Numerical Study of Blast Protection System against IED

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Abstract. An amphibious 6×6 wheeled armored light armored reconnaissance vehicle LOTR is tested in order to verify effectiveness of a developed ballistic panel system. A 4kg equivalent TNT load is placed 440 mm from the vehicle floor under the center of mass, which represents the situation when IED is situated under the ground. The obtained results show that numerical methods are very effective in explosion modelling. In the described case, a numerical model allowed a new ballistic panel system to be designed in the way that it provides better protection against a pressure impulse. Different methods of panel layers connection were analyzed. Minor differences are observed when acceleration of the vehicle and floor deflection are compared.

INRODUCTION

Crew safety is a crucial problem in current conflicts in which such vehicles are commonly used to patrol the enemy's territory. Many recent incidents have shown that levels of crew protection are not acceptable. IEDs cause the majority of casualties: they produce a blast wave that loads the vehicle hull with a pressure pulse that causes significant acceleration within a few milliseconds. Inertial forces occurring in this way cause often serious injuries to the limbs, spine and head [1]. Based on analyses of incidents in Iraq and Afghanistan as well as guidelines concerning the requirements that modern designs should meet (NATO – Stanag 4569), the current research is aimed at increasing the mine-resistance of military vehicles. Typical constructions used by NATO members are the American HMMWV, the Swiss Eagle and the Turkish Otokar. New types of vehicles are used; however, a complete design and construction of cabins is time consuming and expensive. Developing an advanced ballistic panel protection system in order to mitigate an explosion impact is more effective. Ballistic panels need to be mounted firmly to the existing structure of the floor and suspension. The article presents an attempt to determine the influence of different connection methods on the blast wave load transfer to a vehicle structure. A numerical analysis of explosion is presented utilizing a finite elements method.

PROBLEM FORMULATION

A new amphibious 6×6 wheeled armored light armored reconnaissance vehicle LOTR is tested in order to verify effectiveness of developed ballistic panel system. A 4kg equivalent TNT load is placed 440 mm from the vehicle floor under the center of mass, which represents the situation when IED is mounted under the ground. A ballistic panel protection system consists of a set of regular hexagonal multi-layer components. Each component side dimension is 325 mm and contains four layers. The first layer is a 5 mm thick steel plate, the second one is 25 mm of cork, the third one is 50 mm of an aluminum foam and the lowest layer is a 1 mm thin steel plate. The tested variants describe the cases in which the layers: are not connected, are tied or are connected in six points close to hexagon corner which simulates panel connection by screws. A vehicle displacement, velocity and acceleration is compared in order to verify an influence of each connection type.

MODEL DESCRIPTION

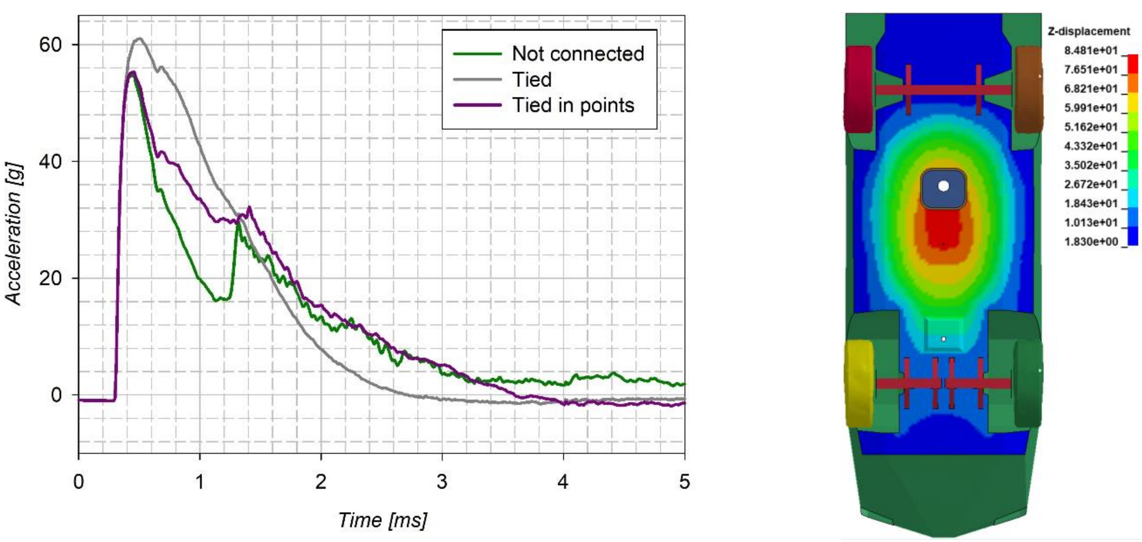
The Finite Element Method (FEM) implemented in the LS-DYNA [2] commercial code was used with an explicit (central difference) time integration algorithm. A vehicle model (Fig.1) is built using 70000 shell and hexagonal elements. To estimate a wave blast impulse, a widely known ConWep method, developed in [3], is used.

(a) (b)

FIGURE 1. Numerical model: (a) LOTR vehicle, (b) single component of the ballistic panel system

RESULTS

A load blast which reached the ballistic panel system caused a significant deformation of the aluminum foam and cork. Energy was transferred to the floor of the vehicle, which resulted in its deformation and movement of the whole structure. Acceleration versus time for different types of panel connection modelling is presented in Fig.2. A rapid increase in acceleration can be observed for each calculation variant. The highest value is registered for tied layers, however, the difference is not significant. Furthermore, deflection of the vehicle floor is analyzed. The maximum value (85 mm) was registered in the variant panels were not connected, a medium value (75 mm) was obtained when panel layers were connected only in chosen points and the lowest deflection (60 mm) was achieved for the tied panels.



(a) (b)

FIGURE 1. Simulation results: (a) acceleration of the vehicle, (b) deflection of the vehicle floor (tied layers)

CONCLUSIONS

The obtained results show that numerical methods are very effective in explosion modelling. Creating a detailed model of the entire phenomenon is difficult and time consuming; however, once built it can be reused easily, especially when minor modifications are performed. In the described case, a numerical model allowed a new ballistic panel system to be designed in the way that it provides a better protection against a pressure impulse. Different methods of panel layers connection were analyzed. Minor differences are observed when acceleration of the vehicle and floor deflection are compared. The highest acceleration is registered when panels are fully fixed, however, deflection of the floor is the smallest in this variant.

ACKNOWLEDGMENTS

The research was done within project no. DOBR-BIO4/022/13149/2013 'Improving the Safety and Protection of Soldiers on Missions Through Research and Development in Military Medical and Technical Areas', supported and co-financed by NCR&D, Poland.

REFERENCES

1. R. Brzozowski, P. Guła, T. Sanak, Bezpieczeństwo wojsk w aspekcie zagrożeń wynikających z użycia improwizowanych urządzeń wybuchowych (IED), (Akademia Obrony Narodowej, Warszawa, 2014), pp. 117-124.
2. J.O. Hallquist, LS-DYNA Keyword User's Manual, Livermore Software Technology Corporation, May 2007
3. C.N. Kingery, G. Bulmash, Airblast Parameters from TNT Spherical Air Burst and Hemispherical Surface Burst, Report ARBL-TR-02555, U.S. Army BRL, Aberdeen Proving Ground, MD, 1984.