Modeling Vibrations Due to Surface Roughness at Planar Sliding Contacts

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1. Introduction

The seemingly simple problem of a block sliding on a flat surface presents interesting challenges to dynamic modeling and testing. Surface texture provides both dynamic excitation and a compliant contact. The roughness is modeled as a Brownian or red noise in terms of wavelength, typical of real surfaces. The dynamic model is linearized from the fully nonlinear equations and includes the role of contact stiffness and damping. Simulink results are compared with previous measurements.

2. Model and Simulation

The study of contact vibrations excited by surface roughness goes back to Gray and Johnson [1] who studies rolling disks. We model a rectangular block being pulled along flat surface as shown below in Fig, 1. The ground surfaces in contact have a band-limited broadband random roughness. The roughness provides dynamic excitation during sliding and a distributed contact stiffness that is inversely proportional to the

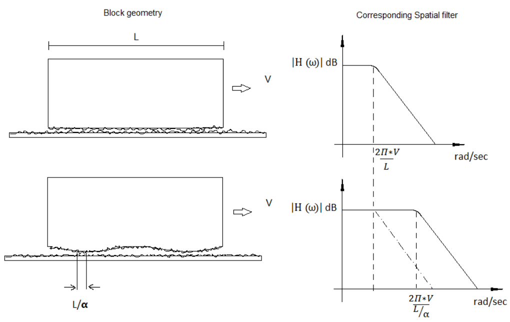

Fig. 1. Ideal and wavy block showing spatial filtering

rms roughness. The full non-linear equations were derived by Hess and Soom [2]. Linearized equations were used in [2] to estimate the primarily normal and angular (rocking) natural frequencies of the block on a massive base. The estimates compared well with measured natural frequencies during both sliding and impact tests [2]. However, no attempt was made in this earlier work to simulate the dynamic response of the block. In the present work, the general simulation approach of Soom and Chen [3] is combined with the linearized Hess and Soom model [2] to simulate the sliding system. The friction coefficient is 0.2.

3. Results

Parametric studies were carried out. A typical result comparing measured and simulated vibration spectra is shown in Fig. 2. The normal and angular natural frequencies are captured. However the angular vibrations are underestimated. The discrepancy could be due to the linearized model or due to challenges in creating an experiment to match the idealized model.

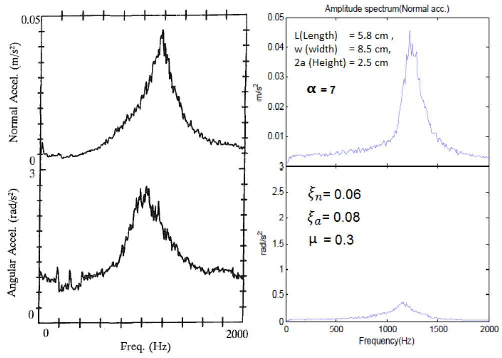

Fig. 2. Normal and angular vibrations during sliding at 30mm/s, σ= 0.5μm. (meas. left, simul. rt) Steel block, L=58mm, W=85mm, height=25mm

4. Conclusions

While some aspects of the dynamic response can be captured, there remain a number of differences between the simulations and measurements. The coupling between normal and angular vibrations is different. Angular vibrations are consistently under-predicted by the model. There are many aspects of the roughness characterization, geometry (flatness) and dynamic model (linear or nonlinear, roughness excitation independent of motions) that must be very well matched. It is not clear whether the fault lies in the model or the experiments. Still, this shows many of the challenges in the detailed dynamic testing and modeling of planar frictional contacts.

5. References

[1] Gray, G.G. and Johnson, K.L., "The Dynamic Response of Elastic Bodies in Rolling Contact to Random Roughness of Their Surfaces," J. Sound and Vibration, 22, Issue 3, 1972, 323-342

[2] Hess, D.P, and Soom, A., "Normal and Angular Motions at Rough Planar Contacts During Sliding with Friction," ASME J. Tribology 114 1992, 567–578.

[3] Soom, A.,and J. Chen, J., "Simulation of Random Surface Roughness-Induced Contact Vibrations at Hertzian Contacts during Steady Sliding," ASME J. Tribology 108, 1986,123-127.