STRENGTH ANALYSIS OF COMPOSITE STRUCTURES UNDER IMPACT LOADING

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Пропонується методика дослідження міцності шаруватих композитних елементів конструкцій сільськогосподарської техніки при ударі жорстким тілом, заснована на методі занурення.

Unsteady processes in structural elements can be caused by short-term intense loads of various nature [1–3]. The complication of the working 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 plates and shells of arbitrary shape is an urgent problem of structural dynamics [4, 5].

The paper proposes a methodology for studying the strength of laminated composite elements of agricultural machinery structures under impact with a solid body. The laminated elements are considered, which are made in the form of plates with a complex plan form consisting of orthotropic layers of constant thickness. The plate is assigned to the Cartesian coordinate system associated with the outer surface of the first layer and occupies a one-connected region on the coordinate plane 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 [6, 7]. The forces and moments are determined by integrating the corresponding components of the stress tensor along the thickness of the plate.

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 and a shell of arbitrary shape is solved by the immersion method [8, 9]. As a result, the problem is reduced to solving a system of ordinary differential equations of the second order with respect to the coefficients of the expansion of displacement functions into Fourier series. The resulting system is integrated by expanding the solution into a Taylor series.

As a representative example, the vibrations of a three-layer plate of orthotropic layers under impact with an indenter in the form of a steel ball are investigated. The impact is applied from the outer surface of the first layer of the plate. The shape of the plate plan is described by the Lame equations. Comparison of the results of the calculation of deflections and normal stresses with the results obtained by the finite element method showed their good agreement, which confirms 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 reli-

ability of such an element during its operation under real load conditions.

Thus, a methodology has been developed for studying transients in layered composite plates with a complex planform, which takes into account the geometry of the region at the analytical level, which increases the accuracy of the results obtained. The proposed methodology can be used in the design of laminated structural elements of agricultural machinery under unsteady loads of various nature.

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