Energy dissipation in cyclic indentation of rough soft interfaces

A. Papangelo[1*], M. Ciavarella[2]

[1]Politecnico di Bari, Department of Mechanics Mathematics and Management, Via Orabona 4, 70125 Bari, Italy
[2]Hamburg University of Technology, Department of Mechanical Engineering, Am Schwarzenberg-Campus 1, 21073 Hamburg, Germany
[*]email: antonio.papangelo@poliba.it

Viscoelastic materials are essential in the development of key technologies ranging from soft robots to pressure sensitive adhesives, passive damping techniques in the automotive and aerospace industry. Contrary to the elastic counterpart, viscoelastic materials dissipate energy when they are cyclically loaded, which influences their mechanical response as a function of the excitation frequency. Here, by using the correspondence principle developed by Lee and Radok, and considering the extensions introduced by Ting and Greenwood, we transform the elastic solutions of Persson for the contact of nominally flat randomly rough self-affine surfaces to viscoelastic indentation. Two loading scenarios are considered as an example: (i) a step loading and (ii) a single cycle of harmonic loading. By using the analytical model derived, the effect of the loading frequency, of the ratio between the rubbery and the glassy moduli of the material, and of the mean normal load on the energy dissipated per loading cycle is studied in detail for a standard viscoelastic material. The model is general and could be used for any viscoelastic material provided that its rheology (particularly the creep compliance and the relaxation functions) are known. The results shown are significant for the engineering applications involving cyclic indentation of soft materials, such as in tire-road contact, seals, pick-and-place manipulators and grippers.

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[*]Corresponding author: antonio.papangelo@poliba.it