MATHEMATICAL MODELING OF ROTOR DYNAMICS IN A MAGNETO-HYDRODYNAMIC FIELD FOR THE CASE OF MAGNETICALLY HARD MATERIALS

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In the present work the mathematical modeling of 2-dof non-linear dynamics of the rotor supported on the magneto-hydrodynamic bearing system for the case of magnetically hard materials is performed by means of the additional Bouc-Wen hysteretic model. This model enables simulation of hysteretic loops of various forms for the systems from very different fields, like mechanics, biology, electronics, ferroelectricity, magnetism, etc [1, 2].

In the case of magnetically hard materials the presented mathematical model with hysteretic properties may reveal an unexpected behaviour. On the one hand, hysteresis as any dissipation promotes stabilization of motion and may restrain the occurrence of chaotic vibrations of the rotor. On the other hand, it may be the cause of instability and chaotic vibrations in the system. The last property has been confirmed by the present studies. In absence of hysteresis chaos is not observed. Taking into account hysteretic properties demonstrates that under certain conditions chaotic vibrations of the rotor occur.

The influence of hysteretic dissipation on chaos occurring is investigated using the methodology based on analysis of the wandering trajectories. Conditions for chaotic vibrations of the rotor in the magneto-hydrodynamic field for the case of magnetically hard materials were obtained in parametric planes: amplitude of external harmonic excitation versus hysteretic dissipation, one versus frequency of external harmonic excitation, dynamic oil-film action characteristics, as well as versus the magnetic control parameters. The amplitude level contours of the horizontal and vertical vibrations of the rotor were presented in the various control parameter planes. Phase portraits and hysteretic loops are in good agreement with the chaotic regions obtained.

References:

1. J. Awrejcewicz, L. Dzyubak, C.-H. Lamarque, Modelling of hysteresis using Masing–Bouc-Wen's framework and search of conditions for the chaotic responses, Communications in Nonlinear Science and Numerical Simulation 13, 2008, 939-958.
2. J. Awrejcewicz and L.P. Dzyubak, Chaos caused by hysteresis and saturation phenomenon in 2-dof vibrations of the rotor supported by the magneto-hydrodynamic bearing, International Journal of Bifurcation and Chaos 15(6) (2011) 2041-2055.