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EVALUATION OF DAMPERS USING A RESONANCE ADHESION TESTER

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Abstract

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This paper describes the diagnostics of dampers using resonant adhesion tester. This kind of test is non-invasive and evaluation is based on the EUSAMA methodology. The main goals of this method were to practically measure and evaluate technical condition of the shock absorbers. However, this method does not measure only damper properties, but the whole axle, too. During measurements, one must take into account the fact that the results can be easily influenced by external factors. These include e.g. wrong tire pressure, different kind of shock absorbers, and tires. The actual testing revealed that the measurement results are also influenced by bad condition of the vehicle axles. If we eliminate all these draw-backs, dampers testing can be very accurate.

damper, on-vehicle diagnostics, EUSAMA, Tritec

In general, properly tuned chassis represents a vital component of road vehicles. Without it, the ride is too stiff and uncomfortable for the crew. However, the system of springs cannot prevent spontaneous vibration the vehicle body during driving over uneven road surfaces. Therefore, each wheel is fitted the shock absorbers. These so called dampers form one inseparable assembly together with the suspension. Installing of dampers can provide better vehicle handling and safety during driving. It can affect tire tread wear as well (Klůna, Košek, 1990). It was found that defective or faulty dampers while driving 60 km/h extended braking path of the vehicle up to 2 m. Thus, shock absorber is a very important part of the car chassis and should be examined and maintained carefully. A proper diagnostics of a damper is difficult and often impossible without special equipment that exactly determines source of the fault. A general rule is that a faulty damper cannot be usually repaired and must be replaced with a new. During a visual check, we can only check the status and integrity of the dampers mounts in the vehicle body, gripping rubber, oil leakage from dampers and noise while driving (Motejl, Horejš, 1998).Conventional dampers work on the cataract principle that is pressure-moving of oil from one chamber to another through a hole. Size of the hole determines the flow of the oil and the effectiveness of dampers (Jan, Ždánský, 2000). There are many methods that can be used to measure the size of the damper wear. Each of them has got advantages and drawbacks. The methods can be divided into disassembly and non-disassembly test groups. Disassembly process means that the complete damper is removed from the vehicle and inserted into a special device. Then, the condition of damper is graphically recorded and evaluated. This test is very exact, because it measures only the damper itself. However, it is time-consuming and very expensive, that is why it is not usually used for ordinary road vehicles. The main disadvantage is that the damper is not removed easily from the McPherson axle assembly. After reassembling, the steering geometry must be adjusted anew. We often use non-disassemble damper test, which is faster and less time-consuming. Unfortunately, this test type may not be as accurate as the previous method. The main drawback is that the test is performed on the vehicle axle, which is composed of many parts. They may show traces of fatigue and wear. These deviations can be subsequently reflected in the test results. Thus, we can only test cars with 100% axle condition, with no axle clearance and tires with inflated to the recommended pressure (Vlk, 2006).

MATERIALS AND METHODS

Measurement of dampers was done using the Tritec device with a resonance adhesion test. This non-disassembly test complies with the European methodology EUSAMA. The tester has small overall dimensions and it is rather intended for occasional use in smaller repair shops. The equipment consists of computer equipment (netbook + converter) with software and a mobile oscillating platform in a metal frame on which are mounted Casters and handle. The platform is on one side connected to electric motor with an eccentric shaft and the opposite side is stored in the pivot. Circular cam oscillating alternately lifts the platform with car wheel up to a frequency of 25Hz. Under the platform, there is a tensometer, which is sensing force pressure. Lift height is reduced to 3 mm compared to other devices (having 6 mm). This displacement enables even measurement of a very light car, because the vehicle on the platform is standing still. Figure 1 shows simplified schema of the measuring device.

Prior the actual measurement, it is necessary to check air pressure in all tires according to manufacturer, defects and clearances in all axles, and also to calibrate the tensometric scales. Measurement was carried on five vehicle sample group. On each car, left front (LF) wheel was measured 3 times right rear wheel 3 times as well. All the wheels were at first weighed by the tensometer (this represented the 100% adhesion condition). Then, the motor was started and brought to operating rpm and immediately turned off. The software recorded data from the moment the motor was turned off until its spontaneous stop. In this short time, change of pressure on the vibrating surface was being monitored. If the force on the pad is high, the damper works properly and is fully functional. When the force is too low on the pad, the damper does not work well (i.e. is not fully functional). Sensitive tensometer continuously transmits a signal in mV to the converter and then to the netbook. The DEWESoft user interface allows for viewing of online values, running the analysis, data recording, and exporting to a memory card or USB drive. Measured values are calculated according to the following equation 1.

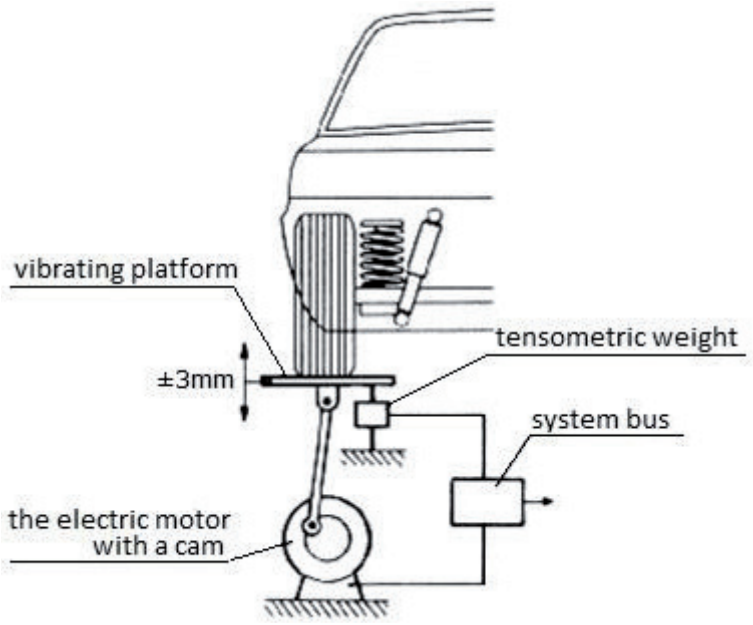
$$EUS = \frac{2F_{Smin} - F_{ST}}{F_{ST}} \times 100, \quad (1)$$

EUS [%] ... measured value by EUSAMA
F_{Smin} [N] ... minimum contact force wheel on the platform
F_{ST} [N] ..... static contact force wheel on the platform.

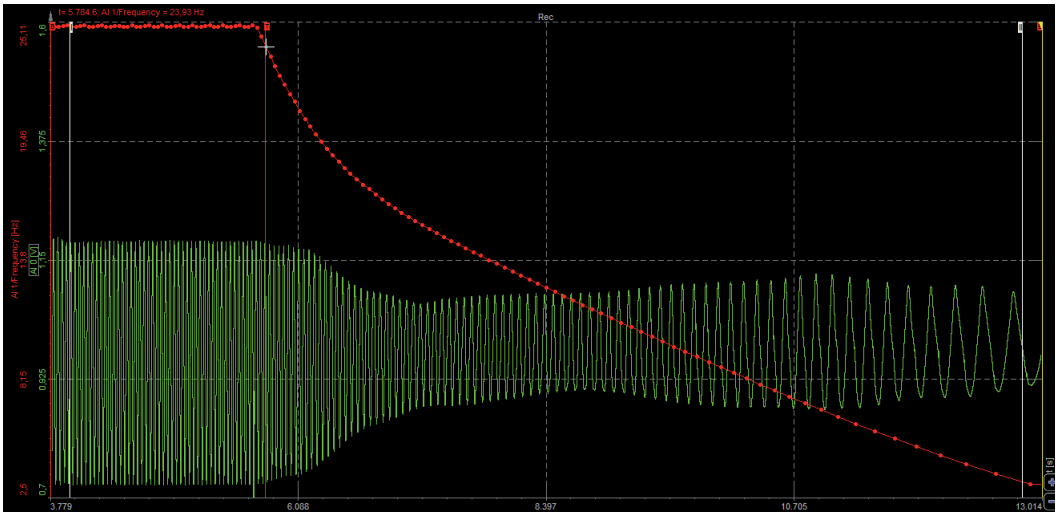
The test result is presented in % and compared with the following table compliant to the EUSAMA methodology.

I: *EUSAMA Classification Criteria*

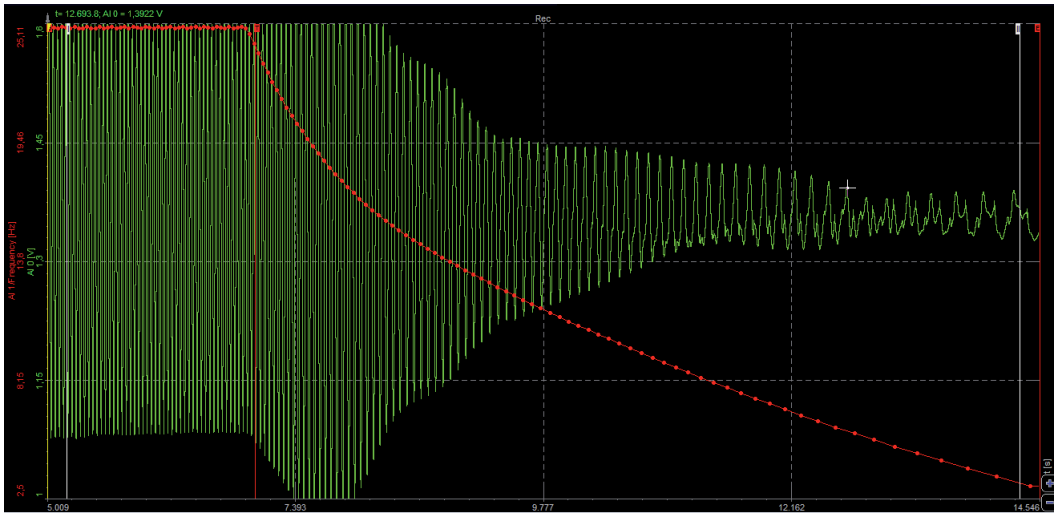
Minimum measured adhesion in [%]	Classification of damper
61 and more	Excellent
41–60	Good
21–40	Satisfactory
1–20	Unsatisfactory
0	Bad (ineffective)



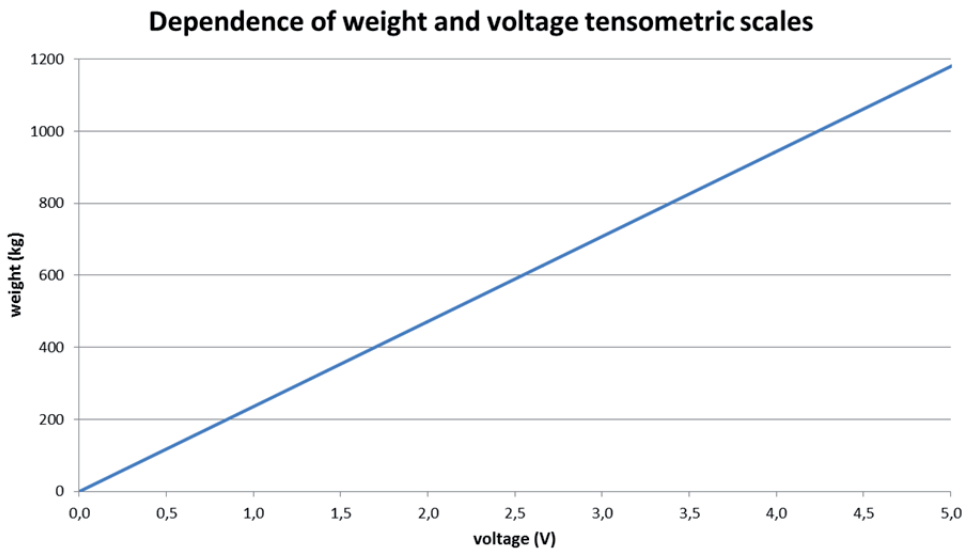
1: *Scheme measuring device (http://www.vutbr.cz/www_base/zav_prace_soubor_verejne.php?file_id=65834)*



2: *RR damper of Toyota Carina vehicle (correct function)*



3: *LF damper of Toyota Carina vehicle (bad condition)*



4: *Graph of voltage and weight on tensometric sensor*

RESULTS AND DISCUSSION

Defects of dampers can be typically found at a frequency of 15Hz. In real life conditions, we deal with a range of 12–16Hz, because the measurement is greatly affected by the correct pressure and tire type, type of damper (e.g. exchange for sport type), and weight of the vehicle. Figs. 2 and 3 show the characteristics of the dampers in good and worse condition. Condition of right rear damper (see Fig. 2) was classified as excellent. The curve has got the correct shape.

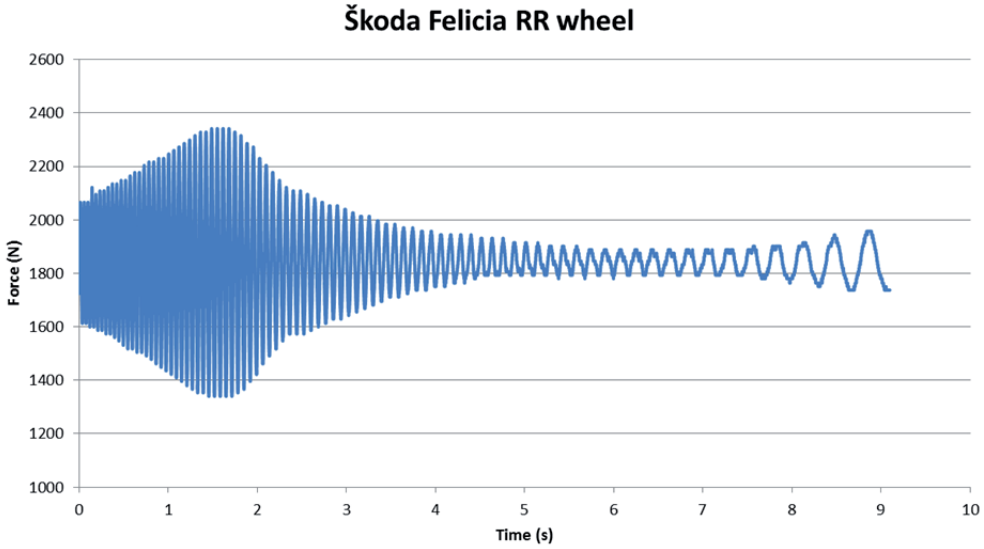
Figure 3 shows right front damper, which was classified as good. During the test, a loud metal-to-metal knocking sound was audible. This was the first indices that something is wrong. The resulting curve was deformed by this defect. Thus, we could find undesired clearance in wheel hubs or worn out elements (e.g. silent block) using this simple tool. The tester classified the dumper as usable, but the actual state of the damper may be different. Therefore it would be necessary to perform a new test after the vehicle repair.

Evaluation is done by the software, which determines the resonant frequency by comparing of previous and current minimum weight. Every change of weight on the sensor results in change of electrical resistance and variation of voltage. The voltage then corresponds to the force/weight. The linear characteristic of the tensometer with weight and voltage is shown in Fig. 4.

Fig. 5 shows graph of time and force on the right rear damper of Škoda Felicia vehicle. It is obvious that the damper is worn-out. An oil leak could be seen on the damper case.

Further measured values including evaluation are presented in Tab. II.

Tester classified the dampers on Ford Mondeo as excellent (i.e. in perfect condition). The Renault Scénic fully met the test requirements as well and its rear dampers received the highest value of 85%. The reason for such a good result is that the old dampers leaked oil and were replaced with new Monroe dampers in 2012 (they had only 45 000 km of operation). This vehicle has a high yearly mileage and the front dampers are expected to start leaking soon (they are still original). Mazda 2 is in good condition. This vehicle has been used mainly in the city. Due to the year of manufacture 2007 and the resulting value, the dampers on this vehicle will serve a long time. Front damper of Toyota Carina reached value of 52%. This is not alarming, but during the test, a metal clicking sound was heard coming from wheel assembly area. Damper tester measured each wheel together with axle and it revealed a defect there. According to the methodology, only axles without defects and in perfect condition can be tested using the device. To



5: *RR damper of Škoda Felicia*

II: *Evaluation of the measurement and classification*

	Front axle of the left wheel			Rear axle of the right wheel		
	Weight [kg]	EUSAMA [%]		Weight [kg]	EUSAMA [%]	
Ford Mondeo I 2.0	391	Excellent	73	292	Excellent	79
Renault Scénic I 1.6	328	Excellent	68	304	Excellent	85
Mazda 2 1.3	315	Excellent	78	165	Excellent	74
Toyota Carina 1.6	318	Good	52	253	Excellent	75
Škoda Felicia 1.3	292	Excellent	68	186	Unsatisfactory	37

obtain proper undistorted values, the measurements should be repeated after the problem is fixed. Rear damper passed the test with a sufficient reserve. The measurement was probably influenced by extra weight of full 45l LPG tank over The tank could not be removed and so measurements was carried out with this extra load. The last vehicle subject to the test was Škoda Felicia. The test revealed the front damper was in excellent state. However, rear damper leaked oil and reached only value of 33%. The damper will have to be replaced in near future. Obviously, it is always vital to replace both dampers on the same axle. Otherwise, the ratio of the damper effectiveness on one axle would exceed 15% and the new damper would be worn out prematurely.

SUMMARY

This paper deals with testing of dampers on resonant adhesion tester. It was verified that under specific conditions, this less common on-vehicle method can be used to evaluate the state of dampers. The main advantage is that it is not necessary to get the damper removed and clamped into a special device. Test of dampers is very simple and the evaluation is ready in an instant. The whole set is quite mobile and can transported by car to a different site. These features of the device predetermine the method for use in small workshops. The disadvantage of the procedure might be that it cannot provide reliable results in situations where there is a defect on the axle assembly. These can include e.g. excessive clearance in wheel hub and torn off silent blocks etc. On the other side, the device can also be used to detect faults on the axles. Before measuring takes place, it is always necessary to check correct tire pressure and take into account different types of tires, because these factors have influence on measurement results.

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