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THIN COMPOSITE SHELLS LIKE «SANDWICH» CONTAINING MAGNETORHEOLOGICAL ELASTOMERS: VIBRATIONS AND THEIR SUPPRESSION

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The vibroprotection of thin-walled structures experiencing an external vibrational load is a subject of great practical interest for mechanical engineers which design and model similar structures. The appearance of the group of new composite materials with active and adaptive properties, called smart materials, opens new possibilities for solving these problems [1]. Some of these composites are magnetorheological (MR) ones and, particularly, magnetorheological elastomers (MRE). They belong to the group of active materials which physical properties such as viscosity and shear modulus can vary when subjected to different magnetic field levels [2].

Laminated cylindrical shells and beams like «sandwich» formed by embedding MRE in between elastic layers are the subject of this study. Similar composite structures are very popular in aerospace and in many other industries due to their light weight and high- energy absorption properties of the MR layers.

The MRE are magnetizable particles molded in either rubbery polymers or deformed inorganic polymer matrices. The optimum weight/density ratio of magnetic particles, carrier viscous liquid and polymer determine shear modulus, viscosity and response time being the integral characteristics of a smart material. Physical properties of the MR layers are assumed to be functions of the magnetic field induction [3]. Because the influence of the magnetic field on all areas of the MR lamina is different [4], it is assumed inhomogeneity of physical properties of MRE.

In general case, the shell structure may be non-circular and not closed in the circumferential direction (cylindrical panel). A system of differential equations with complex variable coefficients depending upon the magnetic field [4], and based on both the assumptions of the generalized kinematic hypothesis for the whole «sandwich» [5] and experimental data for MRE [6], is utilized as governing one.

To analyze damping capabilities of adaptive materials, free vibrations of a three-layered beam [6] and circular cylinder containing interlayer MRE are studied at different levels of the magnetic field. Then the case when applied magnetic field results in nonuniformity of MRE is considered. Using the asymptotic approach [7], eigenmodes of free vibrations of the laminated noncircular cylindrical shell with variable physical characteristics of MRE are constructed in the form of functions decaying far from the weakest plot on the shell structure. It has been shown that applying constant magnetic field may result in strong localization of eigenmodes corresponding to low-frequency spectrum of free vibrations of the three-layered circular thin cylinder with embedded nonuniform MR layer. On the contrary, another example demonstrates capability of the magnetic field to skew and suppress the natural modes localized near the «weakest» line on the surface of three-layered noncircular cylindrical panel containing MRE. Dependencies of natural frequencies, damping decrement and parameter characterizing the power of the eigenmode localization upon the intensity of applied magnetic field are analyzed.

Finally, applying the asymptotic method developed in [8], the problem on soft suppression of localized vibrations running over the adaptive MR shell surface under the effect of the nonstationary magnetic field is studied.

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ASYMPTOTIC SOLUTIONS FOR THIN LAYERS IN ARTICULAR CONTACT

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Introduction. Biomechanical contact problems involving transmission of forces across biological joints are of considerable practical importance in orthopedic