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PROTECTION OF STRUCTURES AGAINST LONG PROJECTILES

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ABSTRACT

The study of the problem of protecting the elements of constructions from impact loadings is very important due to the constant perfection of the means of shock-wave impact on the objects of modern technology. This paper considers the interaction of a projectile with spaced ribbed and uniform plates. This approach leads to the fragmentation of the projectile and then to the deviation from the surface of the target.

Keywords: high-velocity projectiles, fracture, fragmentation, probabilistic approach.

INTRODUCTION

At present, structural elements can be protected against high-intensity dynamic loads (impact, explosion) using the approaches as follows: the stretching of pressure pulses in layered fillers by multiple reflection of waves from layers with different acoustic impedances and the energy dissipation of pressure pulses during the plastic deformation of highly porous fillers or the fragmentation of ceramic materials (Gerasimov, 2013). It is of interest to use porous and functionally gradient materials (FGM) as protective layers in layered systems. These materials with a continuous change in physical and mechanical characteristics in certain directions consist of discrete-continuous layers with the increasing or decreasing values of acoustic impedances for the case when the number of layers is increased. One of the parameters which are varied in the chosen direction can also be the porosity of a protective layer. FGMs are characterized by a continuous change in composition in a specified direction and are the mixed materials, the component concentration of which is spatially distributed according to a certain law (Gerasimov, 1999). It should be noted that in addition to the use of high physical and mechanical properties and peculiarities of a material structure in protective systems, there are a number of constructive methods which increase the protection of ground and space objects. One of such methods for the protection of ground objects against high-velocity projectiles is the throwing of spaced systems containing plates and rods from traditional and composite materials towards projectiles (Gerasimov, 2016). The intensive dynamic interaction leads to the deformation and partial fracture of projectiles, as well as to the deviation from the impact line. As a result, a projectile either ricochets from the surface of a target or deviates from a protected object and does not interact with the target. The deformation and fracture caused by the interaction with a target reduce the penetrating capability of the projectile and the probable damage to the main body of the protected object.

RESULTS AND CONCLUSIONS

A 3-D problem is solved considering the heterogeneity of the real material structure that influences on the distribution of physical and mechanical characteristics over the volume of structural elements and is one of the factors determining the nature of fracture. To consider this factor in the equations of deformable solid mechanics, it is necessary to use probability laws for the distribution of physical and mechanical characteristics over the volume of the structure.

The fracture of real materials is largely determined by the internal structure of the medium, heterogeneities usually caused by the different grain orientation in polycrystalline materials or heterogeneities in the composition of composite materials, and the different micro-strength within the grain and at the intergranular or interphase boundary. Solving 3-D problems requires the consideration of natural heterogeneities in the real material structure that influences on the distribution of physical and mechanical characteristics over the volume of structural elements and is one of the factors determining the nature of fracture.

The technique for the calculation of elastoplastic flows uses tetrahedral cells and is based on the combination of the Wilkins method for the calculation of internal body points and the Johnson method for the calculation of contact interactions (Gerasimov, 2016). A three-dimensional region is divided into tetrahedrons by using the numerical codes for the automatic construction of a mesh.

The results of the interaction of a projectile with spaced ribbed and uniform plates are shown in Figure 1. This approach leads to the fragmentation of the projectile and then to the deviation from the surface of the target.

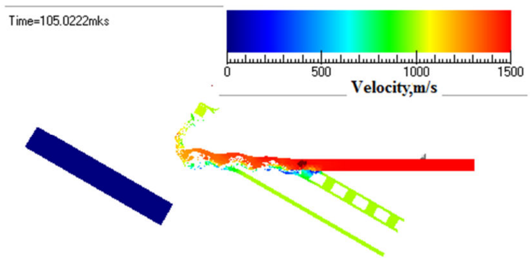

Fig. 1 - Interaction of a projectile with spaced ribbed and uniform plates

The calculations proved that the proposed approach and a numerical method developed on its basis enable to simulate interactions of high-velocity long projectiles with protection systems in a wide range of velocities and collision angles and to investigate the processes of projectile and barriers fragmentation, as well as the nature of the emerging fragmentation fields.

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