ON THE RELATION BETWEEN FRICTION AND MULTISCALE SURFACE ROUGHNESS IN MIXED LUBRICATION

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ABSTRACT
In sliding contacts, the occurring friction is related to the roughness of the surfaces. However, the extent and character of their relation is an ongoing topic of research. There are different approaches of roughness modelling and quantification, as well as different types of friction to consider. When lubrication is introduced, additional aspects need to be taken into account. This presentation focuses on the multiscale nature of roughness and the mixed lubrication regime.

Often, a multi asperity approach is used to model roughness. Exemplary, in the Greenwood and Williamson theory [1] the asperities are assumed to have the same shape and size, but differ in height. In contrast, the multiscale approach roughness is assumed to occur on many length scales. With this type of roughness modelling, the asperities vary in height and in size. When magnifying roughness on a smaller scale will be found where again even smaller roughness is found up to the atomic scale when steadily increasing the magnification.

From norms [2] and guidelines roughness can be quantified with different parameters, graphs, or functions. While many parameters such as the average or the root mean square (RMS) roughness are used in a wide variety of applications and standards, they are not sufficient to characterize multiscale roughness. To fully describe the multiscale nature, two characteristics are required: the probability density function and the power spectral density (PSD) [3]. The former describes the contribution of each surface height to the total roughness, while the PSD is a measure of the contribution of each wavelength.

The relation between friction and certain roughness parameters, such as the RMS roughness or the RMS slope, is known for different types of friction. While adhesive friction increases with RMS roughness and decreases with RMS slope [4], the deformative friction shows exactly the opposite behavior [5]. When one of the contacting surfaces is made of viscoelastic material, the viscoelastic friction may be the dominating type, depending on material properties. This type of friction will increase with the RMS slope [6]. With the PSD, a direct input parameter is used for the calculation of viscoelastic friction in Persson's theory [6]. However, some of these relations are solely defined for specific roughness parameters and do not account for multiscalarity.

For lubricated contacts in mixed lubrication, more aspects must be considered. Roughness does not only have an impact on the friction due to asperity contact, as discussed above, but also a.o. on the film thickness. In addition, in design elements such as sealings, multiscale roughness is of special interest since the real area of contact changes with scale.

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