CALCULATION EFFECT OF INTERNAL EXPLOSION ON ENCLOSED CYLINDRIC SHELL

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When constructing liquid hydrogen cold neutron sources (CNS) a special attention should be paid to their operational safety. The CNS protective shell would withstand the possible explosion of air-hydrogen mixture. As a rule, vessel deformation due to explosive action is defined from one-dimensional vibration equation [1]:

$$\ddot{u} + b\,\dot{u} + w^2 u = pe^{-tv}. \tag{1}$$

However, this equation does not describe such phenomena as increasing system vibrations, beating, boundary effects and so on. As it is shown in experiments, these phenomena are able to increase the maximum enclose deformation up to $3 \div 5$ times.

To obtain more precise information calculations of enclose deformation both in air and in water have been carried out. Models based on the Kirkhoff–Liava and Timoschenko hypotheses have been used [2].

Mathematical approach

The calculations have been performed for enclosed thin cylindric shells with spherical bottoms. The shell movement was described by the Kirkhoff–Liava-type equations including non-linear terms. A liquid, the shell is dipped into, is non-viscous one, the processes have an acoustic

nature. The equations describing the liquid flow are linear ones relatively to the rest state. For the non-vortex flow they have the wave equation form for velocity potential:

$$v = \nabla\phi, \quad \nabla^2\phi - \frac{1\partial^2\phi}{c^2\partial\tau^2} = 0.$$

The dimensionless equations of shell movement in the moving varia bles have a form:

$$\frac{\partial^2 u}{\partial x^2} + \frac{1-\nu}{2}\frac{\partial^2 u}{\partial y^2} + \frac{1+\nu}{2}\frac{\partial^2 v}{\partial x \partial y} + (k_x + \nu k_y)\frac{\partial w}{\partial x} + \frac{p_x}{h} - \frac{\partial^2 u}{\partial \tau^2} + \text{Н.Ч.} = 0,$$

$$\frac{\partial^2 v}{\partial \tau^2} + \frac{1-\nu}{2}\frac{\partial^2 v}{\partial x^2} + \frac{1+\nu}{2}\frac{\partial^2 u}{\partial x \partial y} + (k_y + \nu k_x)\frac{\partial w}{\partial y} + \frac{p_y}{h} - \frac{\partial^2 v}{\partial \tau^2} + \text{Н.Ч.} = 0,$$

$$\frac{h^2}{12}\nabla^4 w - (k_y + \nu k_x)\frac{\partial v}{\partial y} + \left(k_x^2 + k_y^2 + 2\nu k_x k_y\right) w,$$

$$-\frac{k_x + \nu k_y}{2}\left(\frac{\partial w}{\partial x}\right) - \frac{k_y + \nu k_x}{2}\left(\frac{\partial w}{\partial y}\right) - \frac{q}{h} + \frac{\partial^2 w}{\partial \tau^2} + \text{Н.Ч.} = 0,$$

In the case of solving the hydroelasity full task: $q = P(t) + \rho\frac{\partial\phi}{\partial\tau}$ Together with the non-leakage $\frac{\partial\phi}{\partial\tau_{r=R}} = w$ and boundary conditions these equations make the hydroelastic problem enclosed.

The finite difference method in the form of non-explicit difference scheme, the modification of scheme [3], is employed for solving the equations. A run procedure with the iterations is used on each step of the solution [4]. The algorithm is employed in NDP FORTRAN codes.

The basic results

1. The results obtained for different variants of stressing the cylindric shells with the spherical bottoms show that in the experiments with the explosive chambers registed stress oscilograms describing the increase of amplitude of beating are the beating — the result of the close-frequency harmonics addition. A good agreement with the experiments is found out in the ratio of the maximum reached amplitude to the one of the first half wave: $\varepsilon_{\max}/\varepsilon_1 \approx 2.4 - 2.5$ [5]. The localization of the maximum amplitudes is noticed in the vicinity of the bottoms. In these regions this fact can evidently be explained by summation of a great number of equally possible forms of vibrations.

2. Comparability of absolute values of flexural and longitudinal stresses, observed in a lot of considered manners of stressing, makes to necessarily take into account multi-dimension of the stress-deformed state in the sense of effective stresses, developing in a shell.

3. When calculating a round plate, one side of which contacts with water and on the other one the plane wave falls down, a good agreement of qualitative picture of pulsations in the central point of plate and a satisfied agreement of the values of the amplitude stresses with the data [6] have been found. Characteristic high-frequency pulsations are connected with longitudinal deformations. No satisfactory explanation of the results [6] is is possible to obtain with the help of equation 1.

4. It has been shown that the stressing asymmetry for the air located shell leads to the significant increasing the vibration amplitude due to increasing the quantity of the valid harmonics in the spectrum of the asymmetrical vibrations (the spectral density of the asymmetrical vibrations for the cylindrical shell is higher then that of the symmetrical ones).

5. In general, the calculations show that for both air located shells and water located ones the utilization of the proposed model of calculating makes it possible to obtain satisfactory agreement with the experiment.

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