Magneto-Rheological Materials Dynamic Properties Investigation Using Refined Layer-Wise Theory

Bohdan Diveyev, Orest Horbay, Ihor Konyk, Ihor Velhan

Lviv Polytechnic National University
divboglviv@yahoo.com.

Magneto-rheological viscose elastomers (IRVE) are used in layered plates to control vibration. It is important to predict the dynamic characteristics of such elements, in particular the values of dynamic rigidity and energy dissipation - damping controlled by the applied magnetic field.

Dynamic characteristics of layered plates, consisting of rigid layers and internal layers with magneto-rheological (MR) properties, are considered. The influence of the magnetic field on the frequency and the coefficient of losses for different MR's of fillers and external layers of rigid materials and with different fixing of the plate is considered. A new method for accurate determination of dynamic properties determination in multilayered plates with cylindrical bending is presented. This method is adaptive and not based on rigorous assumptions about the model of the plate. The refined theoretical model describes the deformation of each layer, which takes into account the effects of transverse shear deformation, transverse normal deformation and nonlinear displacement changes along the thickness coordinate.

To determine the characteristics of layered compositions, various numerical schemes are used, which are usually closely correlated with known numerical models of the dynamics of composite layered plates. To study the dynamics of thin-walled elements, theories of increasingly high order are used. An important task is to determine the damping properties of structural elements, in particular thin-walled layered elements. In this paper, an adaptive algorithm is used on the basis of generalized kinematic approximations and the classical Galerkin method for the system of equations of linear theory of elasticity [1-4].

In order to determine damping in layered structures, "unified" calculation schemes are proposed in which the order of equations is not limited (an arbitrary number of approximations in the thickness of each layer of a plate is considered). The verification of this model with FEM is presented. On the basis of the specified calculation schemes, the influence of the magnetic field in the layered beam on its frequency spectrum and

damping is determined. A number of beams with different materials of MR and hard layers are considered: aluminum, copper, composite. The material of the MR layers is considered in four types. The first three are materials with frequency-independent parameters, the fourth one - with modules depending on the frequency and intensity of the magnetic field. Considered a cantilever and freely lined beam. Type 1 material is the least rigid and has the most damping, especially at higher frequencies. Materials type 2 and 3 are similar in properties and give similar dynamic characteristics for all types of beams with different hard layers. For material of type 4 - MRF 132DG comparable dynamic characteristics for three and five-beam beams is made. The five-layer beam has a slightly more damping from the three-layer material with similar distribution (the total thickness of MR layers and rigid layers is the same) at small magnetic fields.

REFERENCES

[1] B. M. Diveyev, M. M. Nykolyshyn Refined numerical schemes for a stressed-strained state of structural joints of layered elements // *Journal of Mathematical Sciences.* – 2011. – Vol. 107. – P. 3666-3670.

[2] Diveyev B., Butyter I., Shcherbyna N. High order theories for elastic modules identification of composite plates. Part 1. Theoretical approach // *Mechanics of Composite Materials*. – Vol.44, No.1. – 2008. – P. 25–36.

[3] Diveyev B., Butyter I., Shcherbyna N. High order theories for elastic modules identification of composite plates. Part 2. Theoretical-experimental approach // *Mechanics of Composite Materials*. – Vol.44, No.2. – 2008. – P. 139–144.

[4] Bohdan Diveyev, Solomija Konyk, Malcolm J. Crocker. Dynamic properties and damping predictions for laminated plates: High order theories – Timoshenko beam. *Journal of Sound and Vibration* 413 (2018) 173-190.