TESTING THE INFLUENCE OF CAR LOAD AND PRESSURE IN TYRES ON THE VALUE OF DAMPING OF SHOCK ABSORBERS SPECIFIED WITH THE USE OF THE EUSAMA METHOD

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Abstract

This article contains a short description of available diagnostic methods according to which the technical condition of car shock absorbers is analysed. In Polish diagnostic stands, the devices operating based on Eusama method are commonly used. This method has many advantages, but it also has certain limitations about which the analyst should know. The paper presents the analysis showing how the failure to observe the accepted in regulations way of examining influences the value of damping of shock absorbers.

Keywords: shock absorbers, diagnostics, Eusama method, measurement error

BADANIA WPŁYWU OBCIĄŻENIA POJAZDU I CIŚNIENIA W OGUMIENIU NA WARTOŚĆ TŁUMIENIA AMORTYZATORÓW OKREŚLANĄ METODĄ EUSAMA

Streszczenie

Niniejszy artykuł zawiera krótki opis dostępnych metod diagnostycznych według których analizowany jest stan techniczny amortyzatorów samochodowych. W polskich stacjach diagnostycznych powszechnie wykorzystuje się urządzenia działające w oparciu o metodę Eusama. Metoda ta ma wiele zalet ale posiada również pewne ograniczenia, o których diagnosta powinien wiedzieć. W pracy dokonano analizy jak niedostosowanie się do przyjętego przepisami sposobu badania wpływa na wartość tłumienia amortyzatorów.

Słowa kluczowe: amortyzatory, diagnostyka, Eusama, błędy pomiarowe

INTRODUCTION

Based on accident statistics in Poland [1,2] it is easy to see that the defectiveness of a vehicle has a relatively small impact on the occurrence of accidents. In 2012 there were "only" 155 accidents which can be attributed to defectiveness what – in relation to the whole number of accidents – is only 0.4%. 6 people died in those accidents, and 66 were injured [1]. Most defects which resulted in accidents concerned vehicle lighting – 52.7%, vehicle tyres – 21.8%, and the rest – 25.5% – the steering system, braking and other systems.

When looking at those statistics, we can nevertheless ask ourselves a question: Can we therefore assume that Polish cars are in a really good technical condition? Are the vehicles driving on Polish roads (which are far from the roads we can see drivers use in more developed European countries) and those which on average are more than 10 years old really in a good working order? Does the said condition of the roads and a relatively small technical awareness of drivers have no influence on the technical condition of cars? The cause of an accident, apart from obvious examples, is usually the series of many different factors which can occur at a given moment and in a given place.

Shock absorbers are one of the most important elements of the suspension of cars which significantly influence their safety of movement. The purpose of shock absorbers, as everybody knows well, is not only to increase the comfort of driving (damping the vibrations), but first of all to ensure permanent contact of a wheel with the road. They prevent the wheel from being pulled away from the ground when driving over road bumps. For maintaining permanent contact of the wheels with the road is the necessary condition for the proper operation of other very important systems, e.g. braking or steering systems.

One has to realize that even the "best working" brakes (diagnosed during a technical servicing, e.g. on a roller stands) may turn out to be useless when the wheels will not be in proper contact with the road surface and it will be so in the case of damaged shock absorbers. Hence, shock absorbers belong to the group of sub-assemblies in a vehicle which are particularly responsible for the safety of the vehicle in motion, despite of the fact that many drivers neglects their importance. During the

technical tests, particular attention is usually paid to the values of braking forces, or if the suspension is loose, while the values of damping forces of the shock absorbers (their efficiency) are sometimes treated as "less important".

The assessment of the technical condition of shock absorbers made by the same driver usually includes the assessment of damping of the vibrations of the body after the force ceases and verifying them organoleptically which is limited to specifying if there are any leaks. However, such observations are not sufficient.

1. TESTING THE TECHNICAL CONDITION OF SHOCK ABSORBERS

All registered cars moving on Polish roads are subjected to periodical diagnostic testing the scope of which is specified in many regulations, among others, in the Regulation of the Minister of Transport, Construction and Maritime Economy dated 26 June 2012 "On the scope and manner of conducting technical tests of vehicles and drafts of documents used for such tests" pursuant to Art. 81 section 15 of the Road Traffic Act dated 20 June 1997 (Dz. U. [Journal of Laws] of 2005 no. 108, item 908, as amended)) [3] and in the Announcement of the Minister of Transport, Construction and Maritime Economy dated 6 June 2013 "On the way of announcing the consolidated text of the regulation of the Minister of Infrastructure "on the technical conditions of vehicles and the scope of their necessary fittings" organizing the Regulation of the Minister of Infrastructure dated 31 December 2002 "on the technical conditions of vehicles and the scope of their necessary fittings" pursuant to Art. 66 section 5 of the Road Traffic Act dated 20 June 1997 (Dz. U. [Journal of Laws] of 2012 item 1137 I 1448 and 2013 item 700), and subsequent amendments [4].

The legal regulations specify in detail the procedure of checking the effectiveness of damping of shock absorbers in car suspensions. It was included in Schedule no. 2 to the Regulation [3]. So that the measurement of the effectiveness of damping of shock absorbers could be considered as correctly conducted:

- an diagnostician should, before taking the measurement, verify and possibly adjust pressure in tyres to the nominal value recommended by the producer,
- the examined car should not be loaded (except for the driver's weight), while in the case of a car having own weight smaller than 900kg for which the load of the rear axis is allowed, it should be loaded with the weight equal to two people [3].

Such relatively simple requirements are unfortunately not often observed during diagnostic testing what may unfortunately lead to errors in assessing the technical condition of various sub-assemblies, including shock absorbers.

2. RANGE OF RESEARCH

Tests of effectiveness of shock absorbers were conducted on Bosch Beissbarth diagnostic line equipped with a "Device for the control of shock absorption of axis SA640" presented in Figure 1. The device operates based on a commonly adopted in diagnostic stands Eusama Method (**EU**ropean **S**hock **A**bsorber **M**anufacturers **A**ssociation) –The device with the use of the kinematic system generates vibrations of plates up to control frequencies of 25Hz of constant amplitude (in this case the value of 6mm). Wheels rest on control plates equipped with the system measuring the load - see Figure 1. After the wheels of the examined axis drive onto control plates the measurement of their static load and kinematic release of their movement is made.

After achieving the assumed frequency of vibrations, the system releasing the movement of control plates is deactivated and a gradual damping (suppression) of vibrations (connected with the operation of a shock absorber) occurs. Simultaneously, the load of the wheels on the control plates of the device is dynamically measured.

Fig. 1. The vehicle wheel on the control plates

The indicator specifying the effectiveness of damping of shock absorbers in this method is **Eusama Value (EV)**, (Figure 2) determined as the quotient of static load of the examined wheel onto the control plate to the minimum dynamic load on that plate [6]. In this way the effectiveness of damping of shock absorbers can be specified, which is determined with the measure of "effectiveness of damping" of shock absorbers equated with preventing a tyre from tearing away on possible road bumps.

Eusama method replaced the commonly used in 1980s and 1990s of the previous century Afit-Boge, amplitude - frequency method. At present, the Eusama method is most frequently used for testing shock absorbers in diagnostic stands.

Fig. 2. Presentation of test results

In the previously used Boge method the effectiveness of operation of shock absorbers was specified depending on the value of amplitude of vibrations in the vibration zone of the resonance frequency (when damping the vibrations). The assessment of the effectiveness of shock absorbers according to that method was based on a simple dependence that the biggest the value of the amplitude the lower the effectiveness of damping of a given shock absorber. The main problem in using that method did not consist in the manner of taking the measurement, but in the way of assessing the obtained results. Due to the diversity of vehicles and their types, there occurred a serious problem with the access to relevant technical data. In order to assess the effectiveness of operation of a shock absorber, a specific numerical value of the amplitude was needed after exceeding which, it would be possible (for a given vehicle) to consider the shock absorber installed in a vehicle defective.

At the moment of proposing, the Eusama method very quickly gained popularity. It eliminated the inconveniences connected with the analysis of results obtained with the Boge method and it allows for the quick comparison of the technical condition of shock absorbers of various vehicles. More importantly, it could be done without the necessity to have any technical data of an examined vehicle. For it was enough that the vehicle drove with its wheels onto control plates and the measurement was made of the static load of each wheel of the examined axis.

The simplicity of measurement (caused the deceptive feeling of an ideal measurement) resulted in high popularity of this method, despite the known disadvantages and limitations in using it. The limitations of this method include: small amplitude of control plates of the device (usually in the scope 4÷6mm) and a strong impact of various factors for obtained values of the effectiveness of damping of shock absorbers, e.g. pressure in tyres, space and dry friction in suspension or even the sprung weight of the examined vehicle.

Many articles have been published on the limitations of that method. In paper [9] it was indicated that the result obtained in that method very strongly depends also on the amplitude of control plates. As a result of the simulation, with the change of the plates amplitude from 1 to 7 mm, in an examined vehicle make Fiat Cinquecento the EV (**E**usama **V**alue) changed in the scope from 90% to 0%. The same shock absorber installed in a vehicle could then be considered very good, even ideal in one case, and in some other case (examining the test stands of other force amplitude) it could be considered as bad. The producers of diagnostic stands which use this method do not publicize that problem, but it is well known to analysts in diagnostic station. The producers of diagnostic stands who adjusted the plates amplitude to a certain "type" of examined vehicles, e.g. of heavy weight, only vaguely inform that the diagnosis of shock absorbers of light cars may not be correct. Unfortunately, during tests they recommend adding load to such vehicles when testing them. Similar analyses were also described in papers [5, 8].

The aim of the conducted and described in the article diagnostic tests was to attempt to answer the question: how the conditions of measurement or the way of conducting tests (including failure to observe the binding legal regulations) influence the value of indicator EV of damping of shock absorbers?

The tests were conducted on four chosen vehicles of different own weights. During the tests the effectiveness of damping of shock absorber - EV value - was measured in several variants:

1. pressure changes were made in car tyres, both above (up to 30%) as well as below (up to 50%) the nominal value of pressure recommended by the car producer,
2. changes of additional loads in a car were made.

In the first case, a situation was simulated in which an analyst abandoned the control of pressure in tyres in a diagnostic station. In the case when it was not correct, they could just not refill the air in tyres, or much more seldom, when they did not decrease the pressure.

In the second variant of the tests (despite the method measures the static pressure of tyres), the impact of an additional load of the vehicle on the value of the effectiveness indicator of damping of shock absorbers EV was simulated on the indicated diagnostic line.

Such additional load may be the result of installing in a vehicle specialist development or sub-standard fittings, such as: sound, gas system, safe in bank-vehicles, etc.

3. RESEARCH RESULTS

The tests of the effectiveness of shock absorbers were conducted for four vehicles: Skoda Felicia, Seat Toledo, VW Caravelle and Audi A4.

The results of relative changes of the value of the indicator of EV shock absorbers damping for front axis of vehicles are shown in Figure 3. In the considered scope of changes of pressure in tyres, it is easy to observe that the lower the pressure in tyres the higher the value of damping indicator of shock absorbers - EV. Assuming the effectiveness indicator of damping EV as the initial value for nominal pressure in tyres (characteristic for a given car), its relative change was determined. The value of damping indicator EV for shock absorbers on front axis wheels increases together with the decrease of pressure in tyres even by 35%. It must be remembered that the increase of the damping indicator EV resulted in that case only from the change of pressure in front tyres.

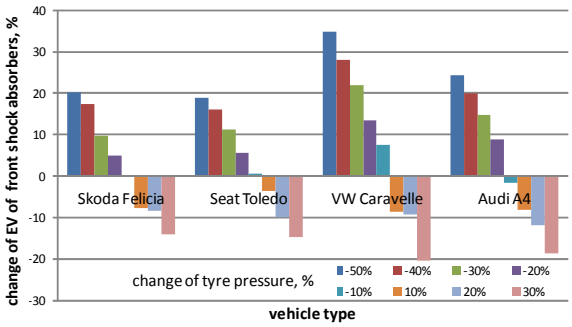

Fig. 3. The change of the EV damping indicator of front shock absorbers depending on pressure in tyres

Too high pressure in tyres may decrease the value of the EV indicator of shock absorbers by approx. 20%. In many vehicles in such a situation there might appear a problem as the producers recommend the change of air pressure (increasing it) in tyres, together with its load (transported people and baggage). In the case of diagnostic tests of a vehicle prepared in such a way for a journey (according to the recommendations), the value of indicator of shock absorbers decreases, though to a smaller degree for by approx. 20%.

In this situation, familiarity with the operating instructions of the vehicle and the described in it necessity of systematic adjustment of pressure in tyres to the existing driving conditions are an important operating issue in modern vehicles.

Relative changes of damping indicator EV of shock absorbers installed on rear axis of a vehicle depending on pressure in tyres are presented in Figure 4.

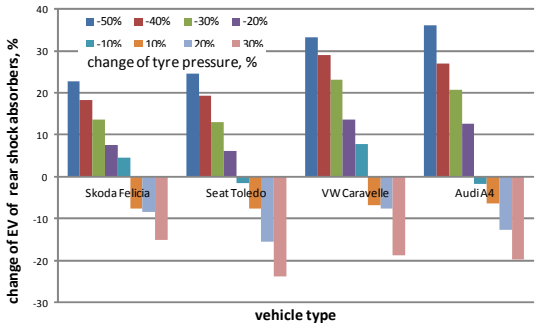

Fig. 4. The change of the EV damping indicator of rear shock absorbers depending on pressure in tyres

Analysing figure 4 it can be noticed that for examined vehicles the impact of pressure in rear tyres on the value of damping indicator EV of shock absorbers is high. In this scope there is a big qualitative similarity in comparison with the analysed shock absorbers of front axis tyres. Relatively the most "sensitive" to the change of the value of pressure in tyres were in this scope heavier vehicles VW Caravelle or Audi A4. The change of the values of damping indicator EV of shock absorbers read on a diagnostic line for lower values of pressures in tyres may relatively exceed even 30-35%. These are the changes which should not be omitted.

Figure 5 presents the dependence of the change of value of damping indicator EV of shock absorbers of front axis on the load of a vehicle. The weight of a vehicle compliant with the requirements, i.e. own vehicle weight plus driver weight (75kg), was adopted as the initial value.

In the case of front axis of a car in which the pressure of front axis wheels on the road surface is not subject to significant changes together with the change of vehicle load, the change of the EV indicator of damping the shock absorbers is small. Therefore, it can be stated that the load of a vehicle, in this case does not have a bigger influence on the value of damping indicator EV of front axis shock absorbers. Together with the increase of tyre load, only few percent increase of the value of indicator of damping EV is observed.

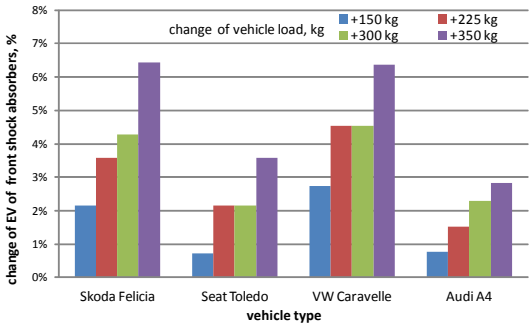

Fig. 5. The change of EV damping indicator of front shock absorbers on the load of a vehicle

A situation is different in the case when we consider the impact of car load on the value of EV damping indicator for shock absorbers of rear axis of the vehicles. Relative changes of damping EV indicator are shown in figure 6.

Analysing the received diagrams, it can be stated that the influence of vehicle load on the value of damping indicator EV for rear axis wheels is very big. In this case the relative change of the value of damping indicator of shock absorbers measured with the Eusama method may be an increase by even several dozens of percent.

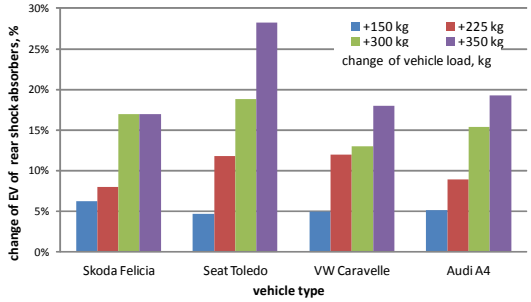

Fig. 6. The change of EV damping indicator of rear shock absorbers on the load of a vehicle

CONCLUSION

Based on the conducted analyses, we can confirm that the value of the damping effectivenes indicator of shock absorbers measured with the Eusama methods EV (Eusama Value) can bear a significant error.

Possible abandoning of pressure control in tyres by an analyst in diagnostic station may result in a relative increase of obtained values of the EV indicator of damping of shock absorbers (in critical cases) of more than even 40% (in the case of lower values of pressure in tyres). One has to realize that the observed dependences are characteristic for the examined vehicles. For other types of vehicles it might look a bit different, but the differences may be of rather quantitative nature.

It is worth to note the fact that the Eusama method, so widely used in diagnostic stands, being significant and what is more important known to a wide circle of specialists, may be used by dishonest drivers for "artificial" increase of obtained values of EV damping indicator, for instance in order to avoid expensive repairs. For the decrease of pressure in tyres generates a significant change of the EV damping indicator.

Hence, we can ask a question: If the results of the tests of effectiveness of shock absorbers carried out with the use of the Eusama method with such simple operations as for example the change of pressure in tyres differ so significantly, then is it necessary to use it at all? The premises which were for introducing it, i.e. the simplicity of the method and the quickness of the diagnosis, can of course be considered important. Nevertheless, if the limitations of using the method are known, all the more during the tests one must absolutely observe the binding regulations pertaining to the way of taking the measurement.

As indicated in the article, the value of the indicator of shock absorbers also depends on the vehicle weight. In the case of shock absorbers on front wheel axis, the increase of vehicle weight (above the assumed in the regulations) does not cause the significant increase of the value of EV damping indicator of shock absorbers. The scope of changes considered in vehicles in this scope did not exceed 5% for the analysed vehicles, hence we may say that in practice it can be omitted.

In the case of the analysis of the impact of vehicle weight on damping effectiveness of rear axis tyres, it indicated that the increase of vehicle weight causes a significant (even by several dozens percent) increase of the value of EV damping indicator of shock absorbers. So, when diagnosing shock absorbers, the increase of the vehicle weight with baggage, full fuel tank or a full LPG cylinder may "significantly change" the obtained values of EV damping indicator. Even though the tests were conducted only for 4 chosen vehicles, we can expect that similar dependences will occur for other cars what can be confirmed by other research [4, 6] conducted by other authors.

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