MATHEMATICAL AND COMPUTER SIMULATION OF THE RESPONSE OF AIRCRAFT COMPOSITE ELEMENTS TO IMPACT LOADING

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Laminated aviation structures are designed to be resistant to hail [1]. But physical tests are very expensive. Therefore, the main method of checking the strength of aircraft elements during their design is mathematical modelling. The present work suggests an analytical approach to investigating vibrations of laminated orthotropic elements of aircraft structures under impact by hail.

We consider aircraft elements as non-closed cylindrical shells with a complicated form in the plan view. Impact loading of a shell is carried out by an indenter, which is dropped on the shell from a certain height. The dynamic behaviour of the shells is described by the first-order theory accounting for transverse shear strain, thickness reduction and normal element rotation inertia in each layer. The motion equations are added by the indenter equation of motion and the condition of joint displacement of the indenter and shell. Contact approach is found by solving Hertzian problem.

The analytical solution of the problem is derived by the immersion method [2]. According to this method, a complex-shape laminated shell is immersed into an auxiliary enveloping shell with the same composition of layers. An auxiliary shell is one whose contour shape and boundary conditions yield a simple analytical solution. In this case, the auxiliary shell is a simply supported rectangular laminated one, allowing to find the problem solution as trigonometric series. To satisfy actual boundary conditions, the auxiliary shell is subjected over the trace of the initial boundary to additional distributed compensating loads. The compensating loads are found from the system of integral equations which results from the system of actual boundary conditions. The system of motion equations of shells is integrated by expansion into Taylor series. After computing the values of intensities of compensating loads, the required parameters of the shell dynamic response are found.

The method potentialities are demonstrated by calculating stresses in three-layer and five-layer orthotropic shells with different boundary conditions. A good match of results obtained by different methods confirms the feasibility and effectiveness of the method offered.

Reference:

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