CONVENIENT FORMULAS FOR MODELING THREE-DIMENSIONAL THERMAL-MECHANICAL ASPERITY CONTACT

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ABSTRACT
Frictional heating is a common phenomenon related to friction and rubbing. Due to the increasingly high demand for compact design, a considerable amount of tribological elements are expected to work in mixed or boundary lubrication, where surface materials and asperities may be subjected to significant heating across the contact interface. The temperature variation in the contacting bodies may cause the contact conditions to change; and in turn, due to thermal deformation and asperity distortion, asperity contact pressure may vary as a function of the level of frictional heat.

Modeling the rough-surface contact in a tribological process that involves frictional heating and thermoelastic deformations requires an interactive thermal-mechanical simulation process and a large amount of numerical calculation [1]. A three-dimensional interactive thermal-mechanical asperity contact model has been developed, which takes into account steady-state heat transfer, asperity distortion due to thermal and elastic deformations, and material yield. The finite-element method (FEM), fast Fourier transform (FFT) [2-5], and conjugate gradient method (CGM) [6] are employed as the solution methods. The model can be used to analyze contact and temperature of the asperities of real engineering surfaces.

The thermal-mechanical asperity contact model is applied to analyze many digitized engineering surfaces of a wide range of statistical properties. Based on the results of the analysis, a group of semi-empirical formulas is derived as a simplified version of the contact model for the convenience of use in the simulation of complicated lubrication and wear process of various tribological elements and systems. The thermal and mechanical properties of materials and the statistical properties of the contacting rough surfaces, as well as the asperity orientation parameter, are used in the formulas to define a contact problem. The maximum asperity flash temperature, contact pressure, and real contact areas are described as functions of the normal approach between the contacting elements. The semi-empirical formulas are compared with the results obtained from the numerical analyses with satisfactory accuracy.

REFERENCES