MAGNETOELASTIC DYNAMIC STABILITY OF FERROMAGNETIC PLATES WITH MAGNETIC AND MECHANICAL LOADINGS

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Different from conventional structures experienced to mechanical loadings, the electromagnetic structures usually are immersed in strong magnetic fields and subjected to mighty magnetic forces arising from the mutual influence between the applied magnetic field and the magnetization of ferromagnetic materials. The strong magnetic force leads to deformation of ferromagnetic structures, even to losing stability [1]. In some ferromagnetic structures, for example the first walls and blankets of fusion power reactors, there commonly coexist the magnetic loadings due to magnetization and eddy currents, as well as the electromagnetic structure subjected to mechanical loadings, such problems of the magnetoelastic interaction should be paid more attention both in research and in engineering design of electromagnetic equipments.

In this paper, we present the analysis of dynamic stability of magnetoelasticity for a soft ferromagnetic rectangular and simply supported plate immersed in an applied transverse magnetic field, as well as subjected to a mechanical loading of in-plane periodic compression. The fundamental equations for the ferromagnetic plate are developed including the effect of magnetoelastic interaction and magnetic damping. In the theoretical model, the expression of induced magnetic force is based on a magneto-elastic variational model [2], and the magnetic damping is due to the Lorentz body force arising from eddy current in the ferromagnetic material. By means of a linearized magnetoelastic theory and perturbation technique, the motion equation of the ferromagnetic plate is reduced to a damped Mathieu's equation and solved with a spectral collocation method [3,4].

The case study of the magnetoelastic dynamic stability of the ferromagnetic plate in absence of mechanical excitation compression is theoretically analyzed. It shows that there exist two stable states comprising magnetic damping stable oscillation and over-damped asymptotically stable motion before the divergence instability of the ferromagnetic plate occurs. The magnetic damping obviously affects the critical field, as the higher is the magnetic damping, the lower is the critical value. The dynamic stability regions for the parametric excitation of the magnetoelastic system with harmonically excited in-plane compression are discussed as well. The effect of magnetic damping and the excitation frequency of in-plane compression on the stability characteristics are simulated numerically which shows that the magnetic damping extends the stable regions of parametric excitation in a certain extent.

References

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