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Composites with Improved Absorption of Noise and Vibration

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Abstract—The development of composites based on thermosetting resins with improved vibration and noise absorption is considered. Mathematical and topological models are proposed to describe the influence of the composition on the vibration and noise absorption and elastic properties of the composites. The composition of filled epoxy, polyester, and polyurethane vibration-absorbing composites is optimized in terms of their loading, dynamic, and economic characteristics.

Keywords: composites, vibration and noise absorption, thermosetting resins, mathematical models, topological models

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For manufacturing today, we need new composites, including those with special properties [1–18].

The periodic vibrations and noise that arise in cutting impair product quality, as well as working conditions (noise levels above 70 dBA). Therefore, it is important to develop materials capable of vibration and noise absorption for use in machine tools [2].

In the construction industry, noise levels are effectively reduced by using parts or coatings with open porosity (hydroconcrete, Antivibrit paste). Because of their unsatisfactory combination of vibration and noise absorption, strength, and deformability, such materials are not widely used in construction and manufacturing. However, composites with the required properties may be obtained by appropriate selection of thermosetting resin, modifiers, and fillers and by optimization of the composite structure [2].

The classical theory of vibrationally insulating suspensions employs a standard formula from elasticity theory for a vibrational machine with a single degree of freedom [3]

$$\alpha = \frac{F_0'}{F_0} = \sqrt{\frac{1+\frac{\gamma^2}{Q^2}}{\left(1-\gamma^2\right)^2+\frac{\gamma^2}{Q^2}}} = \sqrt{\frac{1+\gamma^2\left(Q'^{-1}\right)^2}{\left(1-\gamma^2\right)^2+\gamma^2\left(Q'^{-1}\right)^2}}, \quad (1)$$

where α is the damping factor; F_0' is the amplitude of the force on the transmitting structure; F_0 is the amplitude of the external force (a constant); Q is the Q-factor; Q'^{-1} is the loss factor (inversely proportional to the Q-factor, with a value less than 0.1); $\gamma = p/\omega$; ω is the frequency of the perturbing forces from the vibration source; and p is the eigenfrequency of the composite.

It follows from Eq. (1) that a vibration-damping composite with $\alpha < 1$ may only be used when $\gamma > \sqrt{2}$. The intervals obtained are limiting values in the development of mathematical models for optimization of the structure and properties of the sound-absorbing composites with effective resistance to vibrational loads.

We investigate epoxy and polyester composite. The matrix materials employed are as follows: ED-20 epoxy resin (State Standard GOST 10587–84); dibutyl phthalate (State Standard GOST 8728–88); polyethylene polyamine (Technical Specifications TU 2413-357-00203447–99; 540-M888 polyester resin; Peroxide 1 (a solution of methyl ethyl ketone peroxide in dimethyl phthalate); a simple polyester (Sarel A-04); and polyisocyanate (Sarel B-04). The fillers in the composites are as follows: diabase (ρ_f = 2900 kg/m^3, S_{sp} = 250 m^2/kg); casting waste (ρ_f = 3100 kg/m^3, S_{sp} = 250 m^2/kg); Aerosil A300 (S_{sp} = 300 m^2/kg); and claydite (ρ_f = 2650 kg/m^3, S_{sp} =