Surface Roughness

As described in the previous sections, surface roughness plays an important role in satisfactory operation of elastohydrodynamic lubrication of rolling / sliding contacts. Although machined surfaces appear smooth to the naked eye, they are quite rough at the microscopic levels. In the past few decades a number of different devices have been designed and developed in order to characterize the surface features of machine components. In the past decade, non-contacting (optical) surface profilometry has become the most widely used approach for characterizing various surface features of machine components. Machine elements which have been prepared to operate in EHL regime are usually quite smooth, with roughness being of the main concern. The following terms are usually used to describe a surface which has been prepared by machining, grinding or other processes. *Roughness* is fine irregularities that are produced during a machining process (grinding, polishing etc.). *Waviness* is the result of unwanted vibration, runout, deflection, tool wear, misalignment etc. during the manufacturing process which results in widely spaced surface profiles. *Error of form* is the result of errors in manufacturing process and results in deviations from the desired surface patterns.

A number of standard parameters are used to describe surface roughness of engineered surfaces. *Average roughness (R_a)* is the average of the individual heights (asperities) and depths from the arithmetic mean elevation of the profile.

$$R_a = \frac{1}{mn} \sum_{k=0}^{m-1} \sum_{l=0}^{n-1} \left| Z(x_k, y_l) - \mu \right| \tag{20}$$

Where,

$$\mu = \frac{1}{mn} \sum_{k=0}^{m-1} \sum_{l=0}^{n-1} Z(x_k, y_l) \tag{21}$$

Root mean square roughness (R_q) is the square root of the sum of the squares of the individual heights and depths from the mean line.

$$R_q = \left(\frac{1}{mn} \sum_{k=0}^{m-1} \sum_{l=0}^{n-1} \left(Z(x_k, y_l) - \mu \right)^2 \right)^{0.5} \tag{22}$$

Skewness (R_{sk}) is a measure of the average of the first derivative of the surface (the departure of the surface from symmetry). A negative value of R_{sk} indicates that the surface is made up of valleys, whereas a surface with a positive skewness is said to contain mainly peaks and asperities. Therefore a negatively skewed surface is good for lubrication purposes.

$$R_{sk} = \frac{1}{mnR_q^3} \sum_{k=0}^{m-1} \sum_{l=0}^{n-1} \left(Z(x_k, y_l) - \mu \right)^3 \tag{23}$$

Kurtosis (R_{ku}) is a measure of sharpness of profile peaks.

$$R_{ku} = \frac{1}{mnR_q^4} \sum_{k=0}^{m-1} \sum_{l=0}^{n-1} \left(Z(x_k, y_l) - \mu \right)^4 \tag{24}$$

In order to determine that the lubrication condition has moved from the full film lubrication to mixed and boundary lubrication the minimum film thickness is divided by the square root of squares of R_q of the surfaces in contact.