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A new method to determine periodic solutions in discontinuous systems with application to mass on moving belt

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Abstract: Dry friction is one of the most complex nonlinear phenomena occurring in general machine dynamics. This work deals with the analysis of mass in motion on a moving belt which is undergoes stick slip oscillations due to dry friction between the contact surfaces. The mass attached to a spring damper system and placed on a conveyor belt with a specified velocity is subjected to a periodic excitation. This work generalises a Cluster Based Algorithm (CBA) developed by the authors for design optimisation of nonlinear systems to multi-harmonic excitations. The focus of the work is in the evaluation of parameters of spring and viscous damper in order to obtain a pure slipping condition when the mass is subjected to single and multi-frequency excitations. A cluster based analysis technique based on force and energy balance is used here for parameter evaluation and for finding the parameter regimes which yield pure-slip dynamics.

Keywords: Dry friction, Pure slip, Parameter estimation, Cluster analysis

1. Introduction

Frictional forces arising from sliding relative motion between surfaces are a well-known form of energy dissipation. The initial work dealing with modelling of friction in mechanical systems was done by Den Hartog [1] and well-studied by many authors [2-4]. In this section, a Cluster Based Algorithm as discussed in [5] is implemented in design of mass on moving belt systems subjected to multi-harmonic excitation with friction induced vibrations, to arrive at periodic solutions of pure slip type. The system parameters are the sliding mass (*m*), Damping coefficient (*c*), spring stiffness (*k*) and the friction force (*fr*). The system is schematically shown in Fig. 1 and modelled as Eq(1).

$$m\ddot{x} + c\dot{x} + kx + fr\,sign(\dot{x} - v_b) = F(t) - (1)$$

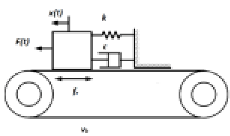

Fig. 1

In this work we consider two excitations (i) $F(t)=F \cos \omega t$, (ii) $F(t)=F_1 \cos \omega_1 t + F_2 \cos \omega_2 t$ and arrive at system parameters (*k* and *c*) to arrive at periodic solutions using the cluster based algorithm.

2. Results and Discussion

It is seen that the parameter sets yielding pure slip periodic solutions will converge to a cluster for single harmonic as well as multi-harmonic excitations. Any parametric point from the cluster will yield to a periodic pure slip orbit as evident from the phase plane plots, which are plotted using the design parameter values obtained from the cluster.

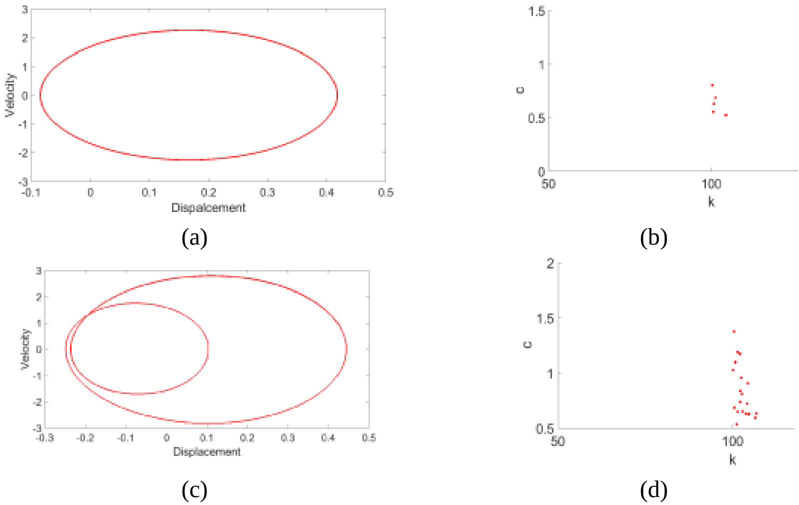

Fig. 2 (a) Phase plane plot for single frequency excitation (b) Optimal parameter cluster for single frequency excitation (c) Phase plane plot for multi-frequency excitation (d) Optimal parameter cluster for multi-frequency excitation

3. Concluding Remarks

In this work the cluster based algorithm is applied to mass on moving belt systems subjected to single and multi-harmonic excitation to arrive at design parameters (*k ,c)* yielding pure-slip periodic response. It is seen that the algorithm can be applied to evaluate design parameters of nonlinear systems subjected to multi-harmonic excitation as well.

References

[1] JP Den Hartog. Lxxiii. Forced vibrations with combined viscous and coulomb damping. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, 9(59):801-817, 1930.

[2] MS Hundal. Response of a base excited system with coulomb and viscous friction. *Journal of Sound and Vibration*, 64(3):371-378, 1979.

[3] U Andreaus and P Casini. Dynamics of friction oscillators excited by a moving base and/or driving force. *Journal of Sound and Vibration*, 245(4):685-699, 2001.

[4] Jin-Wei Liang and Brian F Feeny. Balancing energy to estimate damping parameters in forced oscillators. Journal of Sound and Vibration, 295(3-5): 988-998, 2006.

[5] Premchand V. P. , M. D. Narayanan, Sajith A.S. A New Cluster-Based Harmonic Balance Aided Optimization Procedure With Application to Nonlinear Vibration Absorbers". *ASME Journal of Computational and Nonlinear Dynamics*, 14(7), 2019.