MODELLING OF THE PROCESS PENETRATION OF STEEL BARRIERS BY ELONGATED IMPACTORS

Maxim Yu. Orlov(*)†, Victor P. Glazyrin, Yuriy N. Orlov, Vlad. V. Golubatnikov
Tomsk State University, Tomsk, Russia
(*)Email: orloff_m@mail.ru

ABSTRACT
This paper presents the experimental and theoretical results of penetration through a multilayer barrier. Impactors were elongated metal rods with ogival head part. The initial speed ranged between 400 and 700 m/s. Experiments on penetration the impactor to a steel barrier were considered. Theoretical studies carried by numerical Lagrangian method. The process of penetration three-layer targets by elongated impactor was studied.

Keywords: impactor, penetration, plate, impact, destruction.

INTRODUCTION
At the moment the development of new protective structures is essential for civil and military applications. Of particular interest are multi-layer systems of different materials, including: steel, aluminum, ceramics, functionally graded materials, etc. (Glazyrin, 2006). A distinguishing feature of any multilayer structure is that it retains the specific properties of the layers, but it has new individual properties. Quite often there is the problem of the strengthening of the protective properties of existing structure. There is a need in the selection method of bonding layers. Therefore, the numerical simulation involved to optimize the thickness of layers (Kima, 2016).

The aim of the work is the study of the process penetration through homogeneous and multilayer barriers. The impactors were elongated metal rods with the ogival head parts. The barriers were homogeneous steel plates and three-layer steel plates. Initial impactor velocity ranged between 400 and 700 m/s. The current study consists of experimental and theoretical parts. The plumbeum impactor shock on steel plate is studied in the experimental part. It is found that after the loading impactor was damaged badly. It was revealed that the hole in the barrier was 1.5 times greater than the diameter of the impactor. In the theoretical part of research the penetrating through multilayer barriers by projectile with ogival head part was simulated.

Twenty of calculations variants were considered. Projectile penetration analysis was carried out. The time inception of the first sources of material destruction, densification of the material, hydrostatic pressure, deviatoric stress, projectile velocity history, residual displacement layer, the gap between the layers, ballistic limit are calculated (Glazyrin, 2010).

Mathematical model of the process is based on phenomenological macroscopic model of continuum mechanics. Behavior of material is assumed as elastic plastic. Governing equations is based on the fundamental laws conservation for: mass, momentum and energy. The numerical solution is carried out in two-dimensional statement for the axial symmetry by G.R. Johnson's modified method. This method is lagrangian and it allows to solve the problem of
deep penetration for heterogeneous structures, including modern safety ones. The modification of the method include: algorithm erosion of triangulation elements, nodes splitting algorithm, and free surface constructing algorithm (Orlov, 2016).

RESULTS AND CONCLUSIONS

Figure 1a illustrates the front side of the steel plate after impact. Figure 1b shows the final stage of a three-layer barrier penetration. The presented results of calculations allow to study in detail the penetration of the impactor through three-layer barriers.

ACKNOWLEDGMENTS

The work was supported by the Ministry of Education Russia (Project Code 1567, № 2014/223).

REFERENCES


