

INFLUENCE OF OPERATION CONDITIONS ON THE WHEELED ARMOURED CARRIER CHARACTERISTICS

Wacław Borkowski, Piotr Rybak
Zdzisław Hryciów, Józef Wysocki, Bogusław Michałowski

Military University of Technology
Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 6897752, fax.: +48 22 6837370
e-mail: prybak@wat.edu.pl

Abstract

Participation of Polish military contingent in peace and stabilization missions resulted in the need for new vehicles. Special vehicles – multi-axle ones of good protection abilities and high motion dynamics – have to be adjusted to operation in various climate and terrain conditions. The work presents operation conditions of the wheeled armoured carriers resulting from the execution of required tasks. Threats resulting from driving on unpaved roads and wilderness have been presented as well as their influence on the motion dynamics, technical condition of vehicle chassis, durability and reliability. It is particularly important for the passenger safety.

A mathematical vehicle model, imitating special multi-axle vehicle, have been presented. Calculation abilities of original numerical software for the analysis of vehicle traction characteristics have been presented. Mechanical and hydromechanical drive vehicles can be analysed. Examples of calculation results, illustrated on the diagrams, have been also included. Influence of selected technical – structural parameters on a multi-axle vehicle has been shown. Their influence on traction characteristics and dynamic loads affecting the vehicle, its internal equipment and the passengers has been estimated.

Keywords: wheeled armoured carrier, characteristics, traction features, loads

1. Introduction

Factors determining the traction characteristics are highly significant for providing proper execution of tasks and safety of special vehicle passengers. The features significantly affect the mobility. The mobility meant as a vehicle ability to move on any ground in any weather and climate conditions. It makes an important element of the so-called active defence. It is a notion of a very wide meaning and generally it defines the vehicle pickup ability, manoeuvrability and ability to cross the terrain in assumed operation conditions. It is of high significance for the vehicle and people ability to survive the battle. The mobility of special vehicles, including wheeled armoured carriers, is determined by the following factors:

- usable engine parameters and drive type parameters,
- chassis quality, smoothness of motion at any speed,
- ability to achieve maximum and average speeds in various terrain conditions, particularly average speeds during off-road driving,
- easiness of driving a vehicle (steering system efficiency, steering action response time),
- providing proper driving range per fuelling unit,
- ability to cross terrain, natural and artificial obstacles, including crossing the water obstacles and the area contaminated with the weapon of mass destruction,
- adaptation ability to provide a long-distance transport.

There is an experienced scientific team in the Institute of Motor Vehicles and Transport of the Mechanical Department of the Military Technical Academy. Since the 80's, this team has been dealing with issues related to dynamics, traction characteristics of caterpillar and wheeled vehicles

as well as vehicle passenger protection and safety. The team is equipped with high class measuring and recording apparatus and standard original (experimentally verified) numerical software.

The main objective of this work is to present the abilities of the software for the analysis of influence of operation conditions of:

- engine and drive system parameters on vehicle traction characteristics,
- chassis condition on the vehicle load level.

Analyzed examples of calculations apply technical data of special vehicles that make the equipment of some armies. It should be noticed that the data is close to the real vehicle data. Therefore presented calculation results should not be identified with any particular special vehicle and it should be assumed as hypothetical data.



Super AV Iveco



Piranha

Fig. 1. Profiles of wheeled armoured carriers in various motion conditions

A vehicle with chassis imitating an 8x8 drive wheeled armoured carrier has been analysed. It is equipped with a hydromechanical type drive system. Such system provides smooth start moving, several forward speeds and one (or two) reverse speed(s).

Figure 2 presents the drive system arrangement scheme and mutual positioning of the drive system components in a typical 8x8 drive wheeled armoured carrier.



Fig. 2. Drive system scheme

3. Calculation examples

The work presents two cases of analysis of operation condition influence on the carrier driving characteristics. The first one refers to the influence on the traction characteristics and the second one covers the influence of technical condition of drive system components on the dynamic load level.

3.1. Influence of reduced engine power

The examples refer to the armoured carrier equipped with ZS engine. Calculations have been made for an engine with rated power and an engine with reduced power. A 10% power reduction has been assumed. That kind of assumed power decrease can result from inefficient components of the fuel system, piston – cylinder wear and tear, air filter contamination, vehicle operation in mountain conditions (up to app. 3000 m above the sea level) or the use of substitute fuel.

DYNH and ROZBIEGH original numerical software, developed in the Institute of Motor Vehicles and Transport, has been used to identify dynamic and run-up characteristics. Obtained characteristics are presented on Fig. 3 and 4. The software allows carrying out the analysis of traction characteristics also in case of gearbox and driving axle damage, reduced drive system efficiency and deterioration of ground properties.

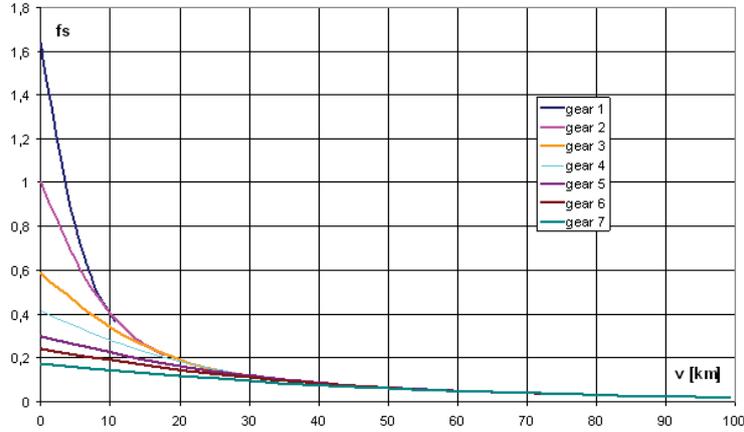


Fig. 3. Dynamic characteristics for a vehicle with rated engine parameters

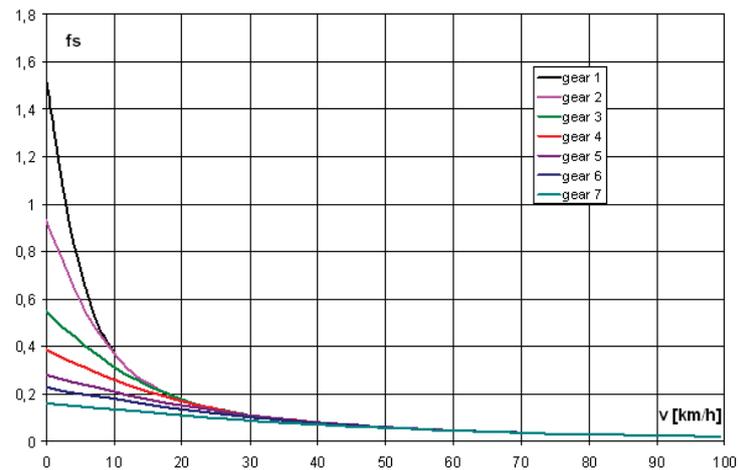


Fig. 4. Dynamic characteristics for a vehicle with reduced engine parameters

Figure 5 present the run-up characteristics of a wheeled carrier for two analyzed drive engine efficiency cases.

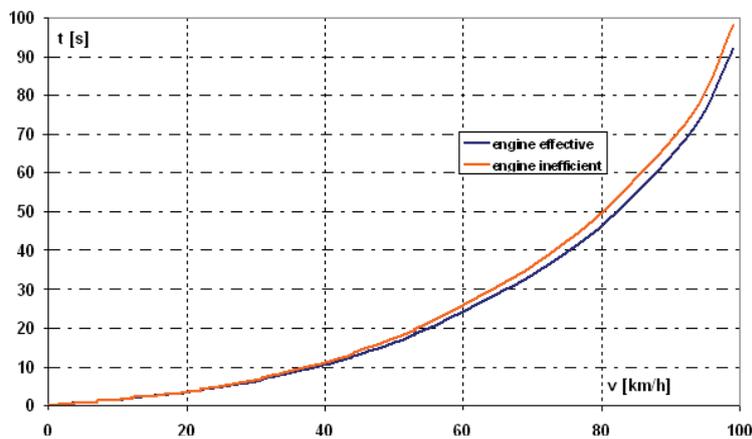


Fig. 5. Vehicle run-up diagram

3.2. Influence of inefficient drive system on the carrier loads

The tests have been carried out for selected chassis defects. Wheel damage and spring-dampening suspension component damage have been assumed. The level of dynamic loads affecting the vehicle and passengers has been evaluated. Simulation tests have been carried out for the most common cases i.e.:

- a) efficient vehicle,
- b) vehicle with damaged suspension of one front wheel (without a spring-dampening element),
- c) vehicle with damaged front wheel tire (driving on a *RunFlat* type rigid internal ring),
- d) vehicle with damaged height adjustment valve in one suspension or in all suspension on one side of a vehicle (side tilt).

Calculations have been made for characteristics corresponding to a four-axle wheeled 20-ton vehicle. The vehicle was moving with column marching speed of 30 km/h. Kinematic force of pseudorandom distribution on the vehicle wheels makes the source of force. Ground characteristics correspond to unpaved road with bad surface condition. Calculation results allowed determining courses of displacement, speeds and general accelerations of concerned vehicle elements. Moreover, the course of wheel-ground impact forces has been identified.

Figure 6 presents vertical accelerations of vehicle centre of mass and driver seat for efficient vehicle data. Higher vertical acceleration values of the driver seat result from the fact that it is located far from the vehicle centre of mass and summation effect of linear vertical vibrations and angular vibrations towards to the transverse axis.

Figure 7 presents courses for a vehicle with damaged suspension. Compared to the operational vehicle, the acceleration values have increased – particularly for the driver seat. It results from the higher angular vibration amplitude. Fig. 8 presents dynamic ground reactions to a selected vehicle wheel for an operational vehicle and a vehicle with damaged suspension of the first wheel (no spring-dampening element). It can be also noticed that, apart from the average value increase, the level of variation of that force is much higher. The load applied to the first wheel has to be taken by other wheels, particularly the second wheel. It significantly deteriorates the suspension operation conditions. In case of a long-distance driving it can result in suspension damage or tire damage in other vehicle wheels.

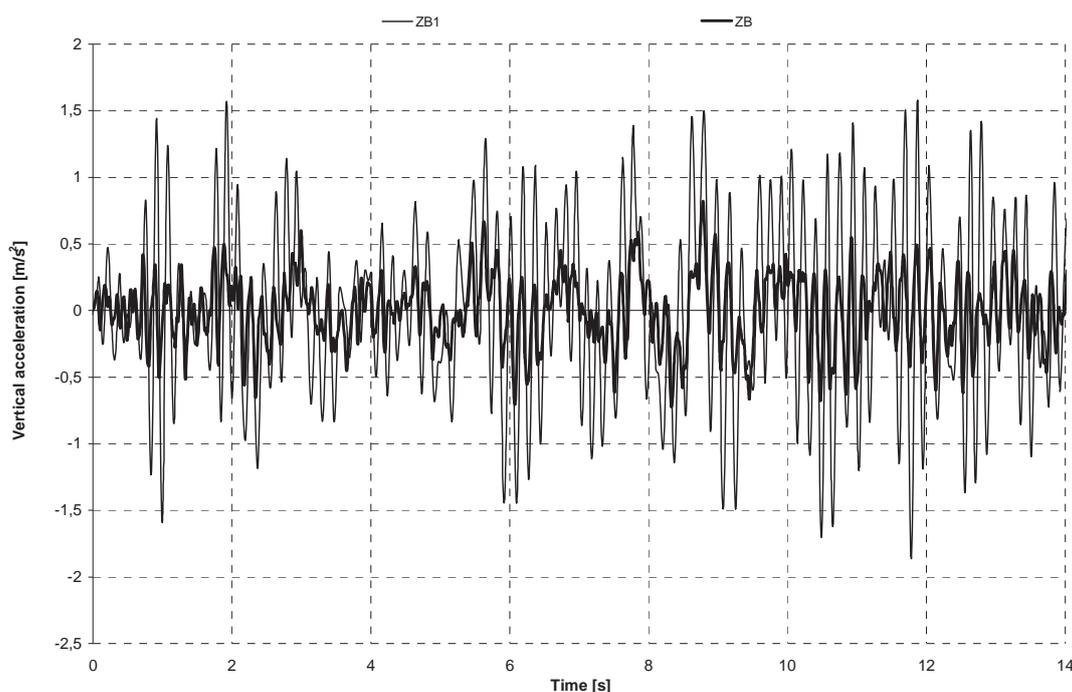
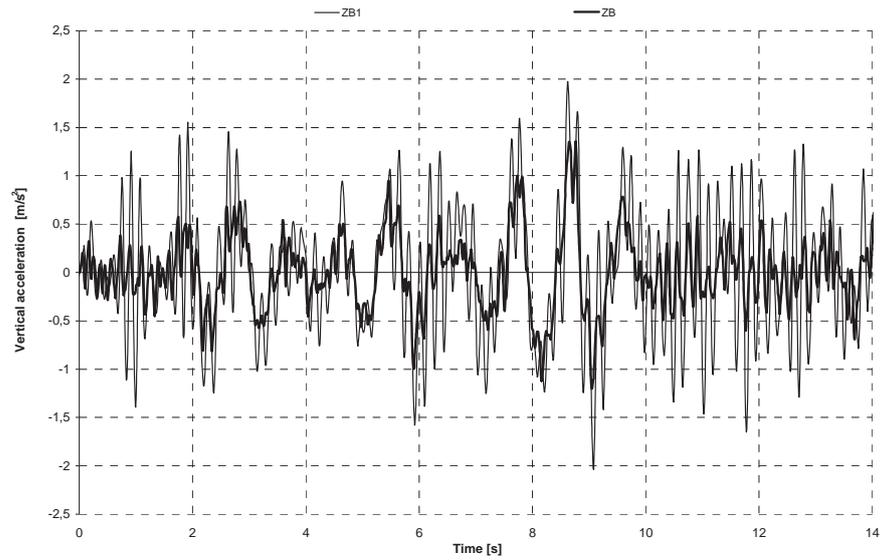


Fig. 6. Vertical accelerations of the vehicle centre of mass – ZB and the driver seat – ZB1 for operational vehicle (asphalt)

a) asphalt



b) pavement

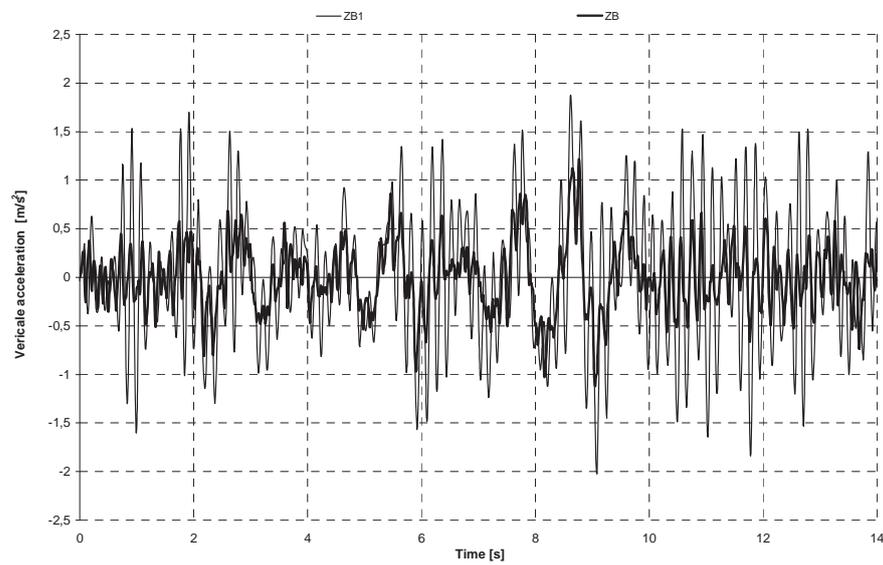


Fig. 7. Vertical accelerations of the vehicle centre of mass (z) and the driver seat (zF) for a vehicle with damaged suspension of one wheel (a – asphalt, b – pavement)

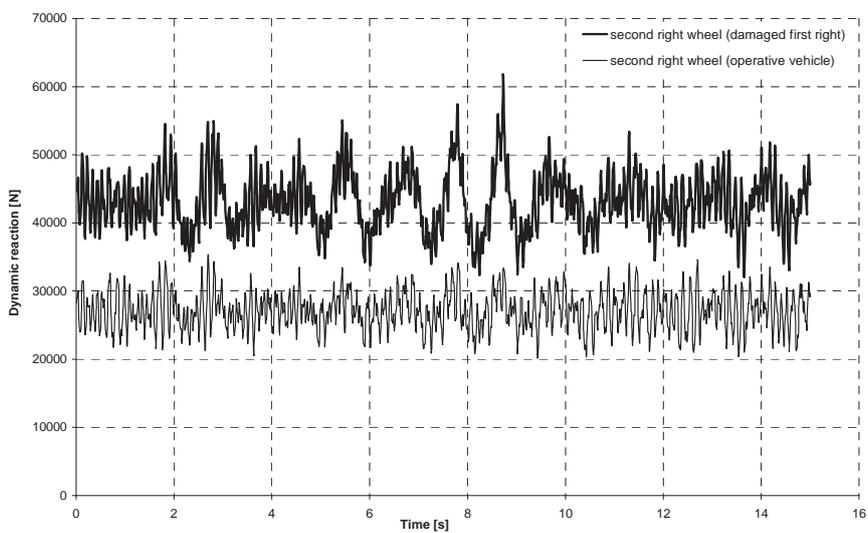
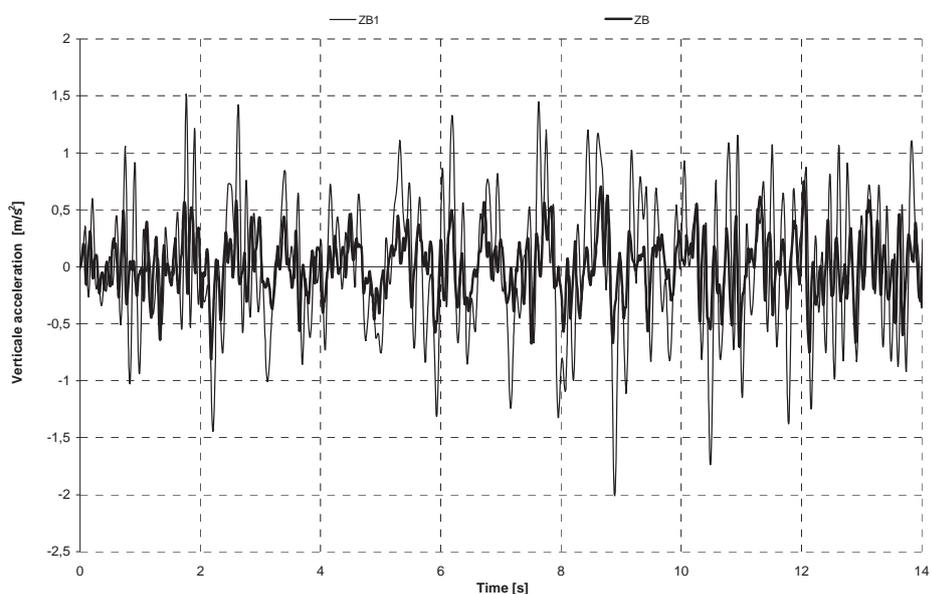


Fig. 8. Dynamic reactions of a selected wheel for operational and damaged vehicles (asphalt)

Figure 9 presents a comparison of vertical accelerations affecting a vehicle and a driver when driving on two different grounds (asphalt and pavement) at a set speed, vehicle with damaged second axle.

a) asphalt



b) pavement

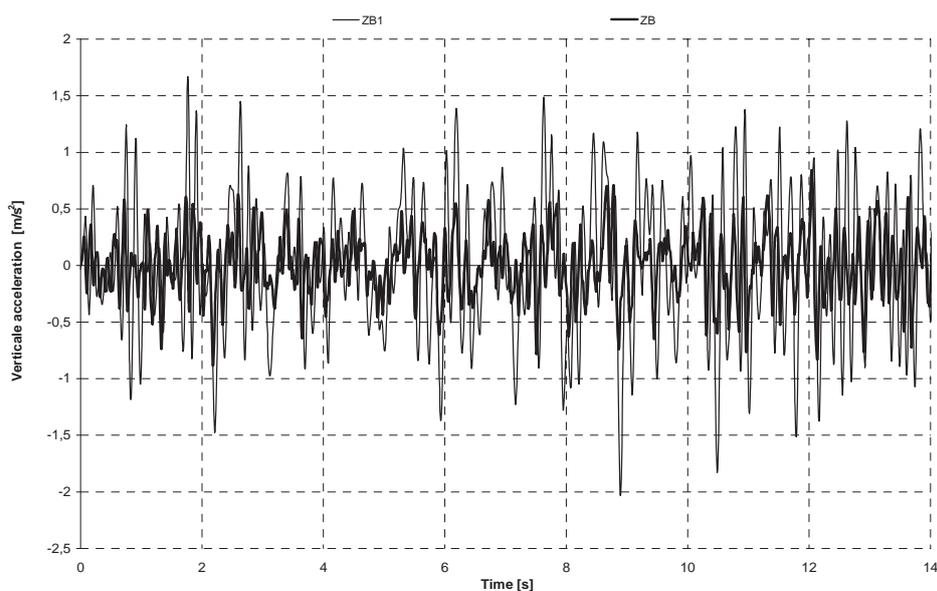


Fig. 9. Courses of vertical acceleration affecting a vehicle with damaged second axle wheels in motion (a – asphalt, b – pavement)

4. Summary

Numerical models used in this work allow providing multivariant performance of carriers' tests, including the cases depending on expected operation conditions and expected incidents during execution of special missions.

Performed model studies indicate that occurring defects can affect a multi-axle vehicle, its crew and its internal equipment to various degrees. Motion characteristics of a carrier are significantly affected by parameters and technical condition of the drive unit, drive system and chassis. It can be noticed that the dynamic vehicle load level is less affected by a number of damaged wheels than by the wheel location in the chassis.

References

- [1] Borkowski, W., Rybak, P., Michałowski, B., Pańczuk, E., *Model investigations of traction properties of the high-speed tracklaying vehicle*, Journal of KONES, Vol. 15, No. 2, 2008.
- [2] Borkowski, W., Rybak, P., Michałowski, B., Wysocki, J., Hryciów, Z., *Traction properties of the tracked combat vehicle at low ered power of the driving engine* , Journal of KONES, Vol. 16, No. 1, 2009.
- [3] Borkowski, W., Rybak, P., Michałowski, B., Wysocki, J., Hryciów, Z., *Właściwości trakcyjne gąsienicowego wozu bojowego przy obni żonej mocy silnika nap ędowego*, Biuletyn WAT Nr 1, 2010.
- [4] Borkowski, W., Rybak, P., Hryciów, Z., Wysocki, J., Michałowski, B., *Wpływ obniżonej mocy silnika na własności pojazdu specjalnego z hydromechanicznym układem przeniesienia mocy*, Seria monografie Nr 183: *Silniki gazowe wybrane zagadnienia*, Politechnika Częstochowska, Wydawnictwo Politechniki Częstochowskiej, Częstochowa 2010.
- [5] Borkowski, W., Rybak, P., Hryciow, Z., Wysocki, J., Michalowski, B., *Combat vehicle dynamic load tests in the aspect of the operation safety*, Journal of KONBiN, No. 1(13), Safety and Reliability Systems, Warsaw 2010.
- [6] <http://legion.wplus.net>, <http://ofp.clan.su>, <http://www.renk.newsfactory.de>, <http://defense-update.com>

The scientific work financed by the funds assigned for the science during 2007-2010 as a developing project.