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COMPARISON BETWEEN TWO METHODS IN ASSESSING THE SURFACE QUALITY FOR DIFFERENT MANUFACTURING PROCESSES

MEREUTA, V[alentin] L[ucian] & PALAGHIAN, L[iviu]

Abstract: *Sometimes, standardized parameters are insufficient for describing surfaces with special technical requirements. In this case, a multiparameter analysis of roughness is recommended by international surface metrology standards, as well as by recent research projects. Such development is also justified when a new parameter is required to improve the quality or performance of an existing application. The present study uses a multiparameter roughness for the characterisation of surface finish, since it is widely used in industry.*
Key words: *surface roughness, multiparameter surface analysis*

1. INTRODUCTION

Surface texture evaluation and analysis are very important from both machining process and tribological behaviour aspects. Roughness generally results from a particular manufacturing process or material conditioning (Dimkovski, Z.; 2006) and plays an important role in determining how an actual object interacts with its environment, often being a good predictor for the performance of a mechanical component, since irregularities in the surface topography may form nucleation sites for cracks or/and corrosion.

There are many surface roughness parameters that can be used to analyze a surface (Amaral, R. & Ho Chong L., 2002; Dimkovski, Z. 2006; Sundararajan, S. et al., 2005). The most common surface roughness parameter used in industry is the average roughness (*Ra*). This roughness parameter is well known but is not sufficient to describe a functional characteristic and fails to accurately represent the surface topography, a multiparameter surface roughness analysis is recommended.

Some 2D parameters are given together with their 3D equivalents (Precision Devices Inc., (2005). A few general statements should be pointed out when 3D Parameters are involved:

- each of them starts with the letter '*S*' rather the '*R*'.
- unlike 2D Parameters that are obtained using several sampling lengths, all 3D parameters are computed from one area.

2. THE METHODS

2.1 2D Measurements

Amplitude Parameters

The roughness average or deviation of all points from a plane fit to the test part surface. The equation for *Ra* is given by:

$$R_a = \frac{1}{L}\int_0^L |z(x)|dx \tag{1}$$

where L = evaluation length, z = height, x = distance along measurement.

The peak roughness R_p is the height of the highest peak in the roughness profile over the evaluation length. Similarly, R_v is the depth of the deepest valley in the roughness profile over the evaluation length. The total roughness (or Total Peak-to- Valley Height), R_t, is the sum of these two, or the vertical distance from the deepest valley to the highest peak.

The Root Mean Square (RMS) parameter *Rq*, is defined as:

$$R_q = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2} \tag{2}$$

Ten-point height, R_z, is the average of absolute values of the five highest peaks and the five lowest valleys over the evaluation length.

Rsm represents the mean spacing of profile irregularities. It is calculated using equation:

$$R_{sm} = \frac{1}{n}\sum_{i=1}^{n} S_{mi} \tag{3}$$

2.2 3D Measurement

The 3D equivalent average roughness is:

$$S_a = \left[\frac{1}{l_x l_y}\int_0^{l_x}\int_0^{l_y} |\eta^2(x,y)| dxdy\right]^{1/2} \approx \left[\frac{1}{MN}\sum_{j=1}^{N}\sum_{i=1}^{M} |\eta^2(x_i y_j)|\right]^{1/2} \mu m \tag{4}$$

The Root Mean Square (RMS) parameter *Sq*, is defined as:

$$S_q = \sqrt{\frac{1}{MN}\sum_{k=0}^{M-1}\sum_{l=0}^{N-1}[z(x_k, y_l)]^2} \tag{5}$$

The Peak-Peak Height is denoted by three parameters, namely: *Sz, St, Sy*, according to ISO, ASME and reference. They are defined as the height difference between the highest and lowest pixel in the image.

Maximum Valley Depth *Sv*, is defined as the largest valley depth value. Maximum Peak Height *Sp*, is defined as the largest peak height value. The total peak-to-valley height 3D parameter**,** *St*, is defined as a sum of the maximum peak height, *Sp*, and the lowest valley depth, *Sv***,** within the sampling area (Jun, Qu & Shih A. J., 2003):

$$S_t = \left(|S_p| + |S_v|\right) \tag{6}$$

The Surface Skewness, *Ssk*, describes the asymmetry of the height distribution histogram, and is defined as:

$$S_{sq} = \frac{1}{MNS_q^3}\sum_{k=0}^{M-1}\sum_{l=0}^{N-1}[z(x_k, y_l)]^3 \tag{7}$$

3. EXPERIMENTAL DETAILS

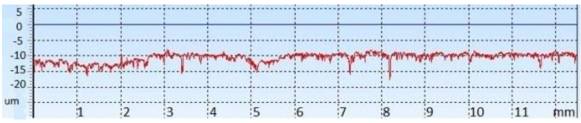
The aim of this study is to characterise the surface textures in terms of roughness parameters using Portable Surface Roughness Tester TR-200™ (with stylus), and Profilometer PRO500 3D (with stylus) to measure the surface topography (Precision Devices Inc., 2005) assisted by a dedicated soft (The Scanning Probe Image Processor SPIPTM, Version 4.7, 2008).

The TR200 portable surface roughness tester is a complete, easy to use instrument with 13 roughness parameters and maximum drive length 17.5 mm.

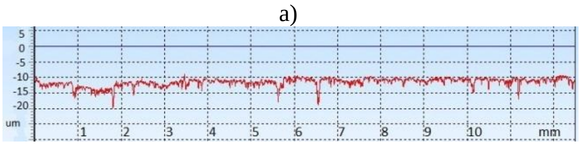
Steel specimens (S1, …, S5), were prepared to five various degrees of roughness, on *S355JR* and *S235JR* steel plates.

Before each experiment, the steel plates were thoroughly cleaned with acetone. The surface roughness of all steel plates was measured for all the five kinds of surfaces in the three points, because a single 2D with Portable Surface Roughness Tester or 3D measurement with Profilometer PRO500 is not sufficient for qualifying the surface quality. A maximum drive length with TR-200 and a areas of 500μm x 500μm with PRO 500 were investigated, all records have been done with 100 point on each line.

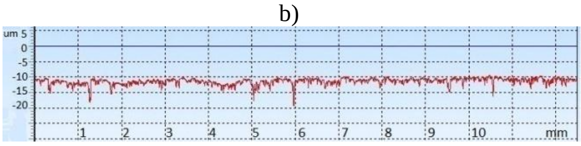
4. EXPERIMENTAL RESULTS AND DISCUSSION



a)



b)



c)

Fig. 1. Results of investigating with Portable Surface Roughness Tester - Specimen Type 1: a) point 1, b) point 2, c) point 3

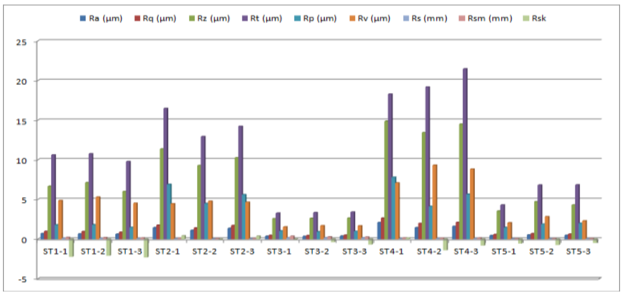


Fig. 2. Values of 2D Amplitude Parameters for five types of specimen

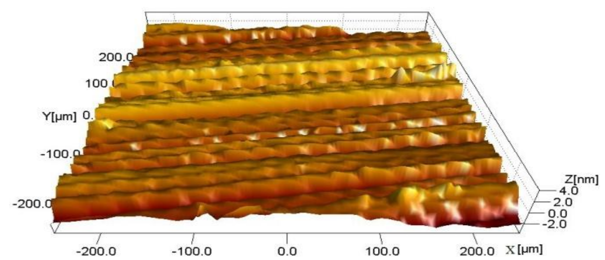


Fig. 3. Virtual images acquired with Profilometer PRO500. Scales in microns: X(1:1), Y(1:1), Z (10:1); Specimen 2 point1

The roughness parameter acquired using Portable Surface Roughness Tester TR-200™ is well known but is not sufficient to describe to accurately the surface topography (fig. 1).

Using a Profilometer PRO500 multiparameter surface roughness analysis is acquired and numerous roughness height parameters, such as average roughness, smoothening depth, root mean square and maximum peak-to-valley height can be closely correlated (fig. 3).

The low variation of roughness parameters was registered from specimen, which was the ground slide with 220 grit emery paper;

The equal values of the parameters, provided by the two methods, were registered for a specimen who has a smother surface.

5. CONCLUSION

Based on the results from the surface texture evaluation using both metods, the following conclusions were drawn:

1. In the case when the surfaces are rougher there are large differences in the value of the parameters, which indicates that using both methods for same tests will not yield conclusive results;
2. Measurements are obtained using a stylus drawn along the surface to be investigated. This registered raw profile is then used to calculate the roughness parameters. This method requires interruption of machine functioning, and the sharp diamond stylus may make micro-scratches on surfaces if stylus load is not correct selected;
3. Making clear observations on the surface characteristics of the plate specimen requires the precise measurement of surface roughness using both instruments: TR-200™ from his advantage – the drive length, and PRO500 for a 3D analysis of roughness parameters.

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