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SOLUTION TO OPTIMIZATION PROBLEMS OF DYNAMIC PROPERTIES OF ELECTRIOVISCOELASTIC SYSTEMS WITH ELECTRIC RESONANT FILTERS

Evgeny P. Kligman [1], *Natalya A. Yurlova [1], Nikita F. Putin [1]

[1] Institute of Continuous Media Mechanics of Ural Branch of RAS (ICMM UB RAS)
Academician Korolev str.,1 Perm, 614013, Russia
yurlova@icmm.ru, http://www.icmm.ru

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ABSTRACT

An important role in the dynamic behaviour of mechanical systems is played by the damping capacity of a material, which leads to attenuation of free oscillations and considerable reduction in the resonant amplitudes of displacements and stresses under steady-state forced oscillation conditions.

The losses caused by the internal processes taking place in the material ("internal" friction) are considered to be the reason for energy dissipation in the deformed systems. The internal friction is related to the dissipative processes during oscillations generated in the material of a system. The dissipative characteristics of such systems can be improved by employing piezoelectric smart composite materials.

For this purpose, the piezocomposite elements embedded in the construction are connected with the passive RLC-circuits. The principle of vibration suppression is based on the conversion of mechanical energy to electric energy followed by its scattering in the form of heat in the external damping RLC-circuits. In this case, the specialized electric circuits are able to provide maximal suppression of oscillations at specific frequency. The effective damping at resonant frequencies corresponding to different vibration modes can be realized with the aid of an appropriate set of damping RLC-circuits. A necessary condition for initiation of this mechanism of vibration suppression is the absence of the mutual influence of damping RLC-circuits tuned to their resonant frequencies. The latter can be achieved through incorporation of electric resonant filters into the circuits. At specific frequencies, these filters will "turn on" some damping RLC-circuits and "turn off" the others, i.e., they will accomplish electronic frequency-dependent commutation.

The quantitative assessment of the dissipative properties of constructions (their ability to dissipate energy) can be obtained from the solution of the uniform non-conservative spectral problem. The spectral problem of electro-viscoelastic systems with general-form passive electric circuits has a number of special features. The use of the final elements method (FEM) for its solution leads to a non-standard algebraic eigenvalue problem [1-2].

The obtained complex eigenvalues of the problem define the resonant frequencies and the damping indices of a system. The complex eigenfunctions define the oscillation modes and phases. The calculation of eigenvalues poses computational difficulties related to, in particular, the significant order of the system. The problem can be solved by the method of main coordinates, for which purpose the algorithm has been developed relying on the Ritz method. As a basis, the natural oscillation modes of a corresponding electroelastic body without external electric circuits are used. The basis can be constructed with the aid of commercial finite element software programs, for example, ANSYS. The order of a system of equations in this formulation will be much lower than in the initial problem.

The improvement of the damping capacity of this system can be made changing the parameters of external RLC-circuits. SMART-materials with external electric circuits can be used most efficiently for solving the optimization problem of dynamic properties of constructions. The optimization algorithm of the problem has been developed based on the sensitivity analysis [3-5]. As the desired parameters (design variables), the vector involving the values of capacitances, inductances and impedances of resistors of external circuits is taken.

The solution of some example problems using the proposed approach showed its high efficiency.

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