Relaxation damping in oscillating contacts

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It is well known that oscillating tangential contacts exhibit frictional damping due to slip in parts of the contact. Solutions for this behavior in the case of spherical surfaces were given by Mindlin et al. in 1952. This contact damping plays an important role in numerous applications in structural mechanics, tribology and materials science. Since this damping arises due to partial slip in the contact of bodies with curved surfaces, when the coefficient of friction tends towards infinity, slip disappears, frictional losses are eliminated, and the oscillation damping becomes zero. However, when a contact oscillates in *both normal and tangential* directions, there is another, purely elastic loss mode that we refer to as “relaxation damping”. In its essence the proposed loss mechanism is similar to a spring that is deflected and abruptly released, converting the stored energy into elastic waves that are eventually dissipated. Thus, an apparently non-dissipative system shows dissipation. The same will also happen in contacts that oscillate normally and tangentially at the same time, even if the motion is very slow (quasi-static). The rate of energy dissipation due to relaxation damping is calculated in a closed analytic form for arbitrary axially-symmetric contacts. In the case of equal frequency of normal and tangential oscillations, the dissipated energy per cycle is proportional to the square of the amplitude of tangential oscillation and to the absolute value of the amplitude of normal oscillation, and is dependent on the phase shift between both oscillations. In the case of low frequency tangential motion with superimposed high frequency normal oscillations, the system acts as a tunable linear damper.

Furthermore, we apply two different numerical methods to solve the problem for arbitrarily shaped surface topographies: the Method of Dimensionality Reduction (MDR) and the three-dimensional high-resolution boundary element method (BEM). Using these techniques, generalization of the results for macroscopically planar, randomly rough surfaces is discussed.