Short Communication

Stick–slip motion in one-dimensional continuous systems and in systems with several degrees of freedom

I. ANDERSSON

Department of Mechanical Engineering, W-hoog 04.101, Technische Hogeschool Eindhoven, Postbus 513, 5600 MB Eindhoven (The Netherlands)

(Received December 15, 1980)

Stick–slip is the name for a vibration phenomenon characterized by a jerky motion in systems that are required to perform uniform sliding at, in most cases, low sliding velocities. This jerky motion is caused firstly by the dependence of the frictional force on the sliding velocity and secondly by the elastic and damping properties of the system. There are many cases where this stick–slip motion can be seen; one of the most investigated examples is the feeding mechanism in machining processes. More trivial examples are the bow sliding on a string of a violin, the chalk sliding on a chalkboard, and squealing brakes. Another example is long moving assembly lines in factories, where stick–slip motion sometimes occurs.

The first examples above can be analysed using a theory with one degree of freedom. The critical feed velocity for the stick–slip problem with one degree of freedom has been presented in an appendix of a thesis by Andersson [1], and references to more detailed papers on this subject are given in the historical survey included in the thesis.

For the assembly line problem, however, it is not correct to use a one degree of freedom theory; the system must be treated as one with several degrees of freedom or as a continuous system. Because of the sometimes rather complicated relation between the frictional force and the sliding velocity this problem has certain similarities to the non-linear wave propagation problem.

The one-dimensional continuous system is discretized by the finite difference technique, and a solution common to this system and to systems with several degrees of freedom has been given [1]. The motion of these systems was calculated numerically by the Runge–Kutta method. The stored energy and the power flow were analysed during the calculated motion and were used in the iterative calculation of the critical feed velocity. Different frictional force models suggested by other workers were used in the calculations. Quantitative results for various values of the parameters and different frictional force models were presented in non-dimensional form.
For continuous systems or for systems with several degrees of freedom that are subjected to stick–slip motion, the methods for preventing stick–slip are the same as those for systems with one degree of freedom, i.e. increased stiffness, increased damping or decreased difference between static and kinetic friction, where the decreased difference between the types of friction is best achieved by using lubricants doped with polar additives.