VISCOELASTIC RECIPROCATING MOTION BETWEEN ROUGH INTERFACES

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ABSTRACT
The mechanics and physics of soft linearly viscoelastic materials is an intricate research field, where the strongly time-dependent constitutive stress-strain relations govern the response of this class of materials and often make classical methodology unfeasible for the solution of mechanical issues. Indeed, the determination of stresses, strains and dissipated energy result even more difficult when attention is focused on contact mechanics problems: in this case, the surface roughness on the contacting bodies often covers several orders of magnitude. Given the theoretical importance of these themes and, at the same time, the implications for many practical components, including a variety of scales and fields (earthquake dampers, mechanical seals, biological scaffolds are only possible examples), a large number of publications has been dedicated to shed light on the contact mechanics of rough viscoelastic solids [1–3]. These contributions include analytical [4, 5] numerical [6, 7] and experimental [8] studies.

The present work deals with an issue of fundamental importance: the reciprocating contact of viscoelastic materials, where the relative motion between the contacting bodies is periodically inverted. We develop a Boundary Element Methodology in order to determine the contact solution in terms of stresses, strains and hysteresis. Specifically, we provide the explicit solution, in terms of a Fourier series, of the Green's function of the reciprocating contact problem between a rigid punch and a linear viscoelastic solid. The periodic features, intrinsically marking the problem, enables us to carry out the parametric calculation of the contact solution for each time step without any necessity of employing the solution in the previous time interval. By implementing such a parametrically time-dependent approach, we obtain the full numerical convergence in each moment of the cycle and, interestingly at the dead points, i.e. when the punch inverts its motion.

Furthermore, we specifically study the influence of the surface roughness on the viscoelastic friction. This shows that, as in the steady-state case, viscoelastic friction strongly depends on the number of scales included in the simulation.

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