On the Nonlinear Dynamics of In-contact Bodies subject to Stick-Slip and Wear Phenomena

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Abstract. The dynamic behavior of a one degree-of-freedom oscillator, subject to stick-slip and wear phenomena at the contact interface with a rigid substrate, is investigated. The motion of the oscillator, induced by a harmonic excitation, is influenced by the tangential contact forces, exchanged with the rigid soil, which in turn depend on specific nonlinear constitutive models considered to account for stick-slip phenomena due to friction as well as wear due to abrasion. The nonlinear ordinary differential equations governing the problem are derived, whose solution is numerically obtained. In this context, the effect of the different interface models on the nonlinear dynamics is extensively analyzed and discussed.

Introduction

Detailed engineering design requires the study of specific mechanical behaviors: this is the case of in-contact bodies. In particular, it becomes a key aspect when interface phenomena such as friction and abrasion take place. In this context, it is thus necessary to formulate richer constitutive models that have to account for the in-time evolution of the interface [1, 2]. The description of stick-slip phenomena due to friction and wear due to abrasion, has been addressed in several studies. New interface models are derived in the general framework of the Thermodynamics of the irreversible processes and account for suitable internal variables of phenomenological type, grounding the formulation of the wear process in the context of Damage Mechanics [3]. Such models have been adopted in [4] to investigate the behavior of elastic bodies in tangential contact with a rigid substrate in discrete points, under quasi-static loading conditions. Motivations of this study rely on the fact that the contact modeling of complex interface behaviors has mostly been conducted in statics, and therefore further efforts can yet be conducted to investigate dynamic regimes, besides some examples can be found in e.g. [5, 6]. The nonlinear dynamic problem has been here addressed with reference to a rigid block, schematically represented in Fig. 1-a, subject to a harmonic load, whose motion gives rise to tangential stresses, evolving in time according to the nonlinear constitutive laws of [3] and sketched in Figs. 1-b,c, without and with wear, respectively.

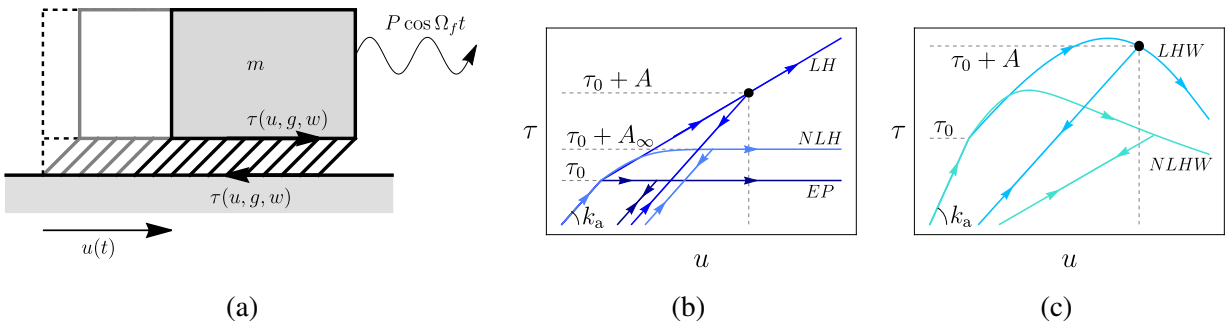

Figure 1: Oscillator in tangential contact: (a) structural scheme; (b) no-wear models; (c) wear models.

Results and Discussion

In the analyzed case, due to the nature of the constitutive equations, it is not possible to a priori know the steady-state response, since it strictly depends on the transient phase. Therefore, a numerical solution strategy is adopted to solve the nonlinear non-smooth ordinary differential equations. The frequency-response curves are the obtained to evaluate the system behavior under different excitation frequencies. Results show that the effect of the interface allows to dissipate the energy introduced by the excitation and the equivalent dissipation capacity strongly depend on the type of contact law.

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