SURFACE TOPOGRAPHY

Figure 2.3 Components of surface geometry

SURFACE ROUGHNESS PARAMETERS
The bearing area curve

Figure 2.8 Method of deriving the bearing area curve
Insufficiency of the roughness parameters

Figure 2.7 Various surfaces having the same C.L.A. value
Height distribution measurement

Asperity Peak height distribution

Distribution of peak heights $\phi_a(x)$

All-ordinate distribution histogram

Sample interval

Smooth surface
Define a surface height distribution function:

\[ y(z) = \frac{\text{# of data points with heights } z \sim z + \Delta z}{N} \frac{1}{\Delta z} \]

\[ \Delta z < 0 \]

Then

\[ \int_{-\infty}^{\infty} y(z) \, dz \approx \sum_{k=1}^{k} y(z) \Delta z = 1.0 \]

\[ y(z) = \text{probability density function of surface heights} \]
Many surfaces exhibit a Gaussian distribution

![Gaussian distribution graph](image)

**Figure 2.10** Typical distribution curve for a ground surface

Gaussian distribution with zero mean

\[ \psi(z) = \frac{1}{\sigma \sqrt{2\pi}} e^{-z^2/2\sigma^2} \]

where \( \sigma \) = standard deviation (RMS roughness parameter)

Usually, 99.9% of asperity peaks lie within \( \pm 3\sigma \)
Autocorrelation of surface profile

*Figure 2.15 Typical surfaces and the resulting autocorrelation functions*
Statistical properties of example surfaces

(a) Shaped surface  
CL A 16 µm

(b) Fine turned  
CL A 14 µm

(c) Ground surface  
CL A 10 µm

(d) Superfinished  
CL A 0.18 µm

Figure 2.16  Examples of engineering surfaces, their distributions and autocorrelation functions
Surface modeled as a population of spherical asperities of some height distribution
The power spectral density (PSD) of a surface profile

The roughness of a contacting surface is often highly random and can be extremely complex to characterize. However, the characterization of surface roughness with a homogeneous, isotropic Gaussian distribution can be relatively simple, requiring only the zeroth, second and fourth moments of the power spectral density (PSD) of a surface profile. The PSD $\Phi(k)$ is the Fourier transform of the autocorrelation function $R(r)$ of the surface profile. The two functions are given by

$$R(r) = \lim_{L \to \infty} \frac{1}{2L} \int_{-L}^{L} z(r_1)z(r_1 + r)dr_1$$  \hspace{1cm} (1)

and

$$\Phi(k) = \frac{1}{2\pi} \int_{-\infty}^{\infty} R(r) \exp(-ikr)dr$$  \hspace{1cm} (2)

where $z(r)$ denotes the height of the surface point at location $r$ along the profile and $k$, the wave number, defining the profile spectral component. The three moments of the PSD are then given by

$$m_n = \int_{-\infty}^{\infty} \Phi(k)k^n dk \hspace{1cm} n = 0, 2, 4$$  \hspace{1cm} (3)

The RMS roughness is given by

$$\sigma = \sqrt{m_0}$$  \hspace{1cm} (4)

The density of summits or asperities is given by

$$D_a = \frac{1}{6\pi\sqrt{3}} \left( \frac{m_4}{m_2} \right)$$  \hspace{1cm} (5)

The average radius of curvature of the asperities is approximately given by

$$R_a \approx \frac{1}{1.5\sqrt{m_4}}$$  \hspace{1cm} (6)

Equations (4) to (6) may be used to help develop a mathematical model for a rough surface by spherical asperities of some height distribution.
Fig. 2 Variation of normalised power spectral density ($G(1/\lambda)/k.m^3$) with wavelength ($\lambda$, m).
The graph shows that many different surface topographies existing in the physical universe have a similar form of power spectrum. Note that the spectra available cover almost eight decades of surface wavelength and throughout this range the r.m.s. power increases, to a good approximation, as the square of the wavelength (solid line, equation (2)).