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DIAGNOSTIC ASSESSMENT OF TECHNICAL CONDITION OF THE SHOCK ABSORBERS IN AUTOMOTIVE VEHICLES IN A SELECTED DIAGNOSTIC STATION

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Summary. The maintenance of the shock absorbers in proper technical condition is essential for operating safety of automotive vehicles and improves the driving comfort of the vehicle. The results obtained from diagnostic tests carried out in a selected diagnostic station for the shock absorbers were put forward in the present paper.

Key words: motorization, diagnostics, shock absorbers

INTRODUCTION

The vibrations occurring in vehicle wheels and body are eliminated or significantly reduced by shock absorbing elements. Their task consists in damping of vibrations generated in the vehicle – suspension system. The damping consists in the reduction of magnitude of the vehicle wheel and body (vibration amplitude) and in the reduction of their duration. The hydraulic shock absorber is the typical and commonly used shock absorbing element.

The correct functioning of the suspension system is essential for travel safety (increasing the tractive adhesion of the vehicle), because it increases the duration of vehicle contact with the ground when travelling across uneven surface. The service life of the vehicle as well as functioning reliability of other subsystems and systems in the vehicle, passengers travel comfort and the condition of transported goods (owing to reduced vibrations transferred to the vehicle) is also significantly affected. Therefore, the determination of its technical condition is crucial for correct vehicle operation.

The testing of suspension system consists in the detection of inefficient elements making the performance of the above-mentioned functions impossible. The assessment of technical condition of the shock absorbers by means of measuring instruments consists in the recording of amplitude curves for the suspension and in the comparison of the obtained characteristics with standard curves for the tested vehicle.

The diagnostic tests for technical condition of the shock absorbers carried out for the group encompassing 29 vehicles was described in the present paper.

METHODS OF SHOCK ABSORBERS TECHNICAL CONDITION ASSESSMENT

The following two methods are commonly used for the execution of diagnostic tests for shock absorbers system installed in the vehicle: free vibration method and forced vibration method.

Testing the shock absorbers using free vibration method

The diagnostics for technical condition of the shock absorbers using free vibration method consists in the shock absorber assessment on the basis of the number and amplitude of recorded vibration cycles of the vehicle body generated in result of pushing the vehicle body from standstill. In practice there are four free vibration methods used to evaluate the technical condition of the shock absorbers installed in the vehicle.

The first method called „release from wedge" consists in the putting of a part of vehicle body (front or rear part) into oscillating motion in result of pushing or pulling the vehicle across the surface irregularity having the shape of wedge. Refer to Figure 1 for schematic diagram illustrating that method. An assessment of technical condition of the shock absorbers consists in an analysis of the number of semi – periods of recorded vibrations comparing them with the results obtained for the same vehicle with rated shock absorbers [Bocheński 2000].

The method called „drop pit", the oscillating motion of the vehicle body is induced by the displacement of the skid, overriding slab or frame structure downward. The vibrations of vehicle body are induced by freely falling wheel (Fig. 1b). An assessment of technical condition of the shock absorbers consists in the comparison of recorded amplitude curves with standard curves.

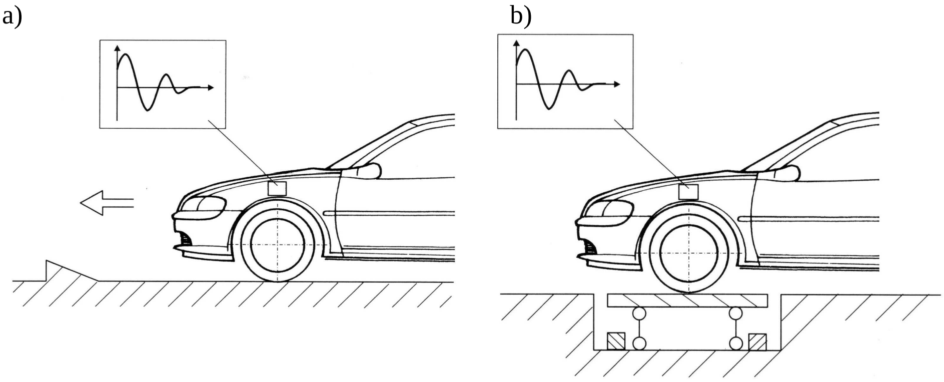

Fig. 1. The schematic diagram of diagnostic methods: a) release from wedge, b) drop pit [Bocheński 2000]

The third method consists in the vehicle body deflection from the equilibrium position in the result of the deflection of elastic elements. After the locking of front or rear wheels, vehicle body is fixed in a determined position by means of specialized measuring equipment. Then after releasing of press down device, free vibrations of the vehicle body are generated and recorded in form of free damped vibration diagram [Niziński 1999].

The forth method consists in full braking of the vehicle on the slab stand with maximal deflection of the shock absorbers as the reaction from braking forces and then the deflections are gradually reduced until the equilibrium position is achieved. The assessment is performed on the basis of an analysis of the obtained suspension oscillations curve [Sitek 1999].

Testing the shock absorbers using forced vibration method

The forced vibration method consists in the forcing of vertical vibration of the wheel being tested and its suspension above resonant frequency level (16–25 Hz). After removal of forcing input, the vibration are damped by the shock absorbers, elastic elements of the suspension, tire elasticity and finally by resistance to motion in the measuring equipment. The reduction of vibration frequency is accompanied by occurring resonance with the amplitude characterizing the shock absorber condition. The manner of vibration damping assessment effectiveness depends on measuring equipment design. Most often the equipment working on the basis of an analysis of vibration vs. time (BOGE) or analysis of wheel pressure onto the ground is used in diagnostic stations for shock absorbers testing by means of forced vibration method.

In case of the first equipment type, the assessment of technical condition consists in the comparison of measurement diagrams with standard curves for the vehicle and shock absorber under test. In case of the second method the measurement results are compared with the requirements table established by European Shock Absorber Manufacturers Association (EUSAMA).

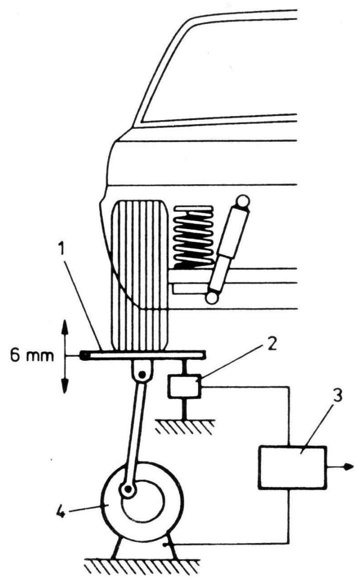

Fig. 2. The diagram of the equipment for shock absorbers testing by means of EUSAMA method: 1 – overriding slab, 2 – strain gauge measuring system, 3 – electronic system, 4 – motor [Trzeciak 2005]

The shock absorbers testing by means of a/m equipment consists of two phases:
- preliminary phase (shock absorber warming up),
- damping coefficient measurement.

Preliminary phase (shock absorbers warming up)

The duration of preliminary phase is about 10 seconds. The phase is carried out at low frequency in order to achieve the correct viscosity of oil filling the shock absorber, because it is essential for an assessment of its serviceability.

Damping coefficient measurement

After the completion of preliminary phase (shock absorber warming up), the essential part of measurement process with the vibration frequency changed smoothly between 30 Hz and 8 Hz. The vibration frequency of the slab is gradually reduced (in steps of 1Hz) by means of optoelectronic converters. Simultaneously, every changed vibration frequency will be stabilized by the converters within the time required for measurement. The analysis of frequency range between 13 and 18 Hz is particularly detailed owing to resonance frequency occurring within that range and associated with the unsprung weight in form of vehicle suspension.

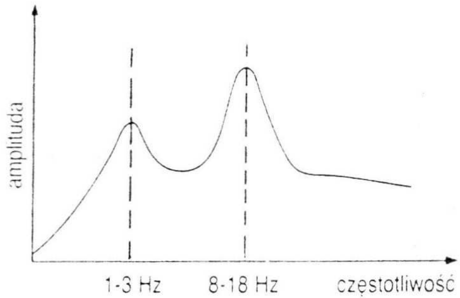

Fig. 3. Vehicle suspension vibrations amplitude vs. Frequency [Sitek 1999]

The forces associated with wheels pressure onto the stand slab are measured for each frequency range in course of the shock absorber compression and tension cycles. Therefore an assessment of the value of sprung weight m_r and unsprung weight m_n as well as calculation of the ratio of both the weights for each vehicle type is possible:

$$a = \frac{m_r}{m_n} \tag{1}$$

An evaluation of wheel suspension condition, to a significant extent depending on the shock absorber functioning, is carried out on the basis of the calculated damping coefficient ξ:

$$\xi = \frac{b}{2 \cdot \sqrt{m_n \cdot k}} \tag{2}$$

where:

b – viscous damping coefficient for the shock absorber,
m_n – oscillating unsprung weight of the suspension,
k – tyres elasticity constant.

TESTING STAND

The diagnostic tests for technical condition of the shock absorbers were carried out for the group encompassing 29 vehicles. The diagnostic tests were carried out at the diagnostics stand SCREEN-TESTLINE 7000 supplied by BEISSBARTH (Fig. 4). The diagnostic line used for testing is classified as so called modular system, enabling fast and complete assessment of the basic systems i.e. the brakes, shock absorbers and toe. The complete diagnosis of technical condition of the vehicle is obtained from the system before its handover to repair workshop. The comprehensive measuring program enables not only the measurement results presentations, but also the graphical representation of measuring process. Additionally, the remote control is possible in case of measurements by means of remote control unit (Pilot) or SUPERAUTOMATIK program can be triggered. Apart from standard printout of measurements protocol, the saving of the testing result in single central data bank is possible in the system by means of workshop network.

Fig. 4. The diagnostic line SCREEN-TESTLINE 7000 supplied by BEISSBARTH [www.precyzja.pl]

Fig. 5. Equipment of diagnostic line STL7000 [www.precyzja.pl]

SCREEN-TESTLINE 7000 consists of the following elements and subassemblies
- central unit – software controlling computer
- brakes testing rollers assembly MICRO-BRAKE 6000,
- shock absorbers testing panels MICRO-SWING 6200,
- side slip testing module MICRO-SIDE-SLIP 6300,
- brake pedal pressure force meter.

RESULTS OBTAINED FROM DIAGNOSTIC TESTS

The diagnostic tests for technical condition of the shock absorbers were carried out for 29 vehicles by means of forced vibration method.

Requirements to be met by the shock absorbers installed in vehicles

The following criterion was assumed for the suspension system (shock absorbers) in EUSAMA method:
- 0 up to 20 % – poor damping efficiency,
- 21% up to 40% – sufficient damping efficiency,
- 41% up to 60% – good damping efficiency,
- above 60% – good damping efficiency.

The difference between the EUSAMA coefficients for LH and RH side of the same axle should not exceed 20%.

Results obtained from measurements and calculations

The results obtained in course of diagnostic tests for technical condition of the suspension system (shock absorbers) in the vehicles subjected to technical condition assessment in diagnostic stations were illustrated in Fig. 6 and 7.

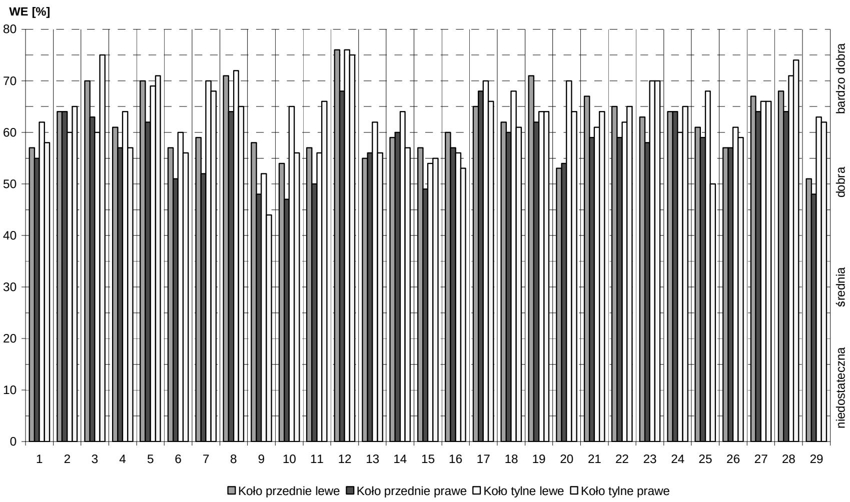

Fig. 6. Shock absorbers damping efficiency – EUSAMA coefficient

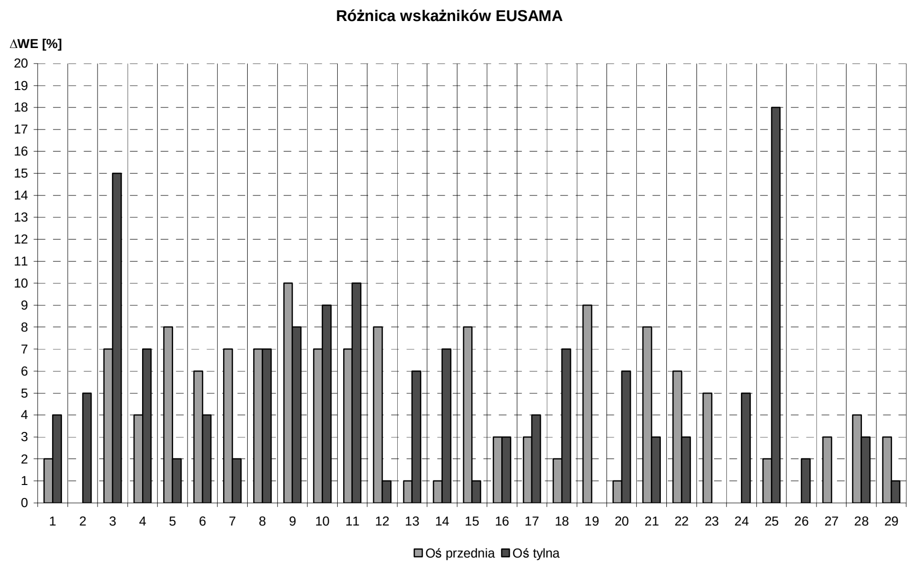

Fig.7. The difference of shock absorbers damping efficiency between the vehicle wheels

CONCLUSION

The following conclusions were drawn from the analysis of the shock absorbers installed in the group of vehicles tested by means of EUSAMA forced vibrations method:

1. EUSAMA (WE) coefficients determining the damping efficiency of the shock absorbers for all tested vehicles are included in the range between 44 and 76%. Therefore good or very good vibration damping efficiency of the shock absorbers was achieved in the tested vehicles.
2. The difference between the EUSAMA coefficients for LH and RH side of the same axle was not greater than 20%,($\Delta WE \leq 20\%$), and for major part of cases was lower than 10 %. Therefore the uniform shock absorbers wearing requirement was also met.
3. Comparing the wear examinations for the shock absorbers installed on both the sides of the same axle of the vehicle, it was detected that the shock absorbers installed on RH side of in major part of vehicles (25 from among 29 for front axle and 20 from among 29 for rear axle) are characterized by higher degree of wear. Such difference is mainly resulted from the unsatisfactory condition of the roads. The condition of the roadways is much worse at their edges (at the walkways, shoulders).
4. The suspension system (shock absorbers) was efficient in all the tested vehicles.

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