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Smetankina N.¹, Misiura Ie.², Misiura S.^{1,3}

(¹Anatolii Pidhornyi Institute of Power Machines and Systems of the NAS of Ukraine, Kharkiv; ²S. Kuznets KhNUE, Kharkiv; ³NTU “KhPI”, Kharkiv)

**DEFORMATION MODELING OF COMPOSITE PLATES WITH
COMPLEX SHAPE UNDER IMPACT LOADING**

E-mail: misuraeu@gmail.com

The widespread use of structures made of composite materials is due to their improved, relatively homogeneous characteristics. Due to their high strength properties combined with low weight, composite materials are widely used in space, aircraft and shipbuilding, and transport engineering [1, 2]. The issues of static deformation of composite structural elements and their free oscillations are the most studied [3]. Transient processes in such structures are less studied [4, 5]. The complication of the operating conditions of modern composite structures associated with impulse and shock loads, the variety of shapes of structural elements, and the use of new materials lead to the fact that the development of methods for solving problems on the stress-strain state of composite elements of arbitrary shape is an urgent problem of structural dynamics.

A methodology is proposed for studying the processes of unsteady deformation of layered composite elements of aerospace structures under impulse loading and impact with a solid body. The elements are considered that are made in the form of plates with a complex plan form. The plate consists of orthotropic layers of constant thickness and occupies a single-connected region on the coordinate plane, which is bounded by a curved contour. It is assumed that the Timoshenko type hypothesis is fulfilled for the package of layers. The stresses in the layers are determined by Hooke's law for an orthotropic body.

Forces and moments are determined by integrating the corresponding components of the stress tensor along the thickness of the plate or shell.

The equations of motion of the structural element and boundary conditions are derived from the variation principle. When solving the problem of impact interaction of the indenter with the structure, the system of equations of motion is supplemented by the equation of motion of the indenter, as well as the condition of joint displacement of the indenter and the structure. The contact interaction is taken into account with the modified Hertz's law. The problem of the dynamics of a layered plate of arbitrary shape is solved by the immersion method [1]. As a result, the problem is reduced to solving a system of ordinary differential equations of the second order for the coefficients of the expansion of the displacement functions into Fourier series. The resulting system is integrated by expanding the solution into a Taylor series. After determining the compensating loads, the displacements, deformations, and stresses in the layers of the plate are calculated.

As a representative example, the vibrations of a pivotally supported three-layer plate of orthotropic layers under impact with an indenter in the form of a steel ball are studied. The shape of the plate plan is defined by the Lamé equations. The impact is applied from the outer surface of the first layer of the plate. A comparison of the results of the calculation of deflections and normal stresses with the results obtained using the finite element method showed their good agreement, confirming the reliability of the results. Despite the high level of impact load intensity, the stresses did not exceed their permissible values, which makes it possible to predict the performance and reliability of such an element during its operation under real load conditions.

Thus, a methodology has been developed for studying transients in laminated composite plates with a complex plan form that takes into account the geometry of the region at the analytical level, which increases the accuracy of the obtained results. The proposed methodology can be applied in the design of layered composite structural elements for aerospace and ground vehicles subjected to the influence of unsteady loads.

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