Determining magnetic and electromagnetic springs forces and their usage in damping vibrations

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Abstract. The paper presents analysis of dynamic characteristics of mechanical, magnetic and electromagnetic springs. Since electromagnetic spring force can be controlled by altering the current in coil they can be used for damping the vibrations. New physical model of magnetic springs have been proposed and have been subjected to experimental verification on a specially designed and built experimental stand. The stand consists of an aerostatic guide that has one degree of freedom. Thanks to aerostatic supports we can neglect dry friction. The article presents a method of changing the characteristics of magnetic springs by controlling the current in the coil. Numerous experiments were carried out to determine the characteristics of specific system components and verify the correctness of the proposed mathematical models. In order to damp the vibrations of the whole system, a current controller with feedback loop has been developed and presented in this work.

Introduction

We treat two or more magnets moving coaxially as a nonlinear magnetic spring. By electromagnetic spring we mean a magnet moving coaxially in the vicinity of powered coil. Such defined spring, along with mechanical linear spring were studied in this work. Stiffness characteristic of these springs were analysed separately. In order to damp the oscillations with electromagnet a configuration consisted of mechanical and electromagnetic spring has been introduced. All analyses and simulations were supported by experimental research. The experiments took place on a stand for testing the characteristics of the springs (Fig.1).

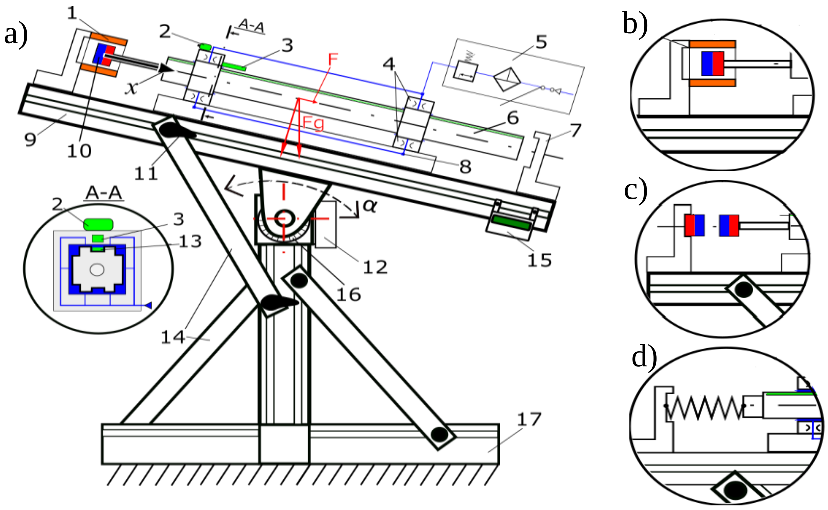

Figure 1. Diagram (a) of the experimental rig with aerostatic supports: 1 - coil, 2 - inclinometer, 3 - position sensor, 4 - aerostatic supports, 5 - air preparation system, 6 - guide, 7 - bracket, 8- compressed air, 9 - base , 10 -magnet, 11 - angle adjustment locks, 12 – worm gear, 13 - magnetic ruler, 14 - supports, 15 - displacement display, 16 –angular scale, 17- rig frame. Different configurations (b, c, d) of springs (electromagnetic, magnetic and mechanical) mounted to the brackets and the guide.

We could study magnetic and electromagnetic springs on this stand thanks to use of non-ferromagnetic elements.

Results and discussion

By changing the current in the coil, we can change the stiffness of the entire system depending on the position of the magnet. The relationship between the current in the coil and the stiffness of the system was determined. The new mathematical models of the non-linear magnetic spring have been compared with the actual system. There are studies that models the interaction between permanent magnet and coil [1] using different methods such as "filament", "layers", "integrals" or "Babic" methods. In this work force relations between magnet and coil has been verified experimentally.

References

[1] R. Ravaud, G. Lemarquand, S. Babic, V. Lemarquand, C. Akyel, Cylindrical magnets and coils: Fields, forces, and inductances, IEEE Trans. Magn. 46 (2010) 3585–3590. doi:10.1109/TMAG.2010.2049026.