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Preliminary Investigations of Machine Frame Vibration Damping Using Eddy Current Principle

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Abstract. A novel approach to vibration attenuation, based on the eddy current principle, is described. The combined effects of all magnetic forces acting in the oscillatory system attenuate frame vibrations. A mathematical model of the forces balance in the oscillatory system was derived before. Some experimental results from a mock-up machine frame mechanically loaded by a rotating machine and excited at resonance are presented.

Introduction

Vibrations of rotating machinery, mounted on a flexible frame (raft), may interfere with frame eigenfrequencies and resonances can occur. Because of low structural damping the resonance vibrations may exceed the limits of safe operation. Various passive damping methods are used. Apart of visco-elastic and friction dampers occasionally dampers employing electro-magnetic damping principles are used. A very thorough research on their contemporary use is presented in the paper [1]. Author has shown a remarkable attenuation of the excited eigenmodes of cantilever beam transversal vibrations. The first author has analysed an oscillatory system analogous to that one described here; however, with additional coil wound around the permanent magnet [2, 3].

The difficulty of the study of the electro-magnetic dampers in general is their inherent non-linearity, as the physical phenomena are dependent on inverse of the square of the acting distance. It is a non-linear multi-physics problem, which calls for inevitable simplification and linearization.

Experimental device description

The lay-out of the analyzed electro-mechanical system is depicted in Fig. 1. The rotating machine (pos. 1) is situated on a flexible frame, to which a ferromagnetic yoke (pos. 2) is fixed. Below the yoke a rotationally symmetric pot-type core (3) is situated at a static distance d_0. In the axis of the pot core an axially polarized permanent magnet is situated. The mechanical system may be treated as an SDOF oscillatory system with additional magnetic forces. Theoretical analysis of the first order effects was made elsewhere. Here some preliminary experimental results are presented.

Preliminary measurements

The experimental set-up consisted of a frame, fixed to two supporting rigid structures, onto which a commercial small compressor was rigidly fixed. The compressor was loaded by additional dead weight, to excite the frame near its first resonance frequency by machine rotation. Frame vibrations were measured by a MEMS type accelerometer CXL04LP3 (Crossbow, USA) – pos. 4 in Fig. 1; firstly without the damping device and then with the damping device for two different static distances d_0. Acceleration autospectrum, obtained by frequency analysis, is depicted in Fig. 2.

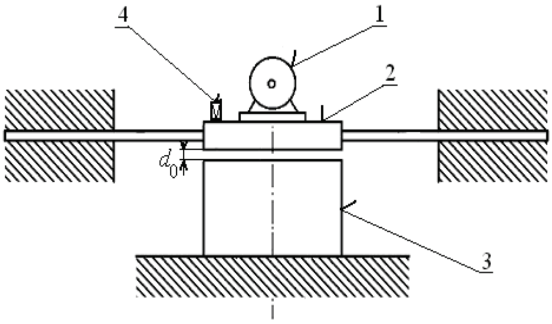


Fig. 1: Schematic lay-out of the treated electro-mechanical oscillatory system.

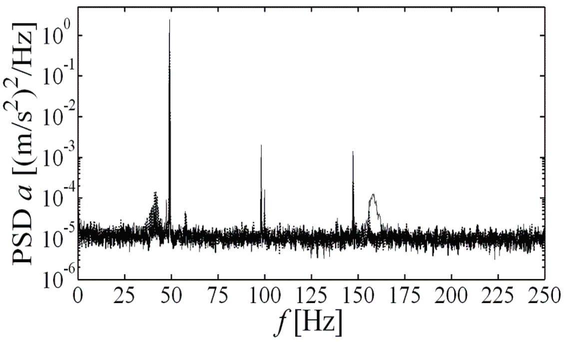
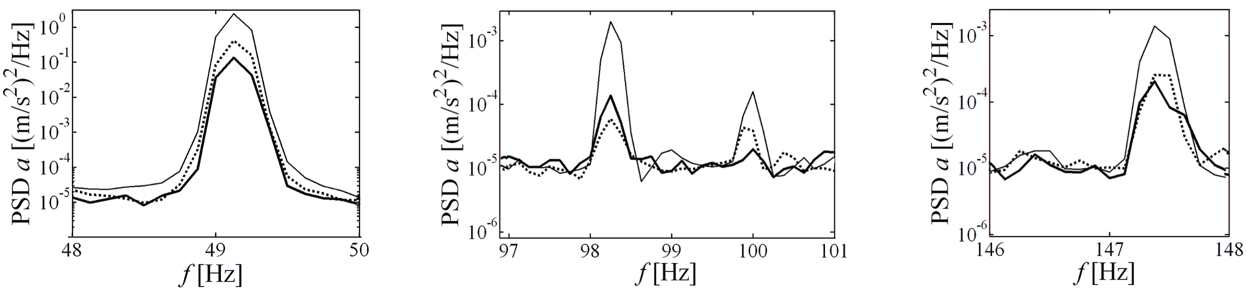


Fig. 2: Autospectrum of acceleration of frame vibrations.

In the autospectrum three marked peaks are seen at the asynchronous rotation frequency and its second and third multiple, as well as the second harmonic of the mains frequency. Enlarged details of each peak are depicted in Fig. 3, where the influence of the damping device is clearly seen.



(a) (b) (c)

Fig. 3: Details of the peaks in the autospectrum: (a) at the rotational speed, (b) second harmonic and mains second harmonic, (c) third harmonic (── frame, ── d_0 = 0.45 mm, ···· d_0 = 0.53 mm).

Conclusion

From the presented preliminary results the good vibration attenuation in resonance due to the eddy current damper is visible. Up to 12 dB attenuation is attainable at resonance (Fig. 3a). However, because the damping is proportional to vibratory velocity, outside of the resonance frequency band the vibration attenuation is much lower or not present at all.

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