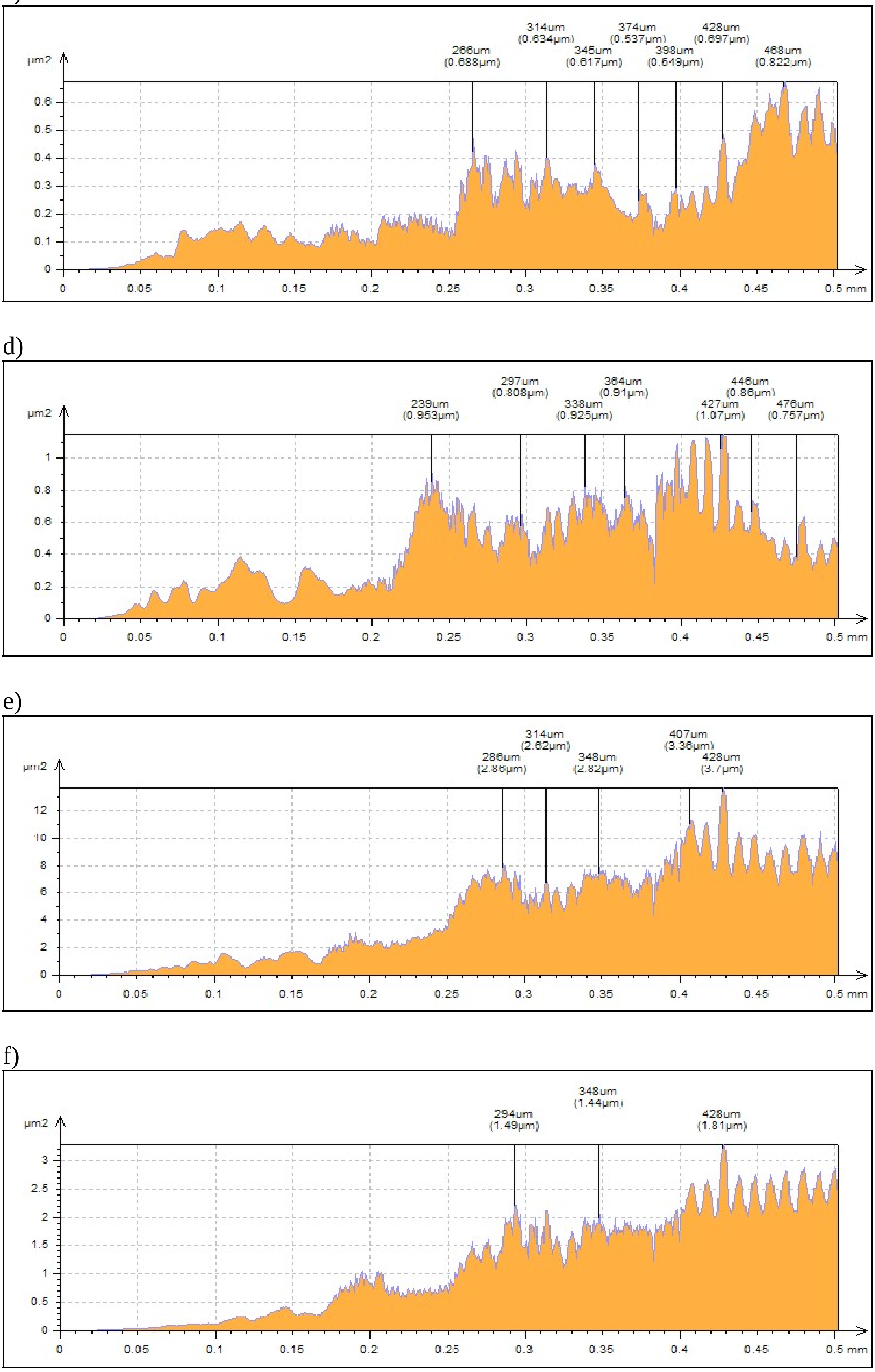


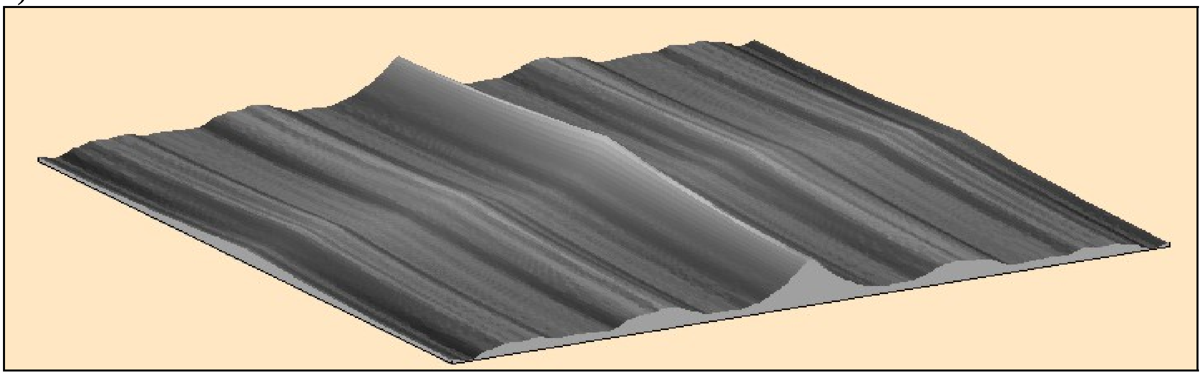
Fig.1. The graphs of the power spectral density function for the following intervals of the friction: a) 0 (without co-operation), b) 100, c) 200, d) 300, e) 500, f) 2000 meters

As it was introduced on the graphs the function of power spectral density changes on the individual stages of the co-operation. On the picture 1a, when the sample did not co-operate yet, we could observe one modal value on the graph. This value becomes from the surface character (definite directive tendency SGS) and from determined way of processing and established parameters.

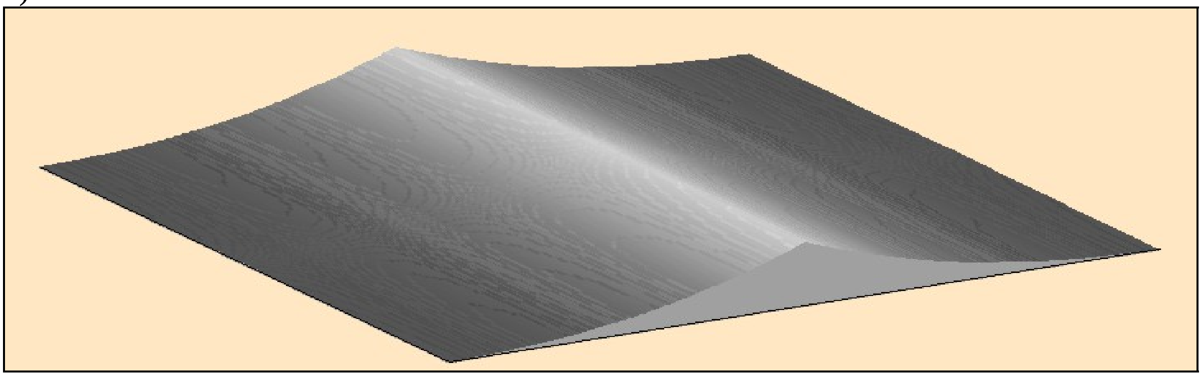
On remaining graphs we don't have one modal value any more this causes from changes formed in the result of the surfaces co-operation. The traces of the processing disappear and the direction of these traces isn't so clearly privileged any more.

The graphic figure of the autocorrelation function of studied structures was introduced on picture 2.

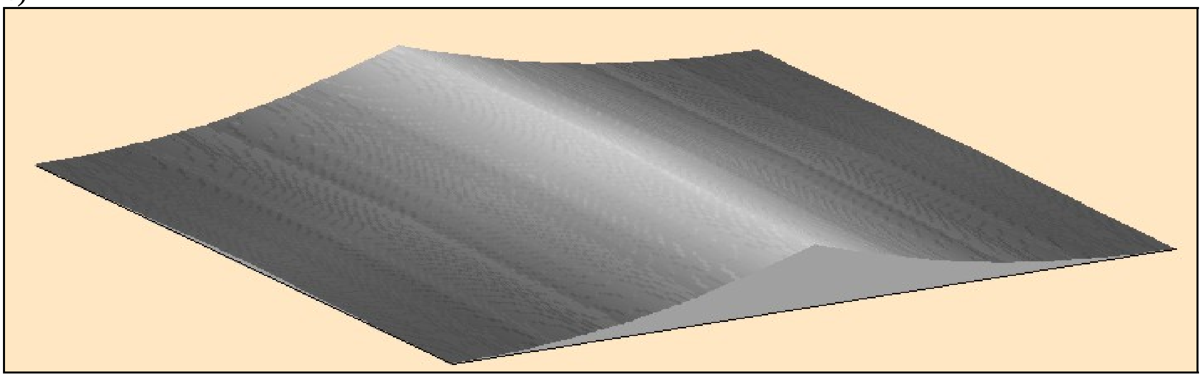
a)



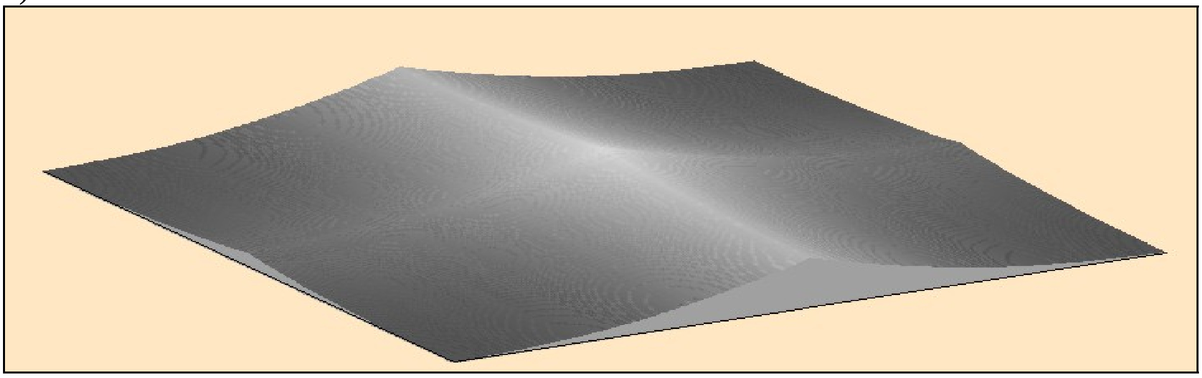
b)



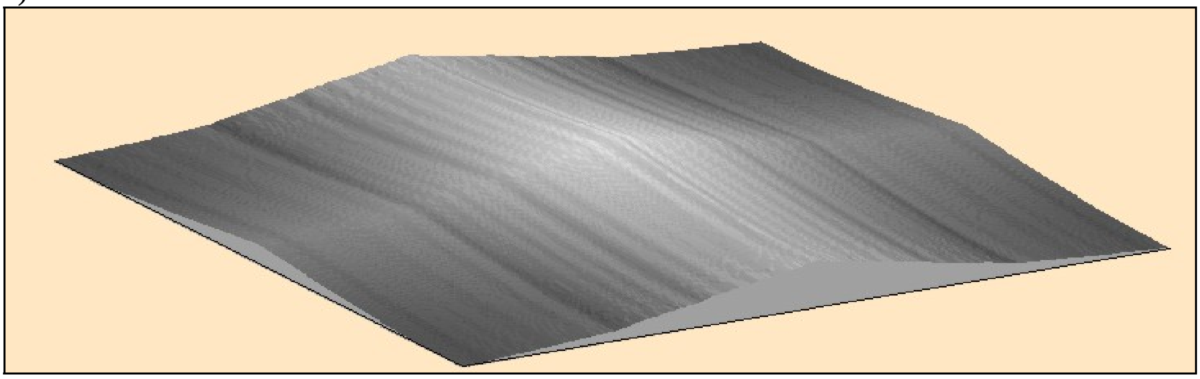
c)



d)



e)



f)

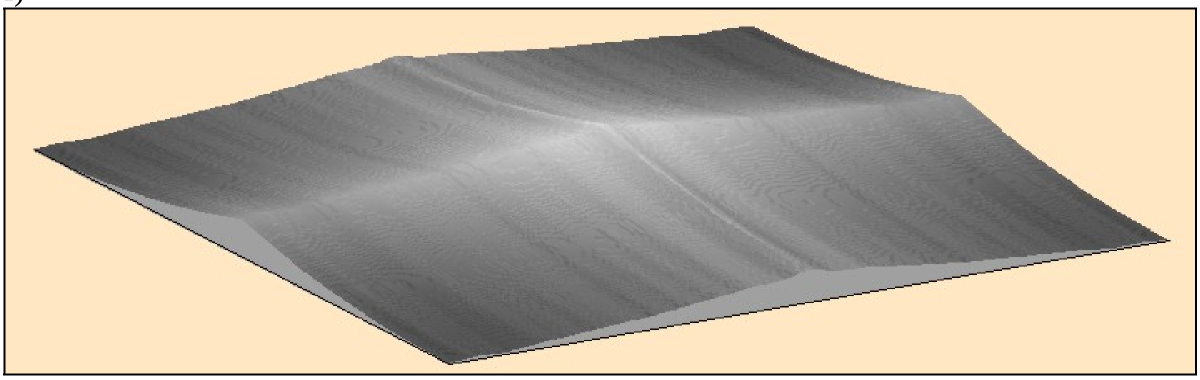


Fig. 2. The graphs of the autocorrelation function for the following intervals of the friction: a) 0 (without co-operation), b) 100, c) 200, d) 300, e) 500, f) 2000 meters

As it was introduced on the graphs we could observe the surface geometrical structure with anisotropic character (introduced on figure 2a) changes into mixed character structure without the clearly privileged directions, but with occurrence directive tendency of SGS shown in figure 2f. We could not observe the full passage into structure with isotropic character with total fading of directive tendency SGS.

4. Conclusion

Basis on conducted analyses in this paper the usefulness of spectral analyses was affirmed in tribology investigations. The received results and graphs of the power spectrum density and autocorrelation functions were very useful in the qualitative opinion of the surface structure. Basis on these functions we could analyse the changes of surface layer during their transformation.

For fuller qualitative opinion of the surface layer condition for studied surfaces of co-operating units it would also execute other analysis basis on the 2D or 3D pictures. It could help with diagnosing about the surface stereometry.

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