Investigations of 3D Surface Roughness Characteristic's Accuracy

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Abstract

The existing surface roughness standards comprise only two dimensions. However, the real roughness of the surface is three-dimensional (3D). Roughness parameters of the 3D surface are also important in analyzing the mechanics of contact surfaces. Problems of mechanics of contact surfaces are related to accuracy of 3D surface roughness characteristic.

One of the most important factors for 3D characteristics determination is the number of data points per x and y axes. With number of data points we understand its number in cut-off length. Number of data points have substantially influence on the accuracy of measurement results, measuring time and size of output data file (especially along the y-axis direction, where number of data points are number of parallel profiles). Number of data points must be optimal. Small number of data points leads to incorrect results and increase distribution amplitude, but too large number of data points does not enlarge range of fundamental information, but substantially increase measuring time. Therefore, we must find optimal number of data points per each surface processing method.

1 Importance of Number of Data Points in the 3D Surface Roughness Measuring with Contact Methods

In the 3D measurement of surface roughness, a certain number of profiles parallel to the main axis of the sample must be collected. The surface displacement is in two orthogonal directions: X - Y. In the x-direction the data is collected with Nx number of data points; in the y-direction there are Ny lines (profiles) [1].

Three experiments will be conducted to determine the optimal number of data points. Experiments will be carried out using a measuring device Taylor Hobson Form Talysurf Intra 50 and data processing program Talymap Expert. Surface benchmarks of surface grinding – Rugotest 104 (DIN 4769) will be studied.

2 Determination of Number of Points with the Correlation Functions

The goal of experiment is to determine the minimum of uncorrelated number of data points on the average spacing – RSm of the roughness profile. The surface roughness of irregular character surfaces (ground, polished, machined with spark erosion, etc.) can be described by a normal random process [2]. One of the basics characteristics of a random process is correlation function. It describes the coherence between profile points. For determination of correlation function, so-called special points of surface splits are used: the profile intersections with the mean line, the local maxima and bending points. Determination of these special points is shown in the Figure 1, where l – cut-off length.

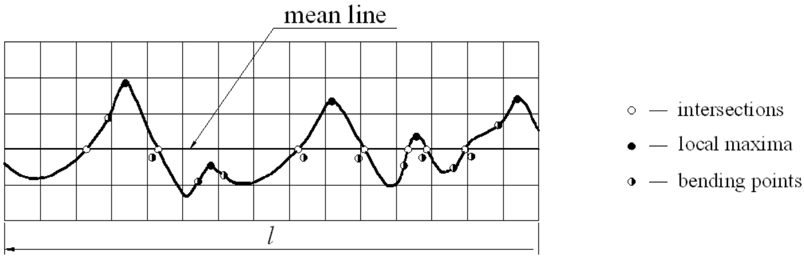

Figure 1: Special points of profile

For determination of output data on each surface were taken five profile charts, according to the profile measurement methodology [2]. Parameter Ra and profile special points were read from profile charts in one sampling length (0.8 mm). Average values were used for further calculations. Calculation example is given below.

1. After processing of profile chart the following output data were obtained:

Ra = 1.57 μm – the mean profile deviation;

n(0) = 25 – number of intersections with profile mean;

m = 37 – number of local maxima;

s = 47 – number of bending points.

2. Determine the dimensionless parameters of the correlation functions, needed for the determination of the correlation function type [2]:

$$\lambda \approx \frac{n(0)}{m} \approx \frac{25}{37} \approx 0.68 \qquad \lambda_S \approx \frac{n(0)}{s} \approx \frac{25}{47} \approx 0.53$$

3. These values corresponding to the first type of correlation function K_τ [2] with the parameter α_H, area of the value λ and rationed correlation function interval τ_{KH}:

$$K_\tau = \left(1+\alpha\tau^2\right)^{-1}; \quad \alpha_H = 0.5; \quad 0 \le \lambda \le 2; \ \tau_{KH} = 0.71 \text{ mm}$$

4. Calculate correlation interval τ_K :

$$\tau_K = \frac{\tau_{KH}}{n(0)} = \frac{0,71}{25} = 0,028 \text{ mm}$$

5. Calculate *RSm* (mean spacing) of the profile on the sampling length (0.8 mm):

$$RSm = \frac{2}{n(0)} = \frac{2}{25} = 0,08 \text{ mm}$$

6. Number of points along the sampling length determined by the following:

$$k = \frac{l}{\tau_k} = \frac{0,8}{0,028} = 29$$

7. Consequently, the number of spacing on the sampling length:

$$z = \frac{l}{Sm} = \frac{0,8}{0,08} = 10$$

8. Number of uncorrelated data points on one spacing:

$$Ps = \frac{k}{z} = \frac{29}{10} = 2,7 \Rightarrow 3$$

In a similar way it is possible to find a number of data points for any surface.

3 Determination of Number of Points Using the Graphical Approximation

Another method for determining the number of points is to describe the roughness using the graphical approximation. In this case from the one surface roughness profile chart in x-axis direction is taken one asperity (Fig. 2.a). There is searched for the number of data points at which the approximated, as example, total deviation of roughness height from the real overall parameter of the height Rt is less than 5%. Figure 2a shows real roughness, 2b shows roughness appearance (shaded area), described with three points, 2.c. roughness described with 10 points, but 2.d. with 22 points.

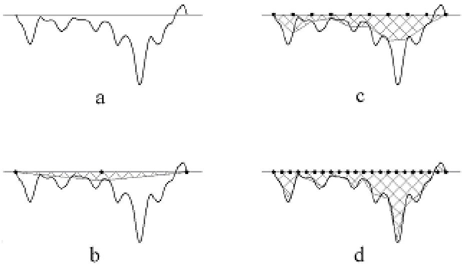

Figure 2: Roughness approximation at different values of point number

4 Number of points at which stabilize the value of the parameters

In this case, will determine the number of data points at which the stabilizing value of, for example, the parameter Ra, permissible deviation is 5%. For determination will be undertaken surface roughness profile charts in x-axis direction, repeatedly in the same place at different number of data points and values of cut-off length. The measurement results are shown in Figure 3. Horizontal axis is the number of data points, along the vertical axis, value of the parameter Ra. Measurement error in this case amounts to 2% + 6 nm. As you can see from the Figure 3, then the parameter Ra begins to stabilize when the number of points is 30.

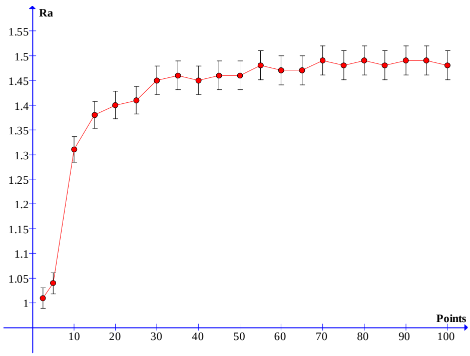

Figure 3: Coherence of parameter Ra and the number of data points

Conclusion

Analysis of the number of data points determination types shows that it is possible to determine the number of data points for random surface processing type, using the roughness structure. Determination of data points with the correlation functions does not give the necessary result, what is explained with the fact that the actual surface roughness is with a significant deviation from the theoretical model. The method of graphical approximation and the number of data points at which stabilize the value of the parameter Ra method produce sufficient good match. Consequently, the number of points we can determine as the average value between results of these two methods. In the case of flat grinding, we can take 26 points on the roughness spacing. This condition is valid for both axes x and y.

References:

[1] Stout K.J., Sullivan P.J., Dong W.P., Mainsah.E., Luo.N. The development of methods for the characterization of roughness in three dimensions. – Great Britain: University of Birmingham Edgbaston, 1993., 360p.

[2] J.Rudzitis. Kontaktnaja mehanika poverhnostej, 1-aja cast (in Russian). – RTU, Riga, 2007, 193. pp.