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Nonlinear normal modes and localization of vibrations in the pendulum system under magnetic excitation

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Abstract: Dynamics of two coupled pendulums under magnetic excitation is considered. Inertial components of the pendulums are essentially different, and a ratio of masses is chosen as a small parameter. Analytical approximation of the magnetic force obtained earlier experimentally in Lodz Technical University, is used in analysis of the system dynamics. The small parameter method is used to construct nonlinear normal modes (NNMs) one of them presents localised vibrations is the system. Stability of the NNMs is also studied.

Keywords: pendulum system, magnetic excitation, nonlinear normal modes

1. Introduction. The principal model

The system containing two pendulums under the electromagnetic motor influence is studied in papers [1,2]. Model of one of the pendulums is shown in Fig. 1.Few corresponding mathematical models are constructed, and their validation is discussed after comparison of the numerical simulation and experimental results. Then some aspects of the system dynamics is analyzed. Here we consider a similar system of two pendulums under magnetic force when inertial characteristics of these pendulums are essentially different. In this case a localization of energy on one sub-system is possible. To describe a dynamics of the system the nonlinear normal modes theory is used. Note that an investigation of nonlinear normal modes (NNMs) is an important part of general analysis of many classes of nonlinear dynamical systems. Different theoretical aspects of the NNMs theory and applications of the theory are presented in numerous publications, in particular, in reviews [3,4].

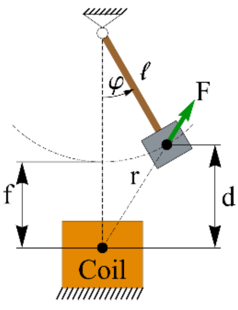

Fig. 1. The pendulum dynamics under magnetic force [1,2]

The analytical approximation of the magnetic force demonstrates a good correspondence with experimental results presented in [1,2] as is shown in Fig.2.

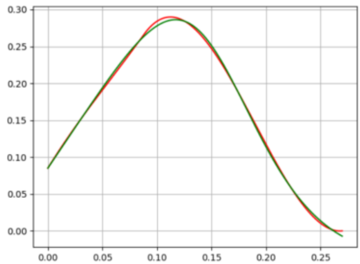

Fig.2. Comparison of the magnetic force analytical approximation with experimental result [1,2].

2. Results and Discussion

The small parameter method in the form by Lindstedt-Poincare approach is used to describe dynamics of the system under consideration. It is assumed that a mass of one pendulum is essentially smaller than one of the second pendulum. Besides, it is assumed that the magnetic force is smaller than main elastic characteristics of the system. An expansion of the magnetic force to the Fourier series permits to construct periodic regimes by the small parameter method with good exactness. Two NNMs are obtained. One of them is close to the in-phase motions, and the second one describes vibrations localized at the small mass pendulum. Besides, a stability of these NNMs is studied. It is obtained a region of the system parameters where the localization of vibrations at the small mass pendulum is possible.

3. Concluding Remarks

Two nonlinear normal modes are described in the system with two connected pendulums under magnetic force. It is assumed that inertial characteristics of these pendulums are essentially different. It the case two nonlinear normal modes can be realized in the system. One of them is a mode of in-phase vibrations, and the second one is a mode of localization of the vibration energy on the small mass pendulum.

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