TEST OF IMPACT RESISTANCE OF TRACKED COMBAT VEHICLE

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Abstract

Among combat vehicles high values have tracked combat vehicles. They are the most universal means of combat, both in offensive and in defense actions. About the usefulness of tanks decide the main battle features, which will include fire power, protection and mobility. The fire power is a feature that describes the quantity, quality and efficiency in terms of the main weapons system. Mobility of tanks reflects the dynamics of motion and manoeuvrability. On the mobility a large impact has: engine, transmission and tracked drive system. Protections (armour, together with additional systems) decide on the resistance to the enemy fire and the survival ability of the vehicle, crew and internal equipment. This paper presents the impact loads on a load -bearing structures of combat vehicle. Load is generated by the anti-tank mine shock wave. Models of objects were worked out using a method of the finite element, assuming the linear characteristics of elements. Studies of loads of the structure of the special vehicle body were carried out for the selected, the most common effects of explosives. Worked out research allows: determining the pressure distribution, evaluating the impact resistance of the hulls of vehicles, predicting the results of impact action, identifying the types of damage, designing or modernization of the hulls of vehicles.

Keywords*: main battle tank, combat vehicles, explosive charge, modelling*

1. Introduction

Contemporary (and past) conflicts and local armed activities, confirms the thesis that the combat vehicles (tanks, infantry fighting vehicles) still are and will be the main means of combat troops on land. Determine it the main combat features that are the fire power, protection and mobility. Combat vehicles during the operation, are exposed to various enemy combat measures, ranging from artillery shells and anti-tank mines, and ending with missile systems and weapons of mass destruction. Figure 1 presents the areas of vehicle exposed to a potential enemy means of fire.

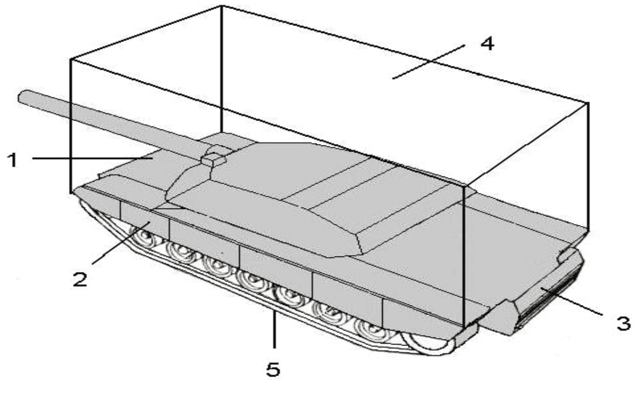


Fig. 1. Destruction zones for tracked combat vehicles: 1-front, 2-sides and drive system, 3-back, 4-upper part of the hull and the turret, 5-bottom plate

As the threat of a impact is possible on each side, hulls of vehicles are shaped mainly with a view to ensuring (with the assumed mass, geometry and external dimensions) high survival on the battlefield and mechanical strength, including:

- the sufficient high strength of carrying structure to dynamic loads resulting from driving in any area,
- stable resistance to potential enemy means of fire,
- effective protection for the hall, the crew and internal equipment systems against various mines,
- geometric and shapes, providing protection for the interior and ergonomic, safety workstations of the crews members.

Loads resulting from the dynamic field driving are minimized through the elastic absorbing elements of vehicle suspension components and vibration isolating elements by which the equipment attached to the inner hull structure.

Provide the required fire resistance to the enemy means of fire depends largely on the quality of protection (passive protection and active protection). Passive protection (armour) plates are made from armour steel or multi-layer structure (steel, light alloys, plastics and ceramics). Some areas and the nodes of the hull can be shaped, configured and combined in the desired manner. The thickness of layers and the respective angles of inclination to give increased protective properties. Protection enabled the reactive elements arranged in the most vulnerable areas or systems detecting missile in flight before the main hall and its destruction. Figure 2 presents factors illustrate survival ability of combat vehicles.

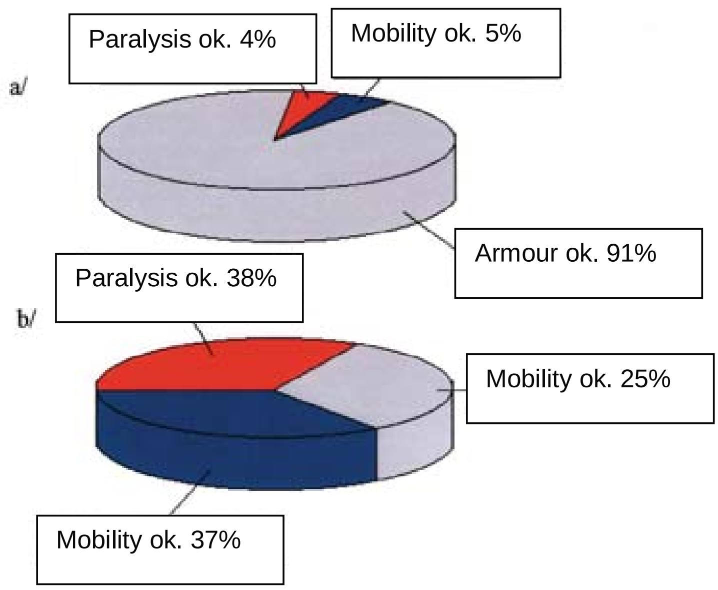


Fig. 2. Factors illustrating survival ability of tanks: a) at the current battlefield, b) in the future [4]

The problem of duration of the vehicle appears to shape the mine protection inside of the vehicle. Mainly from the so-called non contact mines. The main destruction factor of non contact mine is the pressure on the front of the post explosion striking wave. This wave acting on an encountered obstacle in this case, the bottom or a different area of the vehicle, causing deformation affecting technological bases, eliminates the vehicle with their operation. About the mine said that the "humanitarian" as a major factor in their destruction – after blast shock wave - does not affect directly people but vehicles. A similar destructive nature is improvised explosive devices (IED). Manufacturers of military and special equipment restrict access to specific data on technological solutions, methods and measures which strengthen the effectiveness of protection. Figure 3 shows a fragment of their own research of tank laded by mine explosion under his bottom.

Fig. 3. Mine explosion under the tank (photo P.Rybak)

Figure 4 presents the effect of such mines. That led to the fact that the scientific work - research to improve the design of hulls and investigate phenomena accompanying impact loads - must be continued on an ongoing basis.

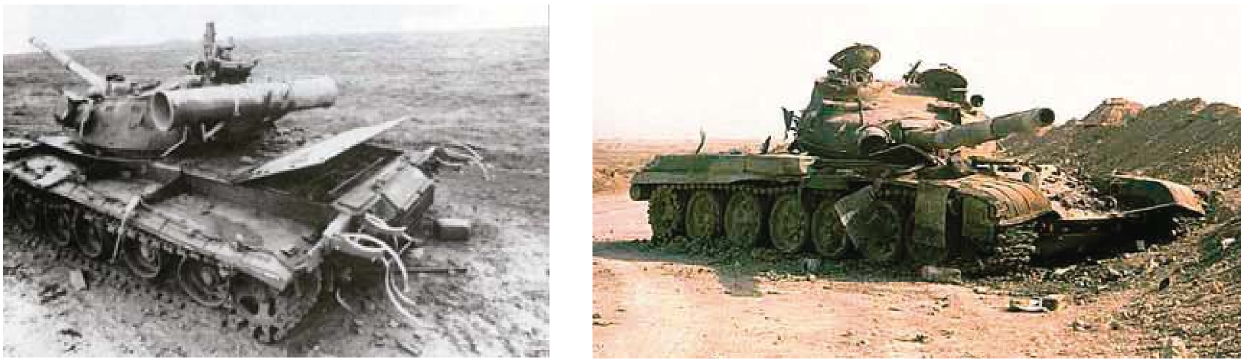


Fig. 4. Influence of antitank weapon on tanks [6]

The paper presents the results of research carried out for the modified models of the load and the real object.

2. Model testing

The model research was conducted on the assumption that the source of load is after blast shock wave generated by anti tank, anti bottom non contact mine. Objective tests include:

- Assessing the technical condition of the vehicle after the anti bottom mine explosion,
- Estimate the effects of certain parameters of explosion on the resistance of the hall,
- Identify the weak structure nodes,
- An indication of direction to increase the level of protection on impact load,
- Improvement of numerical research methodology.

2.1. General formulation of the problem

The problem was formulated as follows: shock wave generated at any point in space, the shock wave propagated in the gas environment acts on encountered an object on its way. It is understood that the resulting loads does not cause permanent structure deformation, and the resulting deformation can be considered in the small displacement theory.

2.2. Load Model

Has been assumed that the shock wave is considered us load, and spreads with the supersonic speed. Has been assumed that the resulting shock wave propagates in all directions and affects the surface structure (the bottom or side of the vehicle). In a small distance from the bottom of the vehicle may be multiple reflections from the bottom and the ground. Also assumed that:

– the pressure acting on an object can be determined independently of the response of the object,
– hull surface is composed of a series of interconnected flat elements with different sizes,
– the analysis of wave reflection from the analyzed surface of tank was used local theory of reflection, of the inclined striking shock wave, from a rigid barrier.

For the assumptions developed a mathematical model of loading (experimentally verified), describing the multiple impact of after blast wave on the hull - Fig. 5, which included in the calculation system WAT-KM. A detailed description of the load model is given in the work [1-4].

a)

b)

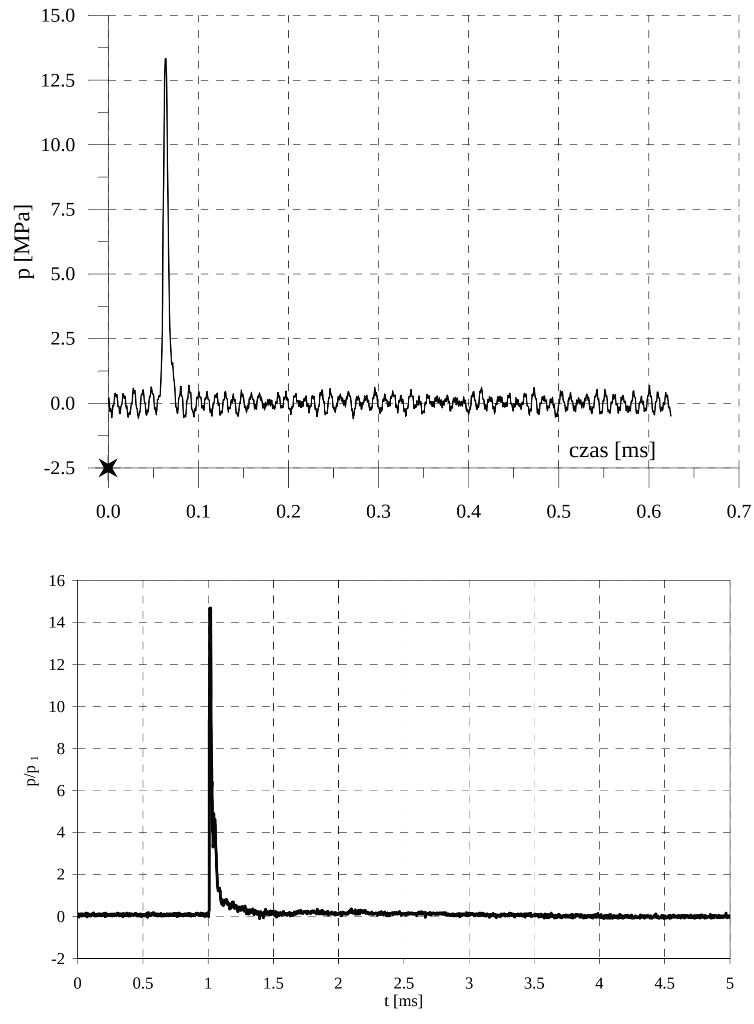


Fig. 5. Sample chart of the pressure on the front of striking wave: a) experimental research, b) with the numerical calculations

2.3. Models of research objects

Tests carried out on the hypothetical models, the size, geometry and general layout of the design similar to operated vehicles. Simplifying assumptions adopted in the structure and characteristics of the used materials do not identify models with any real object. Figure 6 shows the profiles of objects in which the models inspired by.

Discretization of the structure was carried out on the basis of the finite element method using movement formulation of the modified system WAT-KM. The main assumption adopted in the construction of models, was the representation of their core subassemblies, and interact with one another. Hence, the developed object models can be distinguished partial models: the bottom of the hull, self-caring hull, the suspension of the vehicle, propulsion system, the internal fittings and the system chassis.

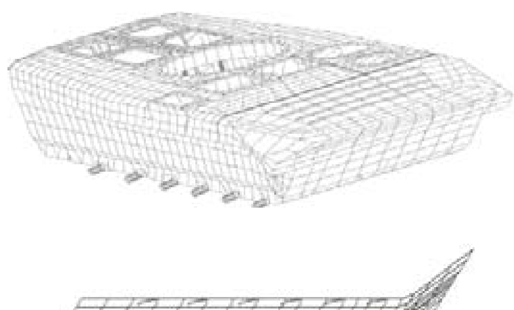
Fig. 6. Profiles of test objects

Given the accepted purpose of the research, particular attention was paid to the bottom of the hull and the side plates. Modelling them as shell and rod elements, imitating complex geometry and reinforcement elements. Hull with turret has a well-defined centre of mass and determined the mass and mass moments of inertia. Models of individual subassemblies were built using deformable and rigid finite elements and weightless elastic elements. The characteristics of the elements were chosen to imitate the dynamic characteristics of the object. With the adopted assumptions, the equation of motion of a discrete model is matrix second order differential equation with fixed coefficients

$$M\ddot{q} + C\dot{q} + Kq = f(t), \tag{1}$$

where: M - inertia matrix of discrete model, C - damping matrix, K - stiffness matrix, q - vector (single column matrix) generalized movements of nodes of the model, while the f - vector of external forces reduced to the nodes of the model (the input for vector are data generated by the model of loads). Models of objects for research - the caring structure of combat vehicle, including a fragmentation of their components - are presented in Figure 7.

a)



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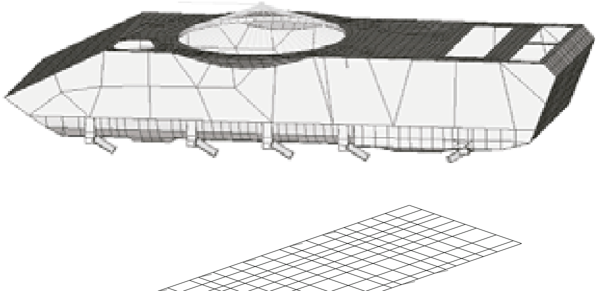


Fig. 7. Models of vehicles, including a partition of their components: a) infantry combat vehicle, b) tank

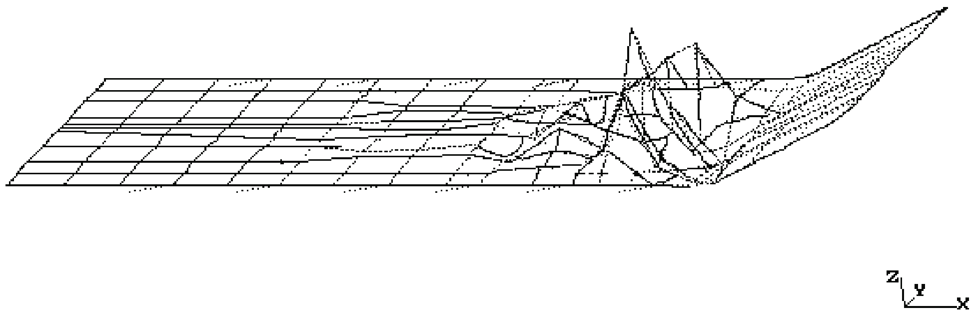
Models, in the first stage, analyzed their own vibrations. The results indicate that the basic dynamic parameters characterizing models, correspond with frequency range of free vibrations and their associated figures, given in the literature and own findings.

2.4. Results of model tests

Here are selected results of model research.

Infantry fighting vehicles

Figure 8 presents deformation of the bottom of the vehicle for selected moments of time and the time course of the reduced stress in the one of shell elements located under source of the load.



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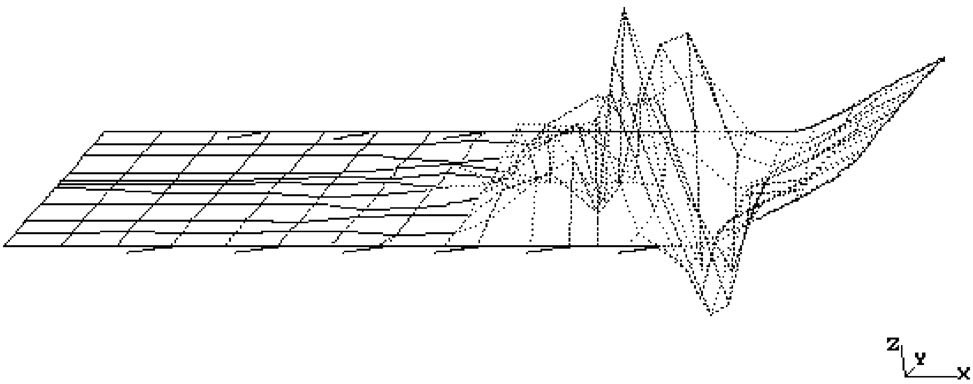

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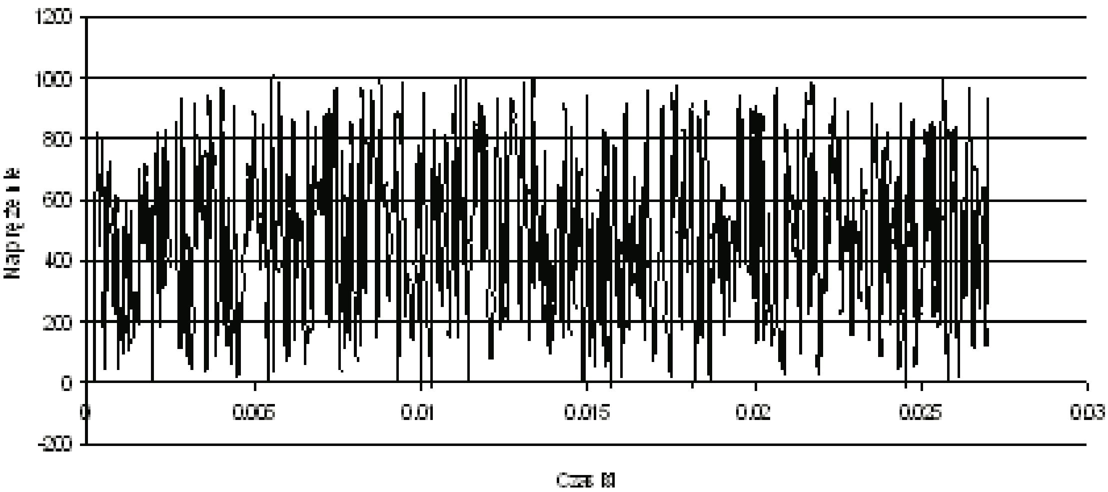

Fig. 8. Stress in the bottom of the infantry fighting vehicles

Tank

Model of tank was loaded by pressure of striking wave generated by explosion of anti-bottom mine with set parameters (mass of explosive, the location, the ground). For assumed variant a mine was placed under the driver's seat. Deformation of the bottom plate for selected moments of time and movement of the selected node of the structure present Figure 9.

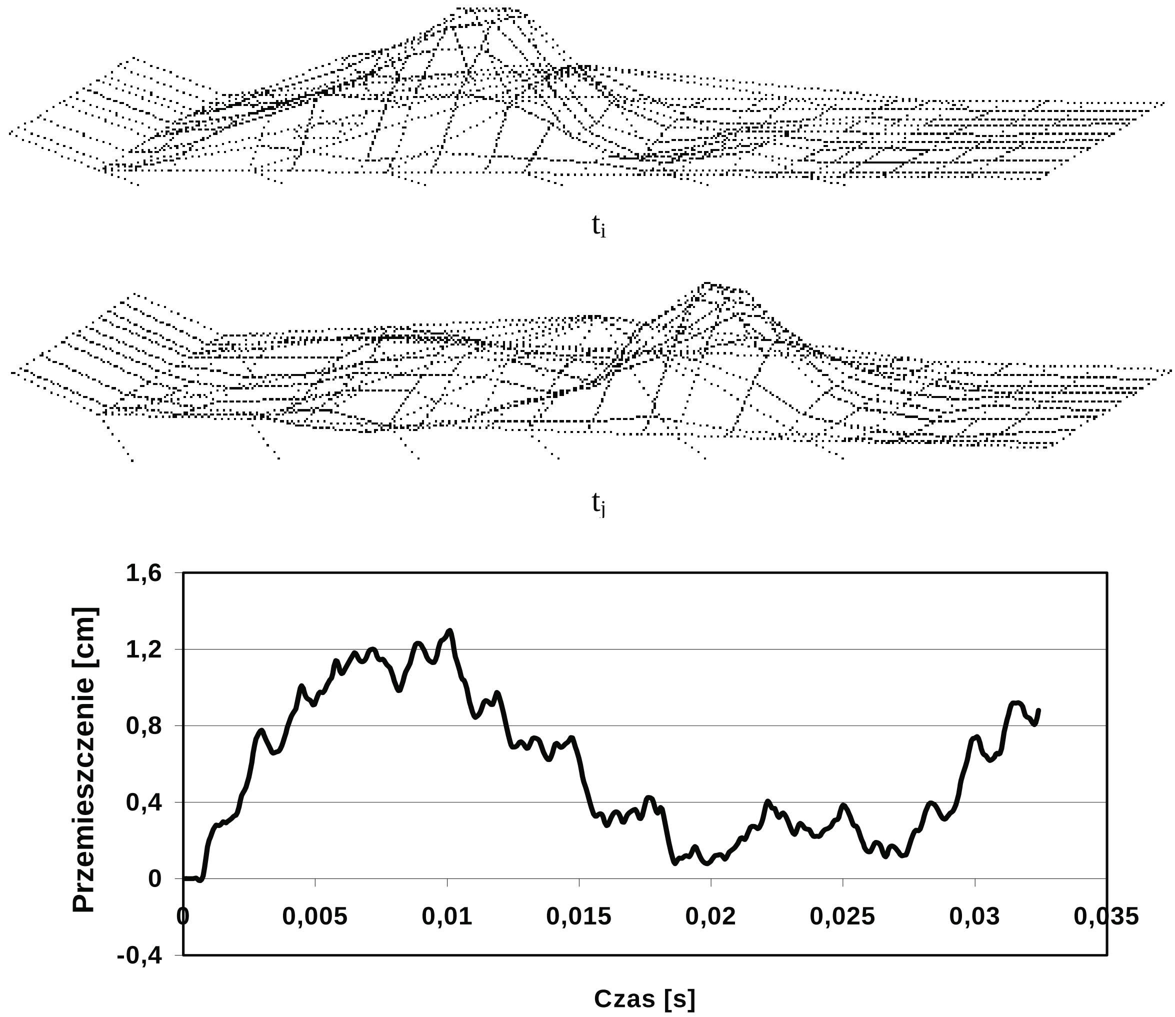

Fig. 9. Propagation of wave deformation in the bottom plate and the movement of the selected node

3. Conclusion

The obtained results of model studies confirm the necessity and ability of impact resistance of combat vehicles structures development. One of the ways may be an appropriate mix of shapes, dimensions and geometric parameters of the overall system design.

Worked out research methodology allows:

- determining the pressure distribution along the surface of the test structure,
- evaluating the impact resistance of the hulls of vehicles,
- predicting the results of impact action on the stage of the design or modernization,
- identifying the types of damage and possible options for their repair,
- designing or modernization of the hulls of vehicles with increased impact resistance.

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