FORCED VIBRATION OF THE HYDRO-VISCOELASTIC (HYDRO-ELASTIC) SYSTEMS CONSISTING OF THE VISCOELASTIC (ELASTIC) PLATE, COMPRESSIBLE VISCOUS FLUID AND RIGİD WALL (REVIEW)

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ABSTRACT

This paper gives review of the investigations related to the forced vibration of the hydro-viscoelastic as well as of the hydro-elastic systems consisting of elastic or viscoelastic plate, compressible viscous fluid and rigid wall. The sketch of this system in some particular case is given in Fig. 1.

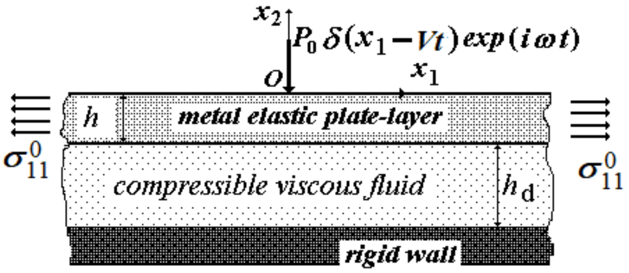

Fig.1. The sketch of the system under consideration

The investigations carried out for the fluid loading cases are also reviewed and under this review the main attention is focused on the studies made by authors. Note that in these investigations the motion of the plate is written by employing three-dimensional linearized equations of wave propagation in elastic and viscoelastic bodies with initial stresses, however the equations of flow of the compressible viscous fluid is described by employing the linearized Navier-Stokes equations. It is assumed that the plane strain state in the Ox_1x_2 plane occurs in the plate and the fluid flow is plane-parallel one and suppose that the plate occupies the region $\{|x_1|<\infty,\ -h<x_2<0\}$, but the fluid occupies the region $\{|x_1|<\infty,\ -h_d<x_2<-h\}$. Within these assumptions we write the field equations for the constituents of the system in the case where the plate material is purely elastic.

For the plate

$$\frac{\partial \sigma_{11}}{\partial x_1}+\frac{\partial \sigma_{12}}{\partial x_2}+\sigma_{11}^{0}\frac{\partial^2 u_1}{\partial x_1^2}=\rho\ \frac{\partial^2 u_1}{\partial t^2},\ \frac{\partial \sigma_{12}}{\partial x_1}+\frac{\partial \sigma_{22}}{\partial x_2}+\sigma_{11}^{0}\frac{\partial^2 u_2}{\partial x_1^2}=\rho\ \frac{\partial^2 u_2}{\partial t^2}.$$

$$\sigma_{11}=(\lambda+2\mu)\varepsilon_{11}+\lambda\varepsilon_{22},\ \ \sigma_{22}=\lambda\varepsilon_{11}+(\lambda+2\mu)\varepsilon_{22},\ \ \sigma_{12}=2\mu\varepsilon_{12},$$

$$\varepsilon_{11}=\frac{\partial u_1}{\partial x_1},\ \varepsilon_{22}=\frac{\partial u_2}{\partial x_2},\ \varepsilon_{12}=\frac{1}{2}\left(\frac{\partial u_1}{\partial x_2}+\frac{\partial u_2}{\partial x_1}\right). \qquad (1)$$

For the fluid flow

$$\rho_0^{(1)}\frac{\partial v_i}{\partial t}-\mu^{(1)}\frac{\partial v_i}{\partial x_j\partial x_j}+\frac{\partial p^{(1)}}{\partial x_i}-(\lambda^{(1)}+\mu^{(1)})\frac{\partial^2 v_j}{\partial x_j\partial x_i}=0,\qquad \frac{\partial \rho^{(1)}}{\partial t}+\rho_0^{(1)}\frac{\partial v_j}{\partial x_j}=0,$$

$$T_{ij}=\left(-p^{(1)}+\lambda^{(1)}\theta\right)\delta_{ij}+2\mu^{(1)}e_{ij},\theta=\frac{\partial v_1}{\partial x_1}+\frac{\partial v_2}{\partial x_2},\quad e_{ij}=\frac{1}{2}\left(\frac{\partial v_i}{\partial x_j}+\frac{\partial v_j}{\partial x_i}\right).\ a_0^2=\frac{\partial p^{(1)}}{\partial \rho^{(1)}}\ . \quad (2)$$

where $\rho_0^{(1)}$ is the fluid density before perturbation. The other notation used in Eq. (2) is also conventional. The meaning of the equations (1) and (2) and notations used in those are explained in the References [1 – 10].

The following boundary and contact conditions are satisfied.

$$\sigma_{21}\big|_{x_2=0}=0,\sigma_{22}\big|_{x_2=0}=-P_0\delta(x_1-Vt)e^{i\omega t},\ \frac{\partial u_1}{\partial t}\bigg|_{x_2=-h}=v_1\big|_{x_2=-h},\ \frac{\partial u_2}{\partial t}\bigg|_{x_2=-h}=v_2\big|_{x_2=-h},$$

$$\sigma_{21}\big|_{x_2=-h}=T_{21}\big|_{x_2=-h},\ \sigma_{22}\big|_{x_2=-h}=T_{22}\big|_{x_2=-h},\ v_1\big|_{x_2=-h-h_{\mathrm{d}}}=0,\ v_2\big|_{x_2=-h-h_{\mathrm{d}}}=0. \qquad (3)$$

Thus, in the present paper the results obtained within the scope of the equations (1) – (3) and published in the works [1 – 9] are discussed. The cases where $\{V=0;\ \omega\neq 0\}$, $\{V\neq 0;\ \omega=0\}$ and $\{V\neq 0;\ \omega\neq 0\}$are considered separately. Moreover, the cases where the plate material is a viscoelastic one and this viscoelasticity is described by the fractional exponential operators by Rabotnov are also considered.

Under numerical investigations the main attention is focused on the determination of the influence of the fluid viscosity and compressibility of the frequency responses of the interface stresses and flow velocities of the fluid. In particular, it is established that the magnitude of the influence of the fluid velocity on the absolute values of the mentioned quantities increases with decreasing of the ratio $h_d/h,$ i.e. with decreasing of the fluid depth under fixed plate thickness. Moreover, it is established the cases where the influence of the fluid compressibility on the frequency responses is considerable.

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