Surface Texture (Surface Roughness, Waviness and Lay)

Executive Summary

In cases of disagreement regarding the interpretation of surface texture measurements, it is recommended that measurements with skidless stylus based instruments with Gaussian filtering be used as the basis for interpretation. The following key measurement parameters must be established for proper surface texture specification and measurement.

Filtering

The spatial wavelengths to be included in a surface texture measurement are generally limited by digital bandpass filtering. For measurement of roughness, short wavelength cutoff, \( \lambda_s \), specifies the short spatial wavelength limit and is defined as the wavelength where the Gaussian filter will attenuate the true profile by 50%. Spatial wavelengths less than \( \lambda_s \) are severely attenuated and minimally contribute to the roughness measurement.

The roughness long wavelength cutoff, \( \lambda_c \), specifies the long spatial wavelength limit and is defined as the wavelength where the Gaussian filter will attenuate the true profile by 50%. Spatial wavelengths greater than \( \lambda_c \) are severely attenuated and minimally contribute to the roughness measurement.

The ratio of \( \lambda_c \) to \( \lambda_s \) (\( \lambda_c: \lambda_s \)) is the bandwidth of the measurement. Some instruments allow the selection of \( \lambda_c \) and \( \lambda_s \) individually and/or the selection of a bandwidth, typically 100:1 or 300:1. The spatial wavelengths comprising the texture between \( \lambda_s \) and \( \lambda_c \) are minimally attenuated by the Gaussian filter.

The cutoffs, \( \lambda_c \) and \( \lambda_s \) should be chosen by the designer in light of the intended function of the surface. When choosing \( \lambda_c \) and \( \lambda_s \), one must be cognizant that the surface features not measured within the roughness cutoff bandwidth may be quite large and may affect the intended function of the surface. Thus in some cases it may be necessary to specify both surface roughness and waviness.

When surface waviness control is important, digital bandpass filtering is applied similarly as it is for roughness filtering. For waviness, the waviness short wavelength cutoff (\( \lambda_{sw} \)) and waviness long wavelength cutoff (\( \lambda_{cw} \)) are applied to obtain the waviness profile. An important consideration is the correspondence of the roughness long wavelength cutoff and the waviness short wavelength cutoff. When these respective cutoff values are not equal, the discrimination of the roughness and waviness features of a given surface can become confounded.
On all surface texture specifications as of January 1997, $\lambda_c$ and $\lambda_s$ must be stated. When $\lambda_c$ and $\lambda_s$ are not specified, guidelines are given in section 3.3.20.1 and 3.3.20.2 of ASME B46.1 – 2002 for the metrologist to establish $\lambda_c$ and $\lambda_s$. These guidelines are intended to include the dominant features of the surface in the measurement whether these surface features are relevant to the function of the surface or not.

**Stylus Tip Radius**

The stylus tip radius may be chosen by the designer or metrologist based on the value of $\lambda_s$ (i.e. the short wave cutoff). For $\lambda_s$ equal to 2.5µm, the tip radius should typically be 2µm or less. For $\lambda_s$ equal to 8µm, the tip radius should typically be 5µm or less. For $\lambda_s$ equal to 25µm, the tip radius should typically be 10µm or less.

**Stylus Force**

The maximum static measuring force is determined by the radius of the stylus and is chosen to assure minimal damage of the surface and that constant contact is maintained with the surface. Specific recommendations for stylus force may be found in section 3.3.5.2 of the ASEM B46.1 – 2002 standard.

**Measurement Parameters**

Many surface finish height parameters are in use throughout the world. From the simplest specification of a single roughness parameter to multiple roughness and waviness parameter specifications of a given surface, product designers have many options for specifying surface texture in order to control surface function. Between these extremes, designers should consider the need to control roughness height (e.g. Ra or Rz), roughness height consistency (e.g. Rmax), and waviness height (e.g. Wt). Waviness is a secondary longer wavelength feature that is only of concern for particular surface functions and finishing processes. A complete description of the various texture parameters may be found in Section 1 of the B46.1 2002 Standard.

**Surface Texture Symbols**

Once the various key measurement parameters are established, ASME Y14.36M 1996, may be used to establish the proper indication on the relevant engineering drawings.