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IMPLICATIONS OF THE NEW ISO SURFACE ROUGHNESS STANDARDS ON PRODUCTION ENTERPRISES

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Abstract: *The aim of this paper is to raise awareness among academics and mechanical engineering community regarding the upcoming new ISO 25178 surface roughness standard. In order to comply with the new three-dimensional surface roughness (texture) approach, production engineers and technologists will have to face many challenges in their daily work. This paper is providing a simplified description of the new surface texture standard and lines out certain practical solutions for immediate interim application in today's production environment: approximate calculation of 3D surface roughness parameters using 2D measurement equipment.*

Key words: *surface texture, roughness parameters, ISO 25178*

1. INTRODUCTION

Currently the surface roughness parameters are regulated by ISO standards that characterise the surface roughness of a workpiece by means of two dimensions (2D). There exist numerous national standards used by industrially developed countries and, on top of those, there is a well established practice regarding these measurements in all the sectors of production engineering. Recently, however, USA has found itself in the lead by having already developed its own national surface roughness standard ANSI/ASME B46.1-2002: Surface Texture, Surface Roughness, Waviness and Lay. Previous standards and technical specifications were based on surface roughness measurements only in 2D, done by profilometers using the contact method. In most cases the industrial measurement equipment is still based on 2D profiles contact gauges and subsequent subtraction of surface roughness parameters from the linear readings.

However, every workpiece is a spatial object and, to obtain complete measurements, such object has to be analysed and mathematically described as a 3D object. Topographical or texture method of the surface analysis instead of the usual surface roughness parameters' approach allows describing the particular surface sufficiently and completely, which reflects real surface conditions. Thus it is an absolutely new concept that differs from the existing surface definitions canonised by the industry. 3D parameters are calculated on the entire surface (in a plane) and no more by calculations derived from the base lengths (cross-cuts), as is the case for 2D parameters (Blunt & Jiang, 2003).

It is important to note that the above mentioned standard is still in the development: "enquiry stage" in September 2010. Although it is difficult to estimate when the new requirements might become mandatory, there is no doubt that the industry shall adapt to the ISO 25178 as soon as possible.

2. BRIEF DESCRIPTION OF THE ISO 25178 STANDARD

ISO 25178: Geometric Product Specifications – surface texture (ISO, 2008) is the very first international standard to provide detailed specification and measurement techniques of a 3D surface micro-topography. Spatial surface texture parameters, their measuring and processing rules will also be covered. It is important to underline that the draft standard in question is based on non-contact measurement methods. Some of these methods are already used in the instrument production industry. However, some of the applied non-contact methods are completely new and will be challenging to implement.

ISO 25178-2 distinguishes among large groups of parameters (see Table 1) that could be grouped in the following manner:

- Height parameters – based on the statistical distribution of the height values along the z axis;
- Spatial parameters – covering the spatial periodicity of the data, specifically its direction;
- Hybrid parameters – relating to the spatial shape of the data;
- Functional parameters – calculated on the basis of the material ratio curve;
- Segmentation parameters – derived from a segmentation of the surface into valleys and peaks.

Type	Symbol	Description
Height parameters	Sq	Root mean square height of the surface
	Ssk	Skewness of height distribution
	Sku	Kurtosis of height distribution
	Sp	Maximum height of peaks
	Sv	Maximum height of valleys
	Sz	Maximum height of the surface
	Sa	Arithmetical mean height of the surface
Spatial	Sal	Fastest decay auto-correlation rate
	Str	Texture aspect ratio of the surface
	Std	Texture direction of the surface
Hybrid	Sdq	Root mean square gradient of the surface
	Sdr	Developed area ratio
Functional parameters	Smr	Surface bearing area ratio
	Sdc	Height of surface bearing area ratio
	Sxp	Peak extreme height
	Vm	Material volume at a given height
	Vv	Void volume at a given height
	Vmp	Material volume of peaks
	Vmc	Material volume of the core
	Vvc	Void volume of the core
	Vvv	Void volume of the valleys
Segmentation parameters	Spd	Density of peaks
	Spc	Arithmetic mean peak curvature
	S10z	10 point height
	S5p	5 point peak height
	S5v	5 point valley height
	Sda	Closed dales area
	Sha	Closed hills area
	Sdv	Closed dales volume
	Shv	Closed hills volume

Tab. 1. Surface roughness parameters foreseen in ISO 25178-2

In order to understand how the new standardised 3D roughness parameters would be measured and calculated, there is a need for some further explanation on the advanced filter system. In simple terms, these filters are needed to eliminate the unnecessary features that may affect the overall "picture" of the surface texture, such as occasional lateral components, potentially too large or too small, thus possibly affecting the description of the surface. The following filters are foreseen:

- S (surface) filter: removes small scale lateral components;
- L (surface) filter: removes large scale lateral components;
- F operator: removes an overall form.

After the application of these filters the new surfaces (without "phone noise") may be calculated by the software:

- S-F surface: derived from the primary source by removing the form using above mentioned F operator;
- S-L surface: obtained from S-F surface by removing the large scale component using an L filer;
- Nesting index: quantifying the amount of "smoothness" of a workpiece surface.

Furthermore, to comply with the requirements of ISO 25178 itself, a completely new generation of the surface micro-topography measurement techniques is foreseen. Part 6 of the standard divides these devices into three groups:

- Microtopographical: 3D profilometers, various types of microscopes, structured light projectors, etc.;
- Profilometric: advanced profilometers, lasers, etc.;
- Integrated or mixed: combining pneumatic measurement, capacitive, by optical diffusion, etc.

3. PRACTICAL IMPLICATIONS FOR MANUFACTURING ENTERPRISES

It is certain that the new international surface texture standard is badly needed and in the long term perspective will bring enormous profit. However, the complexity of the issues covered by it will be extremely challenging for the manufacturing companies all over the world, especially for small and medium size enterprises (SME's) in the developing countries. In this context, the following important considerations should be taken into account:

- Lack of awareness/knowledge of the new rules of the game;
- High complexity of the matter, difficult to understand without advanced training;
- New measurement technique and cutting-edge equipment required;
- Relatively high application costs (both for equipment and technical staff training);
- For a certain period of time, end clients may request the mixture of 2D and/or 3D surface parameters in their production requirements.

Therefore, a lengthy and confusing adaptation period is expected to facilitate the transit to the new 3D surface texture system.

4. SUGESTED TRANSITIONAL MEASURES

Taking into account the above mentioned considerations, the crucial question is: what to do when the manufacturing engineer, instead of seeing the usual Rq in the clients' drawings, is surprised by a Sq? Although it is not a completely precise technique and can not be applied in all cases, a simple mathematical extrapolation of 2D method can be used for the conversion of some parameters from 2D to 3D. The following equation can be used to obtain the value of the root mean square height of the surface (Blateyren, 2006):

$$S_q = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy} \quad (1)$$

where: A – definition area of the reference surface in mm^2;
z(x,y) – ordinate value – height of the scale limited surface at positions x and y.

The same approach can be used for the calculation of Sa, Ssk, Sp, Sv and Sku (see table 1). To obtain 3D values, the general principle is to break down the observed surface to several separate profiles (Kumermanis, Rudzitis & Torims, 2009). These profiles can be obtained by using the existing 2D surface roughness measuring devices. The analysed surface has to be divided into a number of separate profiles. Practice shows that 10 profiles with a measuring trace length $l = 4 \div 5$ mm is a sufficient number, which allows to obtain reliable results. The following equation can be used (example is given for Sa):

$$S_a = \frac{1}{MN}\sum_{j=1}^{N}\sum_{i=1}^{M} R_a(i, j) \quad (2)$$

where: M – number of measurements within a single profile;
N – number of profiles examined;
i – the examined profile;
j – the measurement within the profile.

5. CONCLUSIONS

Obviously, the upcoming surface texture or 3D surface roughness standards are extremely necessary and crucial for the modern metrology needs. Furthermore, they have to be applied quickly to further develop metrology and improve the overall production quality. However, the change to ISO 25178 might be a slow and rather difficult exercise for certain production enterprises. Apparently, this may turn into a lengthy and costly process, bringing along the necessity to purchase new hi-tech equipment and provide state-of-art training for engineers who work in the manufacturing companies. Especially significant difficulties during this transition may be encountered by SME's that do not have R&D departments, and the situation could become even more problematic due to the current economical crisis where many enterprises still struggle to survive.

Without ambitions to a very high accuracy, this article proposes practically applicable equations accompanied by calculation methods. This methodology can be used as a temporary solution only; however, at a certain point the industry will adapt to the new requirements. Nevertheless, the scientific community should make the efforts to facilitate the understanding and implementation of the new 3D surface roughness parameters in the actual production environment. This will be a paramount task for the upcoming years, because the surface texture will be stipulated by legally binding international standard for the very first time.

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