load conditions, and also the rate of their movement after separation. Not only the energy spent in the formation of the fracture surface, but also the work of deformation of the spalled element enter into the work of separation.

The results of the measurement indicated that $E_{\text{sep}} \gg E_f$, i.e., the possibility of the separation of a spalled element of small dimensions is determined primarily by the energy outlays for its deformation to failure. During one-dimensional deformation in the wave stage, the energy expended in the material's deformation are small during spalling. Further development of the process is accompanied, however, by the curvature and thinning of the spalled element, as a result of which the total energy consumption is significant.

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LITERATURE CITED


SPALLING IN A TWO-LAYER PLATE UNDER AN IMPACT LOAD

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A two-dimensional model of a damaged medium is examined. The model is implemented numerically on the basis of Wilkin's method with modifications that take into account the introduction of damages. The impact loading of a two-layer iron and aluminum target is modeled numerically using the developed model of a damaged medium. The results of analysis of target damage are presented.

Problems of the multidimensional modeling of the failure of homogeneous and laminar structures in stress waves are becoming increasingly urgent with development of the theory of spalling failure [1, 2]. Two- and three-dimensional modeling of spalling failure can be accomplished by introducing a scalar measure, as in cases of one-dimensional methods. By its own nature, this approach assumes the isotropic character of the failure process; this is not always observed during spalling. As a rule, microfailures are oriented in space on the one hand [3], and their rate of growth may also have an anisotropic character on the other [4]. Hence follows the need to introduce damage characteristics that differ from the scalar characteristic.

Nikiforovskii [4] previously generalized the model of a damaged medium for the two-dimensional case. A symmetric damage tensor of second rank $\mathbf{E}$ is introduced to describe the
growth and accumulation of damages. The tensor \( \Xi \) can be considered the sum of the tensors \( \Xi = \Xi_i \), each of which is represented in the form \( \Xi_i = \xi_i \left( \hat{n}_i \times \hat{n}_i \right) \), where \( \xi_i \) is the relative bulk content of microdamages \( \xi_i = V_i / V \), that appear and develop in the planes defined by the unit vector \( \hat{n}_i \). In the case of ductile failure (with pores), it is assumed that the direction of the unit vector \( \hat{n}_i \) is related to the direction of preliminary production rolling. For brittle failure, the direction of the unit vector is orthogonal to the plane of the \( i \)-th microcrack.

The basic equations employed in the two-dimensional model of a damaged medium (laws of mass, impulse, and energy conservation), can be written in integral form in terms of averaged values of the density \( \rho \), the tensor of the stresses \( \sigma_{ij} \), and the specific internal energy \( e \):

\[
\frac{d}{dt} \int_{V(t)} \rho dV = 0; \quad \frac{d}{dt} \int_{V(t)} \rho \dot{x}_i = \int_{\Sigma(t)} \sigma_{ij} n_j d\Sigma;
\]

\[
\frac{d}{dt} \int_{V(t)} \rho (e + \dot{x}^2/2) dV = \int_{\Sigma(t)} \sigma_{ij} \dot{n}_j d\Sigma,
\]

where \( t \) is time, \( V(t) \) is the separated volume bounded by the surface \( \Sigma(t) \), \( \dot{x}_i \) are the velocity components, and \( n_j \) are the direction cosines of the external normal of the volume under