STABILIZATION OF LAMINAR AND TURBULENT FLOWS BY SANDWICH-TYPE COATING

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Fluid flows in distensible tubes are characterized by a number of unstable modes and flow stabilization is an important problem for the fluid motion in the tubes of the heat and mass exchangers; the artificial heart, oxygenators and other biomedical devices; microfluidic and nanofluidic cells [1–3]. Flow instability in compliant ducts serves as a cause of flow- and pressure-limitation effects, high-frequency wall oscillations, noise generation, damage of the innermost layer (endothelium) of the blood vessel wall (endothelium thickening), and sound transmission in veins, airways, larynx and glottis. Many important problems of the blood flow through stents and grafts, collapse of airways and apnea in snorers, speech generation and others are determined by the flow interaction with compliant walls and flow instability. Therefore, keen understanding of the mechanics of those instabilities and the precise control over them is needed. In this study a review of the proposed methods of the steady laminar and developed turbulent flows in tubes by means of a proper choice of the rheological parameters of the multi-layer sandwich-type coating is given. The previously elaborated approaches [4–15] as well as some novel results are presented.

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NONLINEAR NORMAL MODES IN SYSTEMS WITH PENDULUM ABSORBERS

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Dynamics of systems containing the pendulum absorber is considered by using the nonlinear normal modes (NNMs) approach. The pendulum systems are classical models on nonlinear dynamics. Besides, it is known numerous applications of such systems in engineering, in particular, in vibro-absorption problems. Here the Kauderer–Rosenberg concept of nonlinear normal modes in combination with some analytical–numeric procedures is used to construct the NNMs and to analyze their stability for two models: the two-DOF system containing the pendulum absorber (Fig.1), and the three-DOF non-ideal system having the pendulum absorber (Flg.2).

In these systems two nonlinear vibration modes can be selected: a) the coupled vibration mode when the vibration amplitudes of the pendulum and the elastic subsystem have the same order; b) the localized vibration mode when the pendulum vibration amplitudes are essentially larger than ones of the elastic subsystem. The last mode is appropriate for absorption of vibrations of the elastic subsystem.

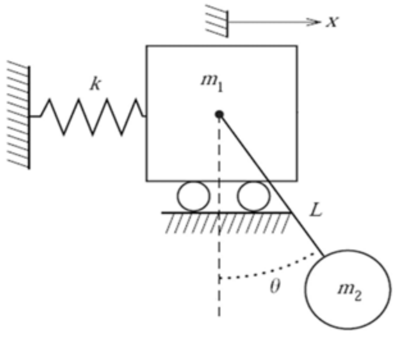

Fig. 1. Mechanical system having the pendulum absorber.

Trajectories of the nonlinear vibration modes in configuration space of the systems are determined by power series. Analysis of the NNMs stability is made by the Hill determinants method and the numerical–analytical method which is a consequence of the classical definition of stability by Lyapunov. Analysis of the modes stability shows that the regions of instability of the localized vibration modes are very narrow for both systems under consideration. So, the localized vibration modes are effective for absorption of elastic vibrations.

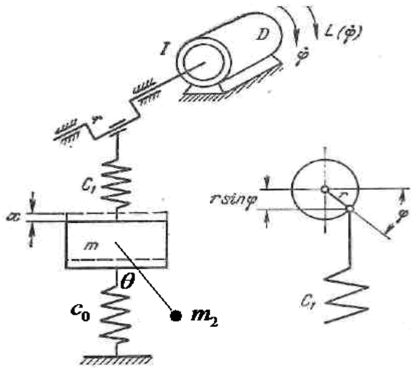

Fig.2. The non-ideal system with pendulum absorber.

Nonlinear normal modes of forced vibrations in the first mechanical system can be obtained by combination of the Kauderer–Rosenberg NNMs approach, and the Rauscher method, modified for n-DOF systems. The modified Rauscher method permits to transform the non-autonomous system to the "pseudo-autonomous" one. In the considered autonomous system the NNMs are constructed. Frequency responses for the NNMs are obtained.

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SINGLE-COMPONENT SURFACE WAVES AND VOLUME VIBRATIONS IN CUBIC CRYSTALS

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Existence of a boundary in a crystal changes significantly the atomic dynamic of the near-surface atoms and makes surface waves to excite. These waves are highly sensitive to surface properties, both for free-surface case and when there is an adsorbed monolayer on the surface. The pure shear surface waves with horizontal polarization (SH-waves) [1,2] show a significant sensitivity comparing with the wide-known Raleigh waves[3].

In the present report taking into account the interactions between the nearest and next-nearest neighbours, dispersion relations of volume and surface vibrations for pure shear waves are carried out in cases of (001), (110) and (111) surface orientations in simple cubic (SC), face-centered cubic (FCC) and body-centered cubic (BCC) free-surface crystals. In addition, we consider an impurity monolayer adsorbed on the crystal surface.

We study both cases when the monolayer consists of lighter atoms than those the crystal has, and having heavier ones. For the lighter atoms, consideration is given to $m_0/m = 1/2$ and $m_0/m = 1/5$; for heavier atoms we study $m_0/m = 2$ and $m_0/m = 5$ (here m_0 is a mass of the each impurity atom in the adsorbed monolayer, *m* is a mass of the each host atom). In case of interaction only between the nearest neighbours in the SC (001), surface waves do not exist. They appear either when accounting for the interaction with more distant neighbours, or if there is an adsorbed surface monolayer. Surface waves dispersion relation curve splits off the upper boundary of the continuous spectrum in case of heavy impurity atoms and it splits the lower limit in case of light ones. Herein, surface waves amplitude decreases monotonously in case of heavy atoms; in case of light ones amplitude decrease is oscillating (but not monotonous). It is shown that a gap within continuous spectrum and surface waves appear if $m_0/m = 11$. Additionally, we carry out the analysis of surface waves characteristics of a crystal within which long-range interaction is also considered and there is an adsorbed monolayer on its surface.

Finally, we study volume vibration bands when the next-nearest neighbours interaction is taken into account. It is shown that consideration of long-range interaction changes the form of volume vibration band. For SC with (001) orientation surface volume vibration