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Statistical model of rough surface contact accounting for size-dependent plasticity and asperity interaction

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Abstract

The work by Greenwood and Williamson (GW) has initiated a simple but effective method of contact mechanics: statistical modeling based on the mechanical response of a single asperity. Two main assumptions of the original GW model are that the asperity response is purely elastic and that there is no interaction between asperities. However, as asperities lie on a continuous substrate, the deformation of one asperity will change the height of all other asperities through deformation of the substrate and will thus influence subsequent contact evolution. Moreover, a high asperity contact pressure will result in plasticity, which below tens of microns is size dependent, with smaller being harder. In this paper, the asperity interaction effect is taken into account through substrate deformation, while a size-dependent plasticity model is adopted for individual asperities. The intrinsic length in the strain gradient plasticity (SGP) theory is obtained by fitting to two-dimensional discrete dislocation plasticity simulations of the flattening of a single asperity. By utilizing the single asperity response in three dimensions and taking asperity interaction into account, a statistical calculation of rough surface contact is performed. The effectiveness of the statistical model is addressed by comparison with full-detail finite element simulations of rough surface contact using SGP. Throughout the paper, our focus is on the difference of contact predictions based on size-dependent plasticity as compared to conventional size-independent plasticity.