OPERATIONAL LOADS OF COMBAT VEHICLES

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Abstract

The paper describes dynamic load-generating sources and their effects on combat vehicles (CV), placed people and equipment within it. The variety of the operation conditions causes a complex dynamic load, both in terms of level, direction and distribution. The effects of the impacts are shown in photographs. It is important to know the level of loads in terms of the development of resistant and safe high-speed tracked combat vehicles.

The selected results of its own researches of high-speed tracked combat vehicles were presented. Research were carried out under conditions similar to those typical for this class of vehicles, both during the rides on the road, the ground and obstacles on the specially constructed for this purpose. The results of research and analysis are compared in the form of graphs and the estimated value.

The paper presents angular movement of the hull of the CV as well as displacements of carrying wheels during overcoming a single obstacle, elastic characteristics of hydro-pneumatic suspension components, distribution of pressure acting on a selected area of the bottom of the hull after mine explosion and power spectral density estimator of tank gun vibration as well as being the source longitudinal vibration of the hull tank.

The presented scope and methodology allows the multi-variants investigation and estimate the loads of the hall, interior fittings and people in special vehicles and other objects that may be exposed to this type of loads.

Keywords: *combat vehicles, maintenance, modeling and experimental research*

1. Introduction

The strong influence on autonomous activities and characteristics of the combat vehicles (main battle tank – MBT, tracked infantry combat vehicle) are the main combat features, mobility, fire power and armor (protection). They are assessed in the predictable conditions of warfare, terrain and weather conditions. The combat vehicles are exposed to:

- the dynamic loads resulting from the ride on road and on land;
- loads resulting from use of the main arms;
- enemy artillery and rocket means;
- mines and improvised explosive devices as well as weapons of mass destruction.

These loads determine the shaping of hall of such combat vehicles tracked for the development of high ability to survive on the battlefield, including:

- low weight and small dimensions;
- geometry and shapes, a good camouflage;
- high strength against dynamic load;
- set up resistance to the influence of enemy striking means;
- good crew and internal equipment protection against mines.

The vehicle was difficult to detect and hit should have a small and compact figure as well as the shape and camouflage paint - not giving the reflections of light - causing the sink to the environment, produce the least heat into the environment (Figure 1).

Dynamic impacts during field ride are minimized by the elastic, damping or elastic - absorbing elements of vehicle suspension, limiters of stroke or end bumpers. This is supported by the smoothing property of the lower part tape of tracks, the construction of the hull and platform support, and flexible connectors.

Protection of the crew and internal equipment against the means of fire of the enemy, with a limited effectiveness is achieved mainly by basic armor, which important areas and nodes can be shaped, configure, select materials and combine them in the most efficient way. To increase the survival ability of vehicles are used for specific reactive and active protection.

Fig. 1. Masking painting of MBT and image of vehicle in the thermal camera (with clearly visible source of heat) [6], [9]

An important problem is the creation of effective protection for the crew and internal equipment against mines. Manufacturers of armored shields did not give the technical and technology data as well as the methods and measures which increase the quality of this protection, including in respect of the time of the in contact impact. Information coming from the battle fields show that the work in increasing resistance to such charges must be continued.

This paper presents the results of certain estimates of dynamic loads acting on the CV. The Institute of Motor Vehicle and Transportation for many years has a team dealing with the problem of the widely understood dynamics of combat vehicles. Results presented below are the result of work carried out by a team of selected experimental research.

2. Conditions of using the combat vehicles

2.1. Field Conditions

The operational threats are the result of the use of CV in complex field conditions, weather and climate (Figure 2). Operational loads negatively affect fuel consumption. Field obstacles causes a reduction in vehicle speed, and in extreme cases can lead to stopping it by: the engine immobilization (for example, if climb on the hill or as a result of flooding by water), get bogged down (boggy field, at the bottom of the water at the edge of the water during leave with water, in snowdrift, etc.), blocking (eg when the vehicle comes to trench), hanging (for example, to trunk of felled trees or vertical walls); capsizing (eg in case of loss of stability at the time of overcoming elevation or slope).

While driving on the CV hull, its crew and internal equipment influence significant dynamic loads from the following sources:

- inputs from bumpy roads,
- interaction between tracks and the drive wheel as well as track chain adjuster,
- backlashes in pin-track connections,
- wavy motion of the upper track band,
- changes in the mass of tracks,
- impacts on the carrying wheels and the upper track band,

- inertia forces,
- engine and propulsion system,
- shooting a gun,
- mine explosion,
- bullet or splinter hitting the vehicle.

Fig. 2. CV in various activities; a) private photo, b, c, d) [8], [9]

2.2. Battle threats

CV are potential targets has five areas of destruction (Figure 3). The front of the vehicle (1), is always turned toward the enemy (in the direction of the enemy), exposed to all its means of fire. The sides of the vehicle (2) have a large surface and are vulnerable to the hand anti armor means and anti-side mines. Rear of the vehicle (3) having low surface area and reduced protection. Due to the nature of the activities is an area with a low probability of destruction.

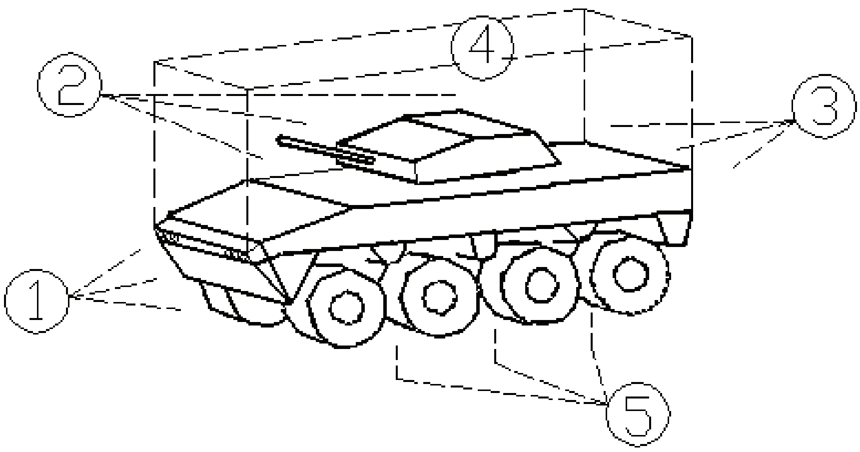

Fig. 3. CV danger zones

The upper surface of the vehicle (4) (the hull and the turret), it has the largest surface area, the most uncovered, high vulnerable. The bottom of the hull (5), is a complex geometry of the plate spread on a rigid platform construction. It is, in most cases, the base for some modules of internal equipment. Figure 4 gives the effect of CV destruction. The wheeled one has front suspension wrenched out by the antitank mine. The tracked vehicle was shot down by the anti-tank guided missile.

Rys.4. The effect of CV destruction [6], [9]

Shooting from the main arms, especially while driving, cause significant lodes on the hull, the propulsion system, engine and tracked driving system (Figure 5).

Fig. 5. Shooting from the CV [5]

3. Test results

Selected results of experimental studies carried out under realistic conditions are presented below.

3.1. Terrain driving

While riding in the individual obstacles or ground roads, with a random height and length of obstacles, the hull affect forces from the ground, which are transmitted through the tracks, carrying wheels, the elastic and absorbing elements of suspension. These forces cause the formation of three types of CV vibration: vertical vibration, angular longitudinal and transversal vibration.

Figure 6 shows the armored vehicles during road tests, and during the shooting.

Wheeled Armoured Vehicle

Light tank Anders

Fig. 6. Vehicles during the experimental tests

Figures 7 and 8 respectively, showing angular movement of the hull of the CV as well as displacements of carrying wheels during overcoming a single obstacle, and in Figure 9 and 10 when driving through the ground.

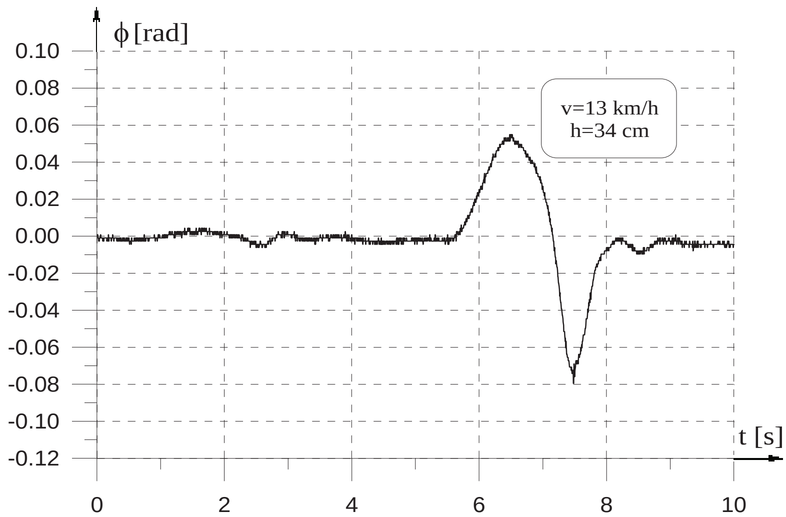

Fig. 7. Angular movements of the hull of the CV

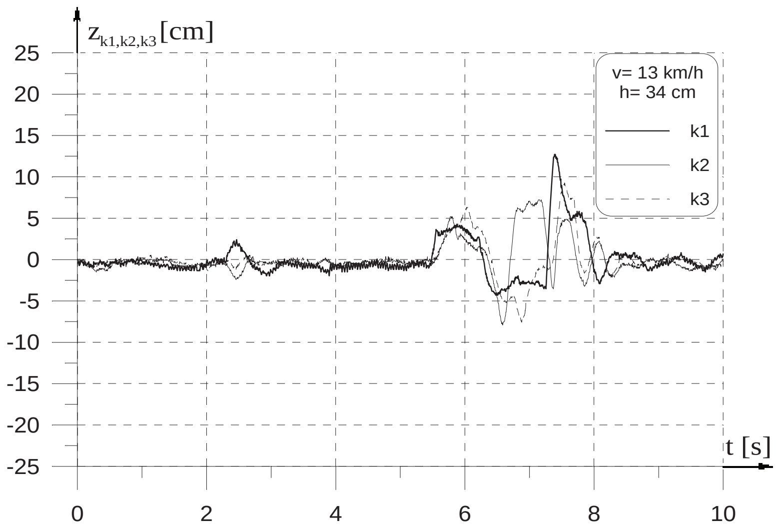

Fig. 8. Vertical displacements of carrying wheels sequentially

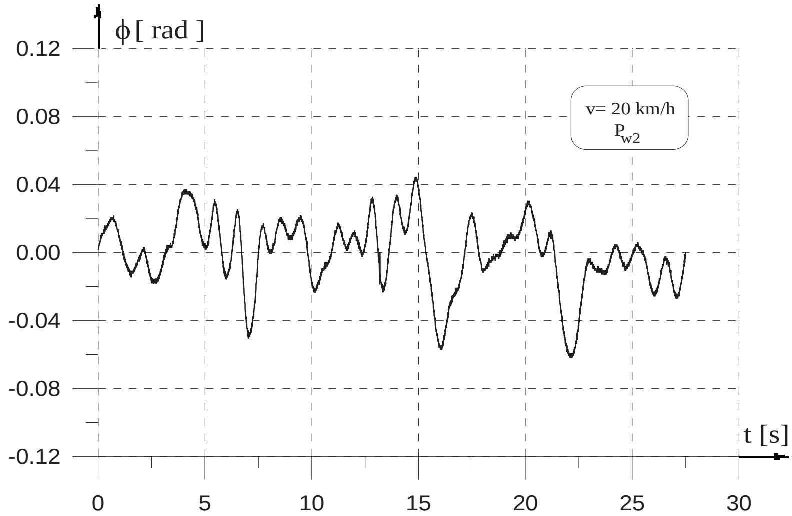

Fig. 9. Angular movements of the hull of the CV when driving through the ground

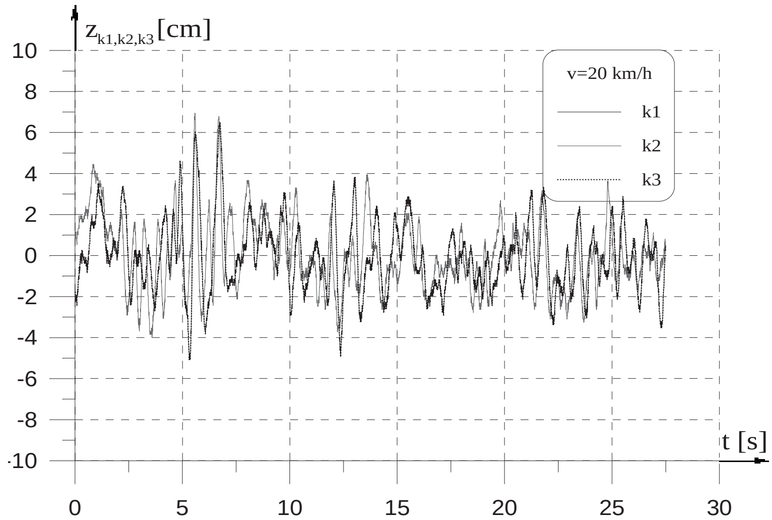

Fig. 10. Vertical displacements of carrying wheels when driving through the ground

Riding in any field conditions whit average displacement of carrying wheels, especially the first generates a dynamic load of 0.5…1 g (g – acceleration of gravity). By moving to a single obstacle or driving on the ground a sufficiently high speed is associated with the maximum stroke of carrying wheels. Arising from the dynamic load acting on the crew members and especially to the driver goes back to 8…10 g, and sometimes even more.

3.2. Experimental research of suspension elements of combat vehicles

One of the major structural elements of combat vehicles that affect their mobility is a suspension. Its quality depends on the average speed, comfort and accuracy of firing on the move. As part of the work carried out by the research team investigated the different elements of the suspension. Figure 11 shows the sample characteristics hydropneumatic suspension elastic element of efficient and inefficient component.

3.3. The impact of the striking means

As a generating source of air shock wave was used formed plastic explosive. Mine was placed on the surface of the deformable ground under vehicle standing in its longitudinal axis, at the place of attachment of flexible shaft of the first wheels at a distance h from the bottom. The study was conducted to put various mass of the explosive charges. Figure 12 presents a fragment of the experimental studies of mines influence on the hull of CV, and in Figure 13 respectively show the pressure distribution on the surface of the structure.

a) b)

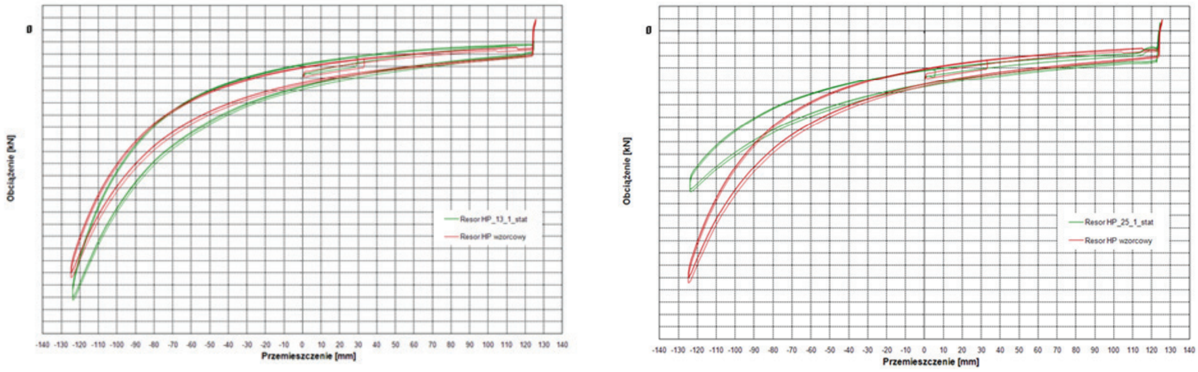

Fig. 11. Elastic characteristics of hydro-pneumatic suspension components along with the characteristics of the master: a) functional element, b) faulty item

Fig. 12. The initial phase of the mine explosion

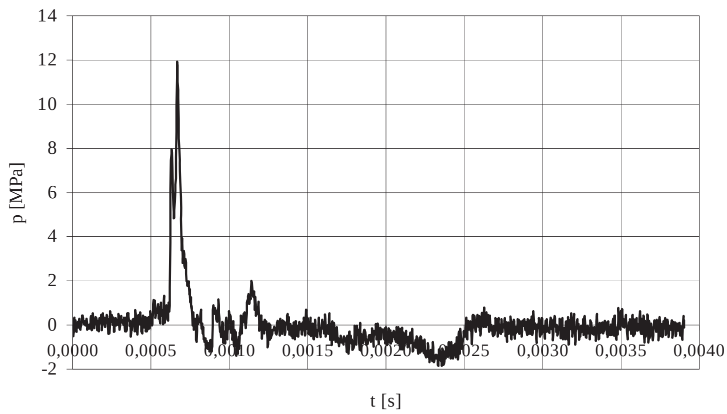

Fig. 13. Distribution of pressure acting on a selected area of the bottom of the hull

3.4. The loads acting on the stabilized gun

Investigations loads acting on a stabilized gun while overcoming obstacles. In Figures 14 and 15 shows the power spectral density estimators of tanks gun vibration and longitudinal vibration of the hull of a tank. On the basis of waveforms can be concluded that the natural frequency of the gun is 2 Hz, while the longitudinal vibration of the hull 1.2 Hz.

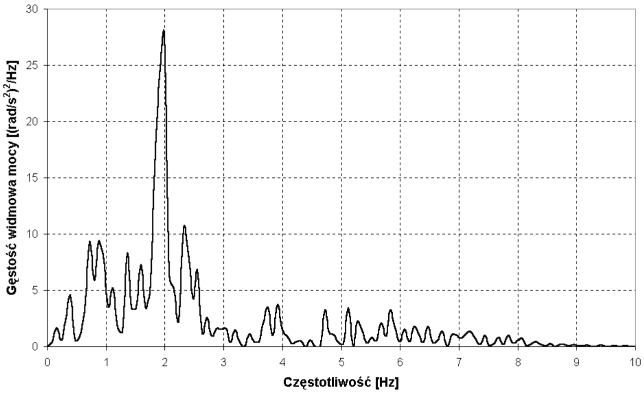

Fig. 14. Power spectral density estimator of tank gun vibration

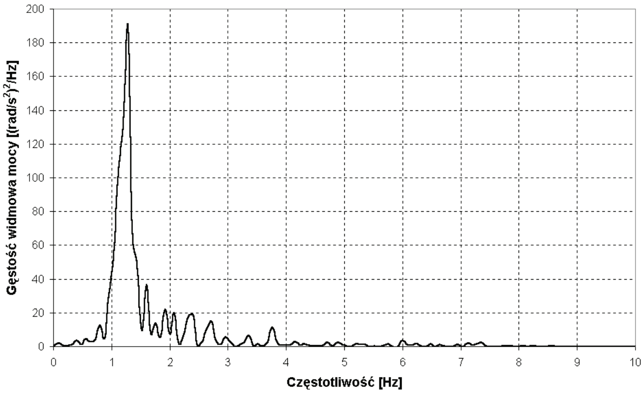

Fig. 15. Power spectral density estimator of longitudinal vibration of the hull tank

4. Conclusion

The presented results of the study confirm the possibility but also the need to load test and analysis of dynamic loads on the vehicle, its crew and equipment within it. Knowing the value of these loads allows for the rational formation of the vehicle structure for obtaining the highest possible technical and combat duration.

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