S

Surface Parameter

Han Haitjema
Mitutoyo RCE, Best, The Netherlands

Synonyms

[Roughness parameter](#)

Definition

Parameter, defined as a number and a unit that characterizes an averaged dimensional property of a surface.

Theory and Application

Surfaces and Parameters

A surface can be characterized by many, many parameters. In fact, it is easier to define a new parameter than to come with a thorough analysis of the usefulness of the already existing parameters. Parameters are defined in many ISO standards (see references). They can be separated in 2-D and 3-D parameters, and further separation is possible in amplitude parameters, spacing parameters, hybrid parameters, parameters derived from integrated probability density curves, and topological parameters.

This section is confined to surface texture characterizing parameters. For the defined R (roughness) parameters, there are equivalent P (unfiltered profile) parameters and W (waviness) parameters that are defined for longer wavelength limits.

Roughness parameters naturally depend on the length scale where they are defined. In dimensional metrology, this scale is confined between the short-wavelength cutoff lengths λ_s and the long-wavelength cutoff λ_c . In the ISO 25178 series these terms are replaced by S-nesting index and L-nesting index respectively. It is a common requirement that within the short-wavelength cutoff length, at least some five measurement points should be taken, to keep the filtering well defined for short wavelengths. Parameters and specifications can only be usefully compared when the same cutoff lengths are used and meant (Leach and Haitjema [2010](#)).

Indication of Surface Parameters on Technical Drawings

In ISO 1302 ([2002](#)), it is described how surface parameter requirements should be indicated on technical drawings.

Uncertainty in Surface Parameters

When measuring surface parameters and comparing these to specifications, it is necessary that an uncertainty in the parameter is calculated. Some of the factors that must be taken into account are:

Inhomogeneity of the workpiece

The parameter may depend on the location on the workpiece and the direction in which the measurement is taken (at least for 2-D measurements). Usually, this is the dominant uncertainty factor.

Uncertainty and traceability of the surface measuring instrument

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The traceability and uncertainty of the coordinates as measured (see section “Definitions”) must be taken into account, as well of uncertainties in the used probe size, filtering, sampling, reference line or surface, etc. For 3-D measurements, it is a problem that the default measurement system is a mechanical probing system. As 3-D mechanical roughness measurements are very time-consuming, most measurements are taken using optical techniques that may have artifacts that are not easily recognized.

A problem with these calculations is that they can become rather tedious and surface dependent (Haitjema 2015; Haitjema and Morel 2000).

2-D Roughness Parameters

In this section, roughness parameters are defined, derived from the measured profile, with a base length l_r and the cutoff wavelength λ_c , filtered with the standard Gaussian filter. This base length is also called sampling length.

Unless otherwise stated, the parameter is calculated for every base length l_r and averaged over the evaluation length l_n that usually consists of five consecutive base lengths.

The defined parameters R are valid analogous as W and P parameters, respectively, for the waviness and unfiltered profile.

Amplitude Parameters (Top-Bottom)

Rz The maximum profile peak height R_p is the largest profile peak height Z_p within the base length (ISO 4287 1997). Analogously, the maximum profile valley depth R_v is the largest profile

valley depth Z_v within the sampling length. The sum of R_p and R_v is the maximal profile height R_z . As commonly the measured length l_n consists of several (typically 5) sampling lengths l_r , R_z is the average of the R_z within every sampling length, at least according to the present ISO standard. Confusingly this definition was different in the past and still may be different in some national standards.

Rt The total profile height R_t is the sum of the largest profile peak height Z_p and the largest profile valley depth Z_v within the evaluation length l_n . This evaluation length usually consists of several (typically 5) of the sampling length as it is illustrated in Fig. 1, where the measurement of one sampling length is given.

Amplitude Parameters (Average of Ordinates)

Ra Ra

is the arithmetic average deviation of the absolute ordinate values $Z(x)$ within the base length, defined in Eq. 1:

$$Ra = \frac{1}{l} \int_0^l |Z(x)| dx \quad (1)$$

Due to the relatively easy calculation, the insensitivity for outliers, and for historical reasons, Ra is by far the most used parameter.

Rq Rq

is the root mean square and standard deviation of the ordinate values $Z(x)$ within the base length, defined in Eq. 2:

$$Rq = \frac{1}{l} \int_0^l Z^2(x) dx \quad (2)$$

Spacing Parameter

RSm RSm

is the average width of profile elements X_s within the base length. A profile element is the area of a peak plus the adjacent valley (Fig. 2):

Surface Parameter, Fig. 1 Definition of R_z . l is the sampling length

Surface Parameter, Fig. 2 Definition of R_{Sm} . l is the sampling length. R_{Sm} is the average length of the profile elements X_{sn}

R_{Sm} is defined in Eq. 3, with the terms as defined in Fig. 2:

$$R_{Sm} = \frac{1}{m} \sum_{i=1}^m X_{s_i} \quad (3)$$

Hybrid Parameters

$R\Delta q$ or Rdq $R\Delta q$

is the square average of the local slope dZ/dx within the base length as defined in Eq. 4:

$$R\Delta q = \sqrt{\frac{1}{l} \int_0^l \left(\frac{dZ(x)}{dx} \right)^2 dx} \quad (4)$$

$R\lambda q$

The square average mean wavelength $R\lambda q$ is a measure for the distance between peaks and valleys and can be calculated from Eq. 5:

$$R\lambda q = \frac{2\pi Rq}{R\Delta q} \quad (5)$$

Topological/Field Parameters

A completely different approach of surface parameters is based on topography of peaks and valleys. Definitions are given in ISO 12085 (1996).

Parameters Derived from Probability Density Curves

The integrated probability density curve of the ordinates is also known as the Abbott-Firestone curve. From this curve several parameters can be derived as it is described in ISO 13565-3 (1998).

Abbott-Firestone curves are used in important sliding applications, particularly cylinder liners.

3-D Roughness Parameters

3-D roughness parameters are generally defined similarly as the 2-D parameters, with some additional parameter that depend on the direction such

as the *Std* parameter. The definitions are given in ISO 25178-2 (2012).

Value and Usefulness of Surface Parameters

One use of roughness parameters is for quality control and commerce so that a buyer and seller can agree on the quality of a product. In quality control it is necessary to be able to discriminate good and bad surfaces.

Another use is in design, so the designer can specify the texture as roughness influences function.

Yet another use of the roughness parameters is in research. In order to optimize the design of products and processes, design and manufacturing engineers need to know about the relation between roughness and performance on one hand and with processing on the other. Functional correlations of both kinds are valuable and depend on selecting the correct characterization parameter.

Surface parameters are also used in research in forensics, physical anthropology, archeology, and cultural heritage conservation.

Cross-References

- [Form Error](#)
- [Functional Correlation](#)
- [Roughness](#)
- [Surface Integrity](#)
- [Surface Texture](#)

References

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