ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1161726

OPERATIONAL TESTS OF BRAKING SYSTEMS FOR HIGH MOBILITY VEHICLES

Włodzimierz Kupicz, Przemyslaw Siminski

Military Institute Armour and Automotive Technology
Okuniewska Street 1, 05-070 Sulejowek, Poland
tel. +48 261 811204, fax: +48 261 811073
e-mail: wlodzimierz.kupicz@witpis.eu, przemyslaw.siminski@witpis.eu

Abstract

The article presents the results of comparative tests of the experimental designs of the braking system of high mobility vehicles. Braking systems determine the safety of vehicles. Higher mobility requirements should not remain without an effect on adapting the braking system to the use conditions. Article developed within the scope of execution of the NCBiR project DOBR-BIO4/021/13355/2013.

The mileage tests lead to a thorough evaluation of the various systems of the vehicle. In order to carry out the mileage test correctly, the vehicle has to be exposed to the most difficult conditions to which it is adapted to, according to the preliminary assumptions. In the case of military vehicles, the most difficult terrain is the training ground terrain with frequent bumps, uphill's, downhill's and water hazards, etc. The vehicle has to be operated at the maximum use of all its components (inter-wheel and inter-axle locks etc.). Only the vehicle that has been properly tested, and meets all the assumptions for a given object can be considered safe.

Keywords: *road safety, mobility, military vehicles, braking systems*

1. Introduction

Developing new vehicle designs should not mean deteriorating their level of safety. Braking system is especially important for the traffic safety [1]. Especially in high-mobility vehicles, it is exposed to additional operational factors worsening its condition. Therefore, the design of the braking system should be durable and resistant to factors that are the result of the way of use of this type of vehicles: mud, water, sand. Brakes continuously have to ensure effectiveness despite being used on unpaved roads.

2. Durability tests

Durability and reliability tests are the basic types of tests that have to be done in the first period of the operation (prototype). Durability is a numerical type of value expressed in the number of hours of operation or the number of kilometres travelled by each vehicle. This means that within a given period of time an assembly, a subassembly or a part, fulfils its function and ensures operating in accordance with the intended use and function.

The basic test method, especially for military vehicles, is to test the whole vehicle through an experimental method. Its assumption is to drive a set mileage for different types of surfaces. Depending on the type of vehicle, there are different types of roads on which the tests should be carried out and their percentage share in the total mileage will be different. During the route planning process, it is important not to forget to include mountain areas, as well as the extreme conditions, characteristic for winter and summer seasons. High volatility of conditions and profiles of surfaces ensure selective conditions for vehicle systems, thanks to which the weak points of the vehicle that result in a reduction in durability and reliability relatively can be quickly found. At the moment, it is difficult to imagine a more selective and at the same time correct way to verify the parameters of newly developed and modified vehicles, than driving through the specific test routes.

Mileage tests meet the hypothesis of accumulation of stress in the material because of variable amplitudes of stress cycles. Performing the mileage test is one of the most effective forms of determining the resistance against mechanical stresses as well as durability and reliability. Performing the mileage tests on the dedicated training ground roads or special test tracks requires the parameterization of surfaces. The knowledge of the road profile is the determinant of generated loads and, as a result, the variable amplitudes of stress cycles. Thanks to that, the mileage tests significantly shorten the overall test time. The appropriate profile of the road contributes to shortening the test time. This is why the mileage tests on the training ground roads are often referred to as accelerated tests. Properly selected test routes allow for shortening the mileages even by an order of magnitude. At the same, the test route has to be as selective and close to the real operating conditions as possible. It cannot be too difficult and be beyond the capability of the vehicle resulting, among others, from its intended use as the results could be flawed. The proper selection of test roads ensures that the appearance of cracks, damages and wear will be consistent with normal vehicle operating conditions. The main idea executed through the mileage tests is to determine the potential damage and wear emerging during the mileage and classifying them to: design flaws, wear and tear, material defects, fatigue wear. This kind of approach requires diverse loads hence the need to take into account the roads with random unevenness. This is achieved through diversifying the test conditions and achieving possibly high speeds. Construction properties of the vehicle (especially the relations between individual elements) as well as speed should be taken into account. The nature of emerging damages has to be analogous to operation damages; the only difference is that they occur much earlier.

One of the most difficult issues is to determine the length of an equivalent mileage. The equivalent mileage should ensure multiplying the mileage up to the real operating conditions. It allows shortening the mileage from the level of a few hundred thousand kilometres by an order of magnitude. Questioning the determining of the length of the mileage results from the lack of interest in the most optimal verification of durability and reliability, and thus operating costs by users, as well as the manufacturers (the warranty repair costs should be important for them). The trend of shortening the testing process as much as possible and going through it in a “painless” way prevails [2].

3. Braking systems of military wheeled vehicles

The braking system plays a key role in vehicle safety. Detailed criteria that are to be met by braking systems and the test conditions are included in the ECE Regulation no 13. This regulation determines the conditions of obtaining the homologation for a braking system. The braking system of a special vehicle is equally important for the safety. This applies particularly to the military vehicles. Military special vehicles are not subject to the obligatory homologation test, including the braking system tests. Nevertheless, always during the prototype tests that place the vehicle in service in the Polish Armed Forces the effectiveness of the brakes is tested by a 0 and 1 test, in accordance with the abovementioned Regulation No. 13. The stability of movement during braking is also an important feature that is subject to assessment. Nevertheless, due to functionality and significant differentiation of working conditions compared to general-purpose vehicles these tests may not be sufficient. The road situations resulting from special vehicles functions and structures may become the key ones for their safety. Such situations may include wading or swimming and driving on mountain roads. This kind of situations poses specific requirements for braking systems. Until now, braking systems were not verified for such conditions. This is why a representative test methodology has been developed [3].

4. Mobility of military wheeled vehicles

Polish defence standard NO-23-A003:2004 defines mobility as a characteristic of an off-road vehicle, allowing it to move while maintaining the ability to perform basic tasks. The same document introduces the concept of high mobility vehicle for the military vehicles; it is an "off-road vehicle, equipped with tires designed for operation at variable pressures, characterized by a unit pressures of no more than 350 kPa and a unit power of not less than 12 kW/t". These parameters have been defined at the level of 450 kPa and 10 kW/t for increased mobility cars. As you can see the issue of cooperation between the wheels and the ground has been reduced to two parameters. Their values are the result of many factors.

There are strong reasons for including the average off-road speed into the classification of vehicle mobility.

The desired increase of the off-road speed forces a proportionately greater efficiency and durability of the braking systems.

5. Operational tests of braking systems

The aim of the tests was to identify design errors of the high mobility vehicles braking systems, impairing the braking performance after the defined mileage in the training ground conditions. The appropriate effectiveness of the braking system affects the safety of the use of the vehicle, which is one of the most important aspects when assessing the safety of the test object.

The high mobility 8x8 car has been the object of the study, as the main object and Star 266 truck, designed in the 70s, has been chosen as a reference object. The vehicles have covered the mileage of 1000 km on bumpy and muddy surfaces of the training ground dirt road.

A comparison of the drum brake structure used in Star 266 vehicle and the one used in the test object are presented in the following figures.

Fig. 1st Star 266 drum brake with the lock as a very important structural element of the drum brake that affects the limitation of penetration of sand, gravel and mud into the drum

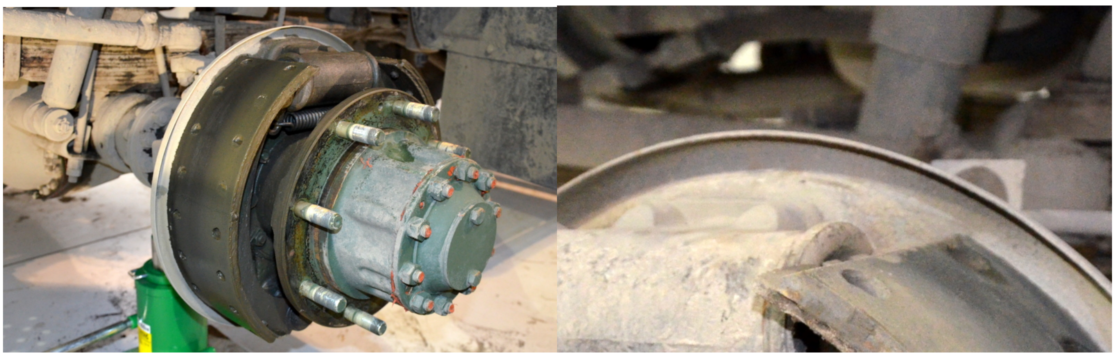

Fig. 3, 4. The brake system actuators cover, its ring is placed inside the drum brake lock

As seen in the above photographic documentation, the designer of Star vehicle has anticipated adapting the brake drum to the operation in a rough training ground terrain.

Adapting the drum brake of the vehicle to the operation in the training ground conditions has a big impact on the effectiveness of the braking system. The photographic documentation of the inside of the drum brake and the brake actuators of the vehicles after travelling the training ground mileage has been presented in the below figures no. 1-6.

Fig. 5. The inside of STAR 266 drum brake after completing the training ground mileage

Fig. 6. STAR 266 braking system actuators after completing the training ground mileage. The elements of the braking system for the main test object have been presented in the Figures 7-12 below

Fig. 7. The inside of the drum brake of the main test object after completing the training ground mileage (scratches and dents)

Fig. 8. Actuators of the braking system of the main test object after completing the training ground mileage

Fig. 9. Actuators of the braking system of the main test object after driving out of the soggy terrain of the training ground

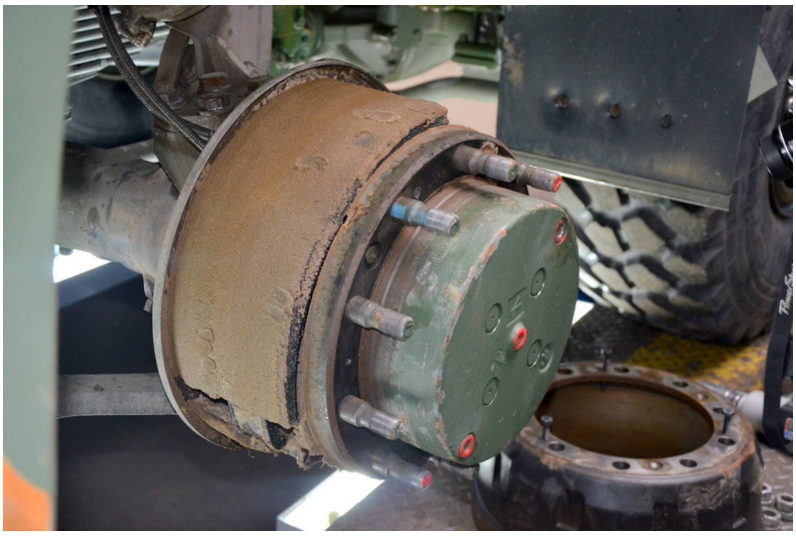

Fig. 10. Actuators of the braking system of the main test object after driving out of the soggy terrain of the training ground

Fig. 12. Actuators of the braking system of the main test object after driving out of the soggy terrain of the training ground

Fig. 13. The inside of the drum brake of the main test object after driving out of the soggy terrain of the training ground

6. Summary

In the above figures you can clearly see how important it is to match the design of individual subassemblies of the braking system to the training ground conditions in order to prevent sand, mud, etc. from entering the inside of the drum brake. The design of Star 266 takes into account the conditions characteristic for high mobility vehicles, whereas in case of the main test object that was not the case. The mileage tests lead to a thorough evaluation of the various systems of the vehicle. In order to carry out the mileage test correctly, the vehicle has to be exposed to the most difficult conditions to which it is adapted to, according to the preliminary assumptions. In the case of military vehicles, the most difficult terrain is the training ground terrain with frequent bumps, uphills, downhills and water hazards, etc. The vehicle has to be operated at the maximum use of all its components (inter-wheel and inter-axle locks etc.). Only the vehicle, that has been properly tested and meets all the assumptions for a given object, can be considered safe.

References

[1] Simiński, P., *Model bezpieczeństwa pojazdu wojskowego*. [*Military vehicle safety model*] Logistyka nr 3/2014. Continued from issue 1, 2014.

[2] Simiński, P., Rola badań trwałościowych w weryfikacji konstrukcji inżynierskich [*The role of durability tests in the process of verification of engineering structures*]. Konstrukcje inżynierskie nr 11, 2014.

[3] Simiński, P., Problematyka ruchu nowoczesnych transporterów wojskowych [*The issue of mobility of modern military transporters*]. Postępy Nauki i Techniki nr 14. p. 244-250, 2012.

[4] Księga procedur WITPiS 2015 edition.