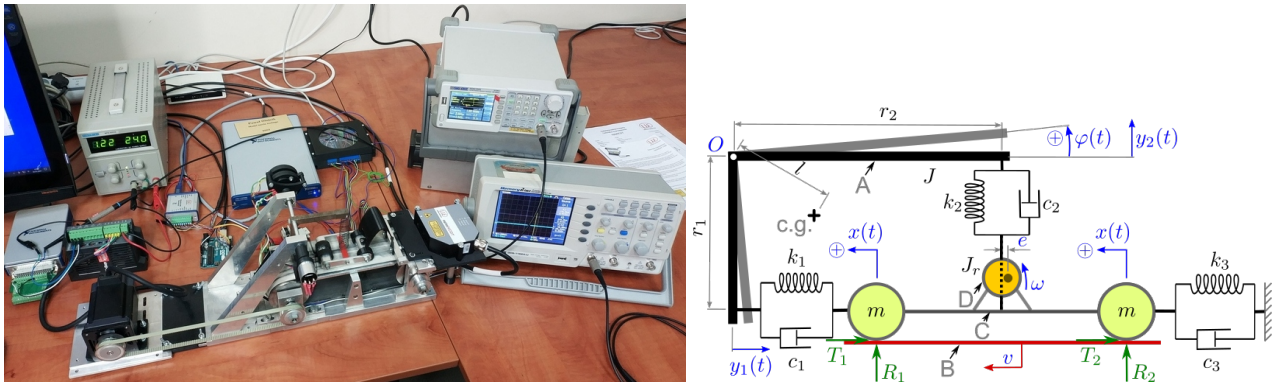
A chain of real mechanical oscillators subjected to creep-slip friction and relatively high-frequency structural vibration

Paweł Olejnik* and Jan Awrejcewicz*
*Department of Automation, Biomechanics and Mechatronics,
Faculty of Mechanical Engineering, Lodz University of Technology,
1/15 Stefanowski Str., 90-924 Lodz, Poland, ORCID 0000-0002-3310-0951

Abstract. In this work, a real mechatronic system of coupled inertia oscillating under the action of relatively high-frequency structural vibrations as well as its mathematical description is presented. A vibration exciter is incorporated into the model system in the form of an imbalanced rotor, simulating the presence of real structural vibration. As such kind of unavoidable excitation can be detected in any real machine's functioning, the very small amplitude and relatively fast forcing is proved to cause a significant change in frictional response of the observed real creep-slip motion.

Introduction

In the design, a structural vibration analysis of specific areas of the machine is often undertaken. The discussed problems of dynamics are often caused by dry and viscous friction or a rotating imbalance occurring, among others, in driving and braking systems, stabilizing platforms, miscellaneous turbine and pump solutions, etc. The most common factor in these different types of vibration is that the structure responds with some repetitive dynamical behavior that affects its physical properties, accurateness of positioning and other. The considered system of mechanical oscillators can be modeled using the physical representation shown in Fig. 1.



(a) the experimental stand

(b) physical model

Figure 1: A real chain of three coupled oscillators (against y_1, y_2, ω) with friction J–m–J_r (a) and its physical model (b): A – stiff pendulum body of mass moment of inertia J, B – horizontally moving soft base, C – stiff beam in a contact at R_1 and R_2 with the base B, coupling the two oscillators J–m, D – imbalanced rotor mounted on C, elasticity: k_1, k_2 k_3; structural damping: c_1, c_2 c_3 of the spring elements and friction forces T_i.

Taking into consideration the three coupled inertia shown in the configuration from Fig. 1, i.e., the pendulum body (A), the frictional oscillator (C) and the imbalanced rotor (D), we begin the analysis from the derivation of mass moment of inertia of the pendulum rotating about its center of gravity.

Results and discussion

Various phenomena caused be high-frequency vibration of the sliding body's structure and occurring in the considered system consisting of coupled rotating elements with the non-ideal source of energy pumped to the considered structure have been reported. The imbalance of the rotor mass m_r (D) on the slider's body (C), as shown in Fig. 1b plays a significant role in the formation and disappearance of self-excited vibration in the structure. In work [1] such a system was considered, where the imbalanced rotor's function was delivered by a direct-current induction motor, mounted in the center of the sliding body. Our experimental observations go beyond the above by presenting real time trajectories at the presence and absence of the additional pump of vibration energy to the system being a reason of intermittent stick-slip behavior.

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References

[1] Vinícius Piccirillo, Thiago Gilberto Prado, Angelo Marcelo Tusset, and José Manoel Balthazar (2020) Dynamic integrity analysis on a non-ideal oscillator. *J. MESA*, **11**:541–547.