ON THE MECHANICS OF STICK SLIP MOTION AND ITS ELIMINATION

Synopsis

This work presents a mechanics analysis and experimental study of three problems associated with the stick slip motion of sliding bodies.

In the first case, the nonlinear variation of friction with the velocity of sliding is considered in establishing a relationship between the steady state friction and the critical velocity for a stick slip system. Justifications are given for the "small parameter" assumption made in the analysis. Krylov-Bogoliubov solution of the transformed equation of motion leads to the concept of critical velocity as one for which the system damping just exceeds the first differential coefficient of friction with respect to the velocity of sliding. The analysis explains the background for some well known methods of reducing or eliminating stick slip.

Effects of force excitation on a stick slip system, in the direction of its motion are studied next. Harmonic and superharmonic responses are obtained by the method of harmonic balance and their stability criteria

outlined in terms of the associated Hill's equation. Subharmonics are studied by the stroboscopic method and are shown to be nonexistent except for a specific case. The stability conditions give indications as to why stick slip is eliminated under only certain values of the amplitude and frequency of the exciting force, including those cases for which a linear theory would have predicted the persistence of stick slip.

Lastly, an attempt is made to explain the elimination of stick slip by transverse vibration of the stick-slipping member. A fundamental study of the friction behaviour under these conditions, considering an idealised geometry for the surface micro-irregularities and an assumed squeeze action on the lubricant resulting from the vibration, fails to give any clue to the possible mechanism. The analysis however points to the nonlinear time-varying character of friction which is next incorporated in, and by way of an extension to, an existing[20,21] analysis. Friction-velocity curves as predicted now by this analysis are more likely to be obtained in practice than those given by the earlier authors[20,21]. However, like in the original works,[20,21] the analysis explains only the reduction in stick slip with traverse vibration.

An experimental study of the above problems is made on an actual stick slip model. Records of stick slip

traces are taken by an oscilloscope camera for four different lubrication conditions and two frequencies of transverse excitation. Stick slip amplitude versus frequency of excitation readings are taken for both transverse and longitudinal excitation. Critical velocity results match well with the theory. Transverse vibration experiments confirm the shallowing down of the friction-velocity curve, but, by showing the disappearance of stick slip under only certain values of the frequency and amplitude of the exciting force, exposes the liminations of the analysis. Longitudinal excitation brings about elimination of stick slip, in these experiments, under three discrete frequency ranges for the same force. This fact alone, not explicable by a linear theory, is taken as a qualitative support for the consideration of nonlinearities given in the analysis.

The thesis ends with an indication of the scope for improvement and extension on the present work.