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SURFACE ROUGHNESS EVALUATION

A. Görög, K. Velíšek and M. Štefánek
Department of Machining and Assembling
Faculty of Material Science and Technology
Slovak Technical University, SK-917 24 Trnava, Slovakia

Abstract: The article deals with possibilities of surface roughness evaluation of machined parts. Non-standard methods are mentioned here, as well as a standard methods (ISO, DIN). It made survey of different approach to surface roughness evaluation.
Keywords: surface roughness, fractal analysis, stratificated surface

1 INTRODUCTION

Surface roughness is one of most important parameters, which influence resultant features of parts, and by this also their right function. Therefore steadily more attention is given to control of machined surface microgeometry. Together with formation of new productions surfaces with specific form of roughnesses are occurring. That is the reason, why occur requirements for using of quite new parameters and procedures, which would be able enough exactly to describe form and size of these roughnesses. On the other hand there is tendency to diminish quantity of parameters which characterising surface of parts.

2 STANDARDIZED PARAMETERS OF SURFACE ROUGHNESS

Standards classify surface roughness parameters into:

- these, which characterising profile roughness in direction of height:
  - arithmetical mean deviation of the profile Ra,
  - root-mean-square deviation of the profile Rq,
  - ten point height of irregularities Rz,
  - maximum height of the profile Ry (ISO), Rt (DIN), ...
- these, which characterising profile roughness in direction of length:
  - mean spacing of profile irregularities Sm,
  - developed profile length Lo,
  - profile length ratio lr, ...
- these, which characterising form of profile roughness:
  - profile bearing length ratio tp,
  - curve of the profile bearing length ratio,
  - distribution of profile departure density, ...

Standard DIN 4776 define parameters, which are determined from curve of the profile bearing length ratio (Abbott`s curve).

- depth of roughness core R_K [µm],
- reduced height of profile peak R_{PK} [µm],
- reduced depth of profile valley R_{VK} [µm],
- material traction M_{r1}, M_{r2} [%].

Figure 1 shows surface roughness profile. Using this profile there is created curve of the profile bearing length ratio (Abbott`s curve) on the figure 2. Here are depicted also roughness profile parameters according to DIN 4776. Through the curve of the profile bearing length ratio is interlaced straight line, which intersect two curve points. Distance of mentioned points on percentage axis (axis x) is equal to 40%. Straight line has to fulfil requirement of minimum of inclination of straight line. The difference of height of straight line in 0% and 100% of curve of the profile bearing length ratio of surface roughness profile determine R_K parameter. Parameter M_{r1} and M_{r2} are simultaneously determined. Parameter R_{PK} is equal to height of triangle, with area equal to area of profile peak. Similarly, parameter R_{VK} is defined with help of triangle with area equal to area of profile valley.

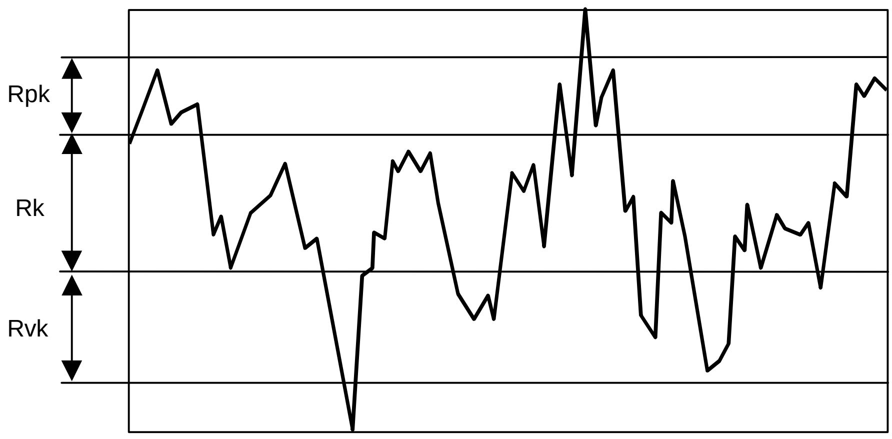

Figure 1. Surface roughness profile

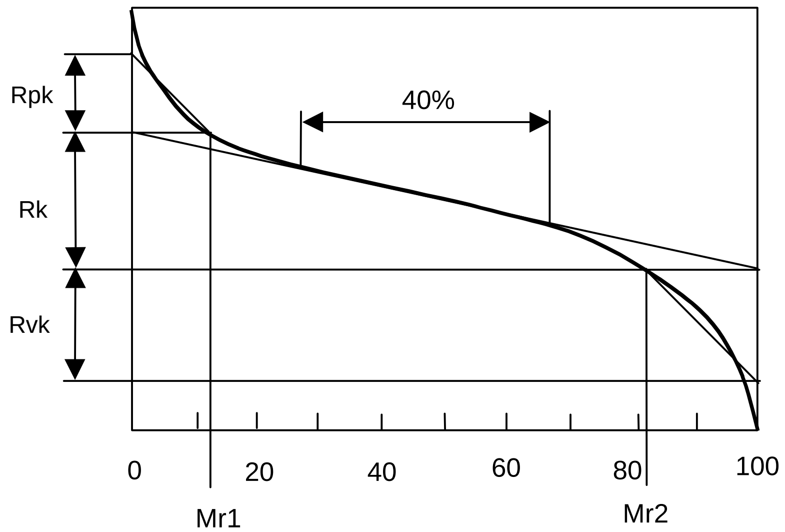

Figure 2. Surface roughness parameter according to DIN 4776

3 FRACTAL ANALYSIS OF SURFACE ROUGHNESS

Because real surface is irregular we can assume, that study of surface profile we can do also by fractal methods. Fractal analysis serves not only for evaluation of irregularity of object structure, but also for similarity in various resolution level. Its basic feature is so called fractal dimension D, which express measure of formation iregularity and is not depend on size of formation. By this it come out from consideration, that length of non-straight line or dimension of non flatness surface depends on used scale. Small scale make possible to measure more fine details than big scale - result of measurement is bigger length or bigger surface. Straight line gives constant length for all scales, resulting fractal dimension is in this case equal to euclides dimension (for straight line D=1). But fractal dimension for non-straight line is bigger than one and increases with increasing roughness until limit D=2. Measured length of line by decreasing of scale fluently increases only by theoretical mathematical fractal objects, which are internal similar one together on all levels and their bigger roughness is always composed from similar smaller roughnesses. Real fractal objects are usually limited by certain upper and lower value of scale. The same is possible to consider also by surface roughness.

We are coming out from starting square area, which sides have standardized length =1 (square with side length equal to 1). In this area is placed whole profilogram (record) of surface roughness, composed from M discrete points. Standardizing of coordinates of these points into interval <0,1> will be done by calculation using transformatiom relations:

$$X_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}}$$

$$Y_i = \frac{y_i - y_{\min}}{y_{\max} - y_{\min}} \quad (1)$$

We will divide initial square into four equal subsquares. In next step we will divide each subsquare into further subsquares. In this way we move forward, whereby number of smaller squares regularly increases. After n steps initial square with unit size contains totally

$$c = 2^{2n} \quad (2)$$

subsquares with side length

$$= 2^{-n} \quad (3)$$

After this we could define fractal dimension by relation

$$D = -\frac{\ln N}{\ln l} \quad (4)$$

where N is number of squares in given step, which contains at least one point of digitalized record of surface roughness profile.
If is enough small, or n enough big, each point of profile lay in different subsquare. From this moment N remain constant.

4 EVALUATION OF STRATIFICATED SURFACES

If by production of part we are using two consecutive technological operations, originate itself so called stratificated surface (surface with stratificated characteristics).One part of profile of such surface is originated by one technological operation and other part by second operation. Such surfaces are situated mostly on parts, to which higher functional requirement are laying on. There are usually grinded surfaces and consequently finished by further machining method (honing, superfinishing, ...).

For evaluation of such surfaces special method was developed. As a basic information source is "probabilitable curve of material" (figure 3), which we determine from surface roughness profile. It represents bearing curve of profile, whereby bearing proportion is expressed as Gauss probability in values of standard deviation. By this method of evaluation the profile is divided into parts originated consequently to individual technological operations. These are then evaluated separately by parameters introduced below.

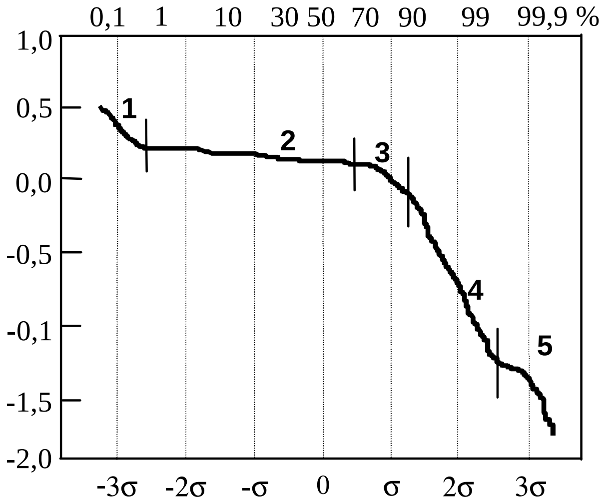

Figure 3. Probabilitable curve of material

We can divide the probabilitable curve of material into markedly different parts. For the next elaboration areas of peaks and walleys are important.
Slope of the regressive curve led through area of peaks Rpq

$$z = Ap . + Bp \quad (5)$$

Slope of the regressive curve led through area of peaks Rvq

$$z = Av . + Bv \quad (6)$$

Bearing ratio in position of peak and walley area conjunction Rmq

$$R_{mq} = \frac{B_v - B_p}{A_p - A_v} \quad (7)$$

Presented parameters of stratificated surfaces are able better render real shape of roughness. Classical parameters have this ability markedly limited.

5 DIGITAL ANALYSIS OF SURFACE

Digital analysis of evaluated surface picture belong to alternative methods of surface roughness evaluation by contactless measuring methods.

Principle of method recline in scanning of evaluated surface by CCD camera. After digital modification of scanned picture number of objects corresponding to walleys of investigated surface is evaluated. This number is proportional to some classical surface roughness parameters.

6 CONCLUSION

New surface roughness parameters extend number of standardized parameters used in practice, otherwise they are contributing to better description of surface profile form. E.g. fractal analysis has assumes to deeper quantitative and qualitative surface description.

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AUTHORS: Ing. Augustín GÖRÖG, Doc. Ing. Karol VELÍŠEK, CSc. and Ing. Michal ŠTEFÁNEK, CSc., Department of Machining and Assembling, Faculty of Material Science and Technology, Slovak Technical University, J. Bottu 23, SK-917 24 Trnava, Slovakia, Phone / Fax: 00421/0805/55 21 061, E-mail: kom@mtf.stuba.sk