A CONTINUUM MODEL OF INTERFACIAL DISSIPATION WITH TIME-VARYING TANGENTIAL AND NORMAL LOADS

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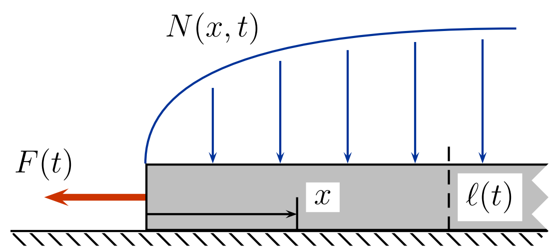
This work describes a continuum model for the dissipation induced by interfacial friction. The physical model describes a semi-infinite elastic rod on a rough surface, subjected to time-varying normal and tangential loading conditions.

We consider the deformation of a rod on a rough surface with a time-dependent frictional intensity $\psi(x,t)$. Within any region which undergoes slip, the deformation $u(x,t)$ of the rod can be described by a nondimensional equation of the form:

$$\frac{\partial^2 u}{\partial x^2}(x,t) = \sigma(x,t)\ \psi(x,t),$$

where $\sigma(x,t)$ represents the sign of the sliding direction at (x,t). Moreover, at the free end, we have the natural boundary condition $u_x(0,t) = -F(t)$.



In the presence of constant normal loads, the deformation can be solved in closed-form. In this case, the frictional dissipation per forcing cycle has been shown to lead to power-law scaling as a function of tangential loading amplitude, with the power-law exponent dependent on the spatial profile of the normal loads [1].

In contrast, the time-dependent normal loads no longer allow a closed-form solution for the deformation of the rod, except in special cases. Instead, the continuum equations are reduced to a set of differential relations that describe the evolution of slip transitions, that is, the locations along the rod at which the rod undergoes a transition from sticking behavior to slip. These differential relations are then solved numerically to describe the behavior of the slip transitions. Once these quantities are known, the deformation of the rod is completely determined by algebraic relations. Thus, the solution for the continuum deformation of the rod is reduced to that of a few differential relations. Finally, these results are compared with simulations of a discrete system of elements subject to identical loading conditions.

References

[1] Quinn, D. D., and Segalman, D. J., 2003, "Using Series-Series Iwan-type Models for Understanding Joint Dynamics," Submitted to the *ASME Journal of Applied Mechanics*.