MODELING CONTACT OF ROUGH SURFACES[1]

R.E. Jones* and **D.A. Zeigler**

Sandia National Laboratories
P.O. Box 969, MS 9405
Livermore, CA 94551-0969
*rjones@sandia.gov (presenting author)

It is well-known that at small scales surface forces can have a dominant influence, relative to bulk forces, on the overall performance of a device. This fact motivates a more detailed approach to modeling the contact of micro-parts than the simple phenomenological models typically employed for the tribology of macro-machines. Despite the inherent complexity of the micro-mechanics of contact, the behavior of unlubricated surfaces is assumed to be in large part governed by the interactions of isolated regions determined by the actual surface topography. This is due to evidence that at a certain scale most surfaces deviate from their nominal dimensions and are considered 'rough' with a population of protuberances commonly known as "asperities." It is these peaks which are actually in intimate contact and thus play a major role in determining the tribology.

Direct modeling contacting rough surfaces is computationally costly even for simple test coupons and prohibitive for multi-component systems due to the differences in the scales that need to be resolved. An analytical model, developed in 1966 by Greenwood and Williamson [1], provides an efficient means of simulating the basic mechanics of a rough surface undergoing normal loading. This model has been quite successful and has engendered a large body of literature. It has two major components: (a) a known distribution of asperity heights derived from surface topography and (b) an asperity-asperity interaction model resulting from a representative boundary value problem. As with most homogenization techniques, it relies on similarity of behavior at the small scale to provide the overall response of the population. It is consistent with the Amontons-Coulomb law, but also provides a framework for describing departures from the scaling necessary for the applicability of this widely-employed constitutive rule for macro-scopic friction.

A method of coupling a Greenwood and Williamson-based analytical model of the surface asperities to a finite element model of the bulk material of a system of contacting bodies has been developed. It allows treatment of the contact interface as a constitutively distinct "third body" undergoing localized deformation. Subsequent developments have extended the framework to plastically deforming surfaces evolving under cyclic loading, and sliding surfaces where frictional processes, such as adhesive bonding, become important. Correlation with experiments and simulation of real devices is ongoing.

References

[1] J. Greenwood, and J. Williamson, "Contact of nominally flat surfaces," *Proc. Roy. Soc. A*, v.295, p.300-319, 1966.

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