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Topological maps for characterisation of engineering surfaces

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Abstract

Characterisation of engineering surfaces has a wide range of methods. Commonly used standard 2D (or 3D) parameters many times do not give enough information about surfaces, but their combination provides extended analysis of the texture. Present study shows four different combinations of surface parameters: Ra-Rz, RKu-RSk, Sdq-Sdr, Sq-Sdq. All parameter combinations were plotted in a topological map containing results of 119 measured surface topography. Based on the analysis of topological maps we drew conclusions about their usage and their information content.

Keywords: Roughness, Surface topography, Topological map, Skewness, Hybrid parameters

1. Introduction

The micro- and nano-roughness, the texture of engineering surfaces play considerable role in their tribological behaviour (see: [1, 2] and provides information about their formations (see: [3, 4]). Therefore, the micro-geometrical and micro-topographical measurements are a part of the tribological examinations and the production process control methods.

In last decades – beside the classical, standardised, parameter based, 2D profile measurements – different surface characterisation methods developed; most of them are based on 3D topography measurements [5]. To meet growing demands, more and more complex methods are appeared. The German automotive introduced the so-called dominant wavelength concept (see: VDA 2007). Nowadays – beyond the parameter-based technique – two dominant research trends can be observed. One is the technique when the local features of topographies are characterized based on the identification of asperities and scratches, while the other is the "global" surface characterisation method using complex mathematical tools. In [6] and [7], one can find the technique to identify asperities and scratches, while for so called „global" characterisation of the topography by power spectral density (PSD) or by fractal analysis [8] and [9] show examples. However, these methods provide exclusive viewpoint and valuable information about the topography their application in practice is limited because of their complexity.

The goal of present study is to introduce the topological maps into surface roughness characterisation. These maps are created with relatively simple surface parameters, but the information content is extended.

Based on 119 topographic measurements we examined the following parameter combinations: Ra-Rz; RSk-RKu, Sdq-Sdr; Sq-Sdq. The topological maps based on these parameter combinations were analysed to identify the information content of them.

2. Materials and methods

The measurements were carried out in Surface Measurement Laboratory at Obada University, Bánki Donát Faculty of Mechanical and Safety Engineering in past few years. From these measurements there were created a database. All measurements of the database were measured by Mahr Perthometer Concept stylus instrument, FRW-750 diamond cone stylus of 5 µm peak radius and 90° peak angle. The measuring area was 1 by 1 mm and the sampling distance was 2 µm in booth direction in all cases.

The topographies of database were separated in different categories summarised by Table 1:

Table 1. Categories of database

	Name of category	Number of measured topographies
Machined surface	Turned	19
	Grinded	26
	Milled	22
	Sintered	4
	Electric discharge	3
	Honed/Lapped	12
Worn surface	Abrasion	21
	Adhesion	12

3. Results and discussion

3.1 Rz-Ra and RSk-RKu parameter combinations

In our former research we realised that parameter combinations give important information about the surfaces. In [10] Rz/Ra (Maximum height of the profile/Average roughness) rate related to feed rate of manufacturing process (see Figure 1.a.).

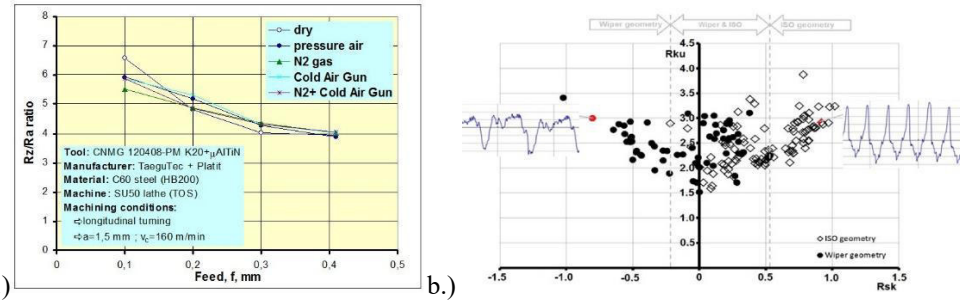

Figure 1. a.) Rz/Ra ratio during environmental-friendly turning operation [10]; b.) RSk-RKu topological maps in terms of cutting edge geometry [12]

The first real „topological map" – which is a diagram of two surface parameters – was introduced by Whitehouse [11]. The position of a measuring profile on a Skewness (RSk) – Kurtosis (RKu) map related to the load bearing behaviour of the surface. This map can be used in evaluation of machined surfaces in point of view of load bearing behaviour (see: Figure 1.b.).

3.2 Sdq-Sdr and Sq-Sdq parameter combinations

Based on our topographic database two type of map was plotted (see Figure 2.). The first one shows high correlation between the hybrid parameters Sdq (Root mean square gradient) and Sdr (Developed interfacial area ratio). Booth parameters are related with the „complexity" of the surface. In case of oriented surface when the surface is „smooth" in the direction of the orientation, we are on the left lower part of the map. In other cases we have „complex" structure that may be useful if the adhesion is important for us (e.g. bonding).

The second map show the correlation between Sq (Root mean square roughness) and Sdq. There is no correlation between these two parameters, but as the colours of the Figure 2.b. show linear behaviour can be detected in all cases of an individual groups. Further investigations are needed to identify the effect of the slope of the linear approximations.

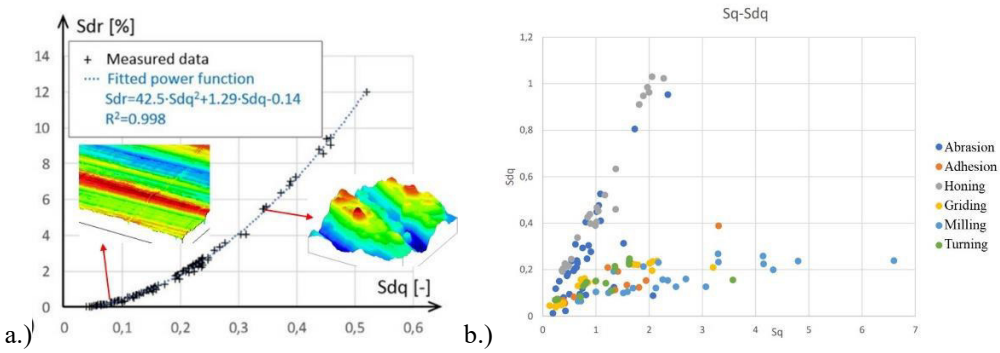

Figure 2 a.) Sdq-Sdr map of measured 119 surfaces [10]; b.) Sq-Sdq topographic map in case of different type of surfaces

4. Conclusion

Based on our investigations the following conclusions can be drawn:

- Using parameter combinations as topological maps provide useful technique to characterise the geometric features and properties of engineering surfaces.
- Rz/Ra rate is correlated with production technologies: during environment friendly turning the increase of feed rate reduced the Rz/Ra ration.
- RSk-RKu map represents the load bearing behaviour of machined surface. Production technologies can be classified using this map.
- Sdq-Sdr parameters are in good correlation. Their topological map gives information about the complexity of the surface structure. The increase of these parameters indicates the increase of complexity.
- Sq-Sdq map separate the different type of surfaces.

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