AN ABBOTT CURVE BASED ROUGH SURFACE CONTACT MECHANICS APPROACH

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ABSTRACT
The topography of a machined surface significantly influences the performance of both lubricated and unlubricated contacts. In this work the unlubricated frictionless contact of rough surfaces is the subject of study. The numerical deterministic contact mechanics model incorporates linear elastic surface material and the dry contact is simulated using classes of surface profiles randomly generated from a given Abbott curve (Abbott-Firestone bearing ratio curve). In this way all the height information of the surface profile is preserved and not only a few parameters, like $R_a$, $R_q$, $R_z$, $R_{sk}$, etc. The aim of this work is to investigate how classes of surfaces based on a single Abbott curve perform in terms of contact mechanical parameters like the real area of contact. The result shows that surfaces taken from a class of random surfaces generated from a specific Abbott curve behaves similar in a contact mechanics simulation. That is, the distribution of for example the real area of contact within such a class is compact, having a small deviation from its mean.

This implies that it is possible to simulate classes of surfaces based on Abbott curves and to use the results to predict contact mechanical properties of real surface topographies.

1 Introduction
Designing machine elements requires knowledge on how the interface between contacting components is influenced by the surface topography. Whether the work is of experimental or theoretical nature, the classes of surfaces investigated has to be restricted for a systematic investigation to be feasible. In the theoretical case there are numerous of possibilities. One way is to characterize the surface by means of classical surface parameters, e.g., $R_a$, $R_q$, etc. and perform systematic variations of these. For theoretical models based on a selections of parameters, see for example [2, 3, 5, 7, 8]. However, these are based on the surface parameter describing asperity curvature which depends on the measurement resolution [1]. It is, therefore, a difficult task to find the correct input for the model. Another theoretical approach is to consider the surfaces to be of fractal nature and deduce the necessary input parameters in accordance to that [9]. In this work the Abbott-Firestone bearing ratio curve, constitutes the basis of surface roughness characterization. The numerical approach utilized is based on a variational formulation (see, [4]) and the solution method described in [6] to solve the contact mechanical problem.

A class of surfaces having identical Abbott curve has the same set of height parameters, i.e., $R_a$, $R_q$, $R_z$, $R_{sk}$, etc. but differs in spatial information/parameters, i.e., the autocovariance, the autocorrelation length, the power spectral density (PSD), etc. A method of surface generation is used that randomly redistributes the surface heights keeping the Abbott curve constant. In this paper it is shown that for a class of randomized surfaces, having the same Abbott curve, the distribution of contact mechanical parameters like the real area of contact is compact. That is, the real area of contact within the class has small standard
deviation ($\sigma$). In turn, this means that the spatial information is of minor importance at least for the different classes of surfaces considered here.

2 Surface Roughness Characterization

The method of surface roughness characterization used is based on the Abbott curve. Parameters like $R_z$, the core roughness $C_r$ and the material ratio $M_r$ are explicitly related to the Abbott curve, viz. Fig. 1. A method of randomization of surfaces is used that randomly redistributes the surface heights keeping the Abbott curve constant.

3 Contact Mechanical Properties

Classes of surfaces based on the Abbott curve shown in Fig. 1 were randomly generated and the real area of contact ($A_r$) was statistically evaluated to estimate the distribution within the class. In Fig. 2 the cumulative distribution of the real area of contact of each profile from a class of 1000 surfaces is visualized. From the figure it is clear that the standard deviation $\sigma$ is less than 10% (actually 7.8%) and that the maximum deviation from the mean value ($\mu$) is approximately 30%. It should be noted that a reasonably high load (500kN/m) was applied which is the reason of the fairly large values of $A_r$ shown in Fig. 2. This choice was made in order to ensure a statistical distribution of $A_r$, resolving the surface profiles discretely, using only 512 grid nodes. Other surface profiles, applied loads and mesh sizes were also simulated showing similar compact distributions of $A_r$.

4 Conclusions

The Abbott curve holds the information necessary for reasonably accurate prediction of the real area of contact, indepen-

REFERENCES