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ANALYSIS OF THE USE OF OBD II / EOBD CONGESTION DIAGNOSTICS IN THE LIGHT OF VEHICLES OPERATION AND THEIR TECHNICAL CONDITION

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Abstract

Transport in human life has played a key role since ancient times. At the turn of years it has evolved, initially using only the power of human legs, then the animals until use internal combustion engines. The first internal combustion engine was presented by Brackenburow in 1836. The construction showed a very desirable type of combustion engine – burning a mixture of hydrogen and oxygen and expelling clean water as exhaust gas. However, the invention was abandoned due to its innovativeness and lack of trust in it. The topic was again taken in 1860 presenting a two-stroke engine using a mixture of natural gas and air with spark ignition. Striving for even greater perfection, Rudolf Diesel in 1893 presented and patented the first self-ignition diesel engine. The first solution, although used today, has shown that automotive engines leave a significant margin of reliability.

The operational reliability of internal combustion engines is important in relation to the conditions of their operation and technical condition. The impact of toxic substances in exhaust gases and their impact on the natural environment these days is an important issue.

One of the forms of work on the problem is the current diagnosis of engine operation. This was possible thanks to the use of the OBD I system, which was later transformed into OBD II / EOBD and the result of the test results obtained to the applicable EURO standards. The system allows testing during a road test in normal car operation. Using the OBD recorder, the operation of an example vehicle will be analysed in various operating conditions, and the obtained results will provide diagnostic possibilities.

Keywords: *on-board diagnostics, diagnostic procedures, OBD, OBD II, EOBD, reliability of engines, operation of engines*

1. Introduction

The purpose of OBD II / EOBD on-board diagnostics will be presented in terms of the use of an analysing system for vehicle performance parameters in mobile car diagnostics. Using the OBD recorder, selected passenger car will be tested and the results will be analysed regarding to diagnostic possibilities. The necessity to comply with current and future ecological requirements will force car manufacturers to produce specific parameters [6].

2. Development of the on-board diagnostic system for passenger cars

The on-board diagnostic system for passenger cars was created in the 1970s. By implementing the OBD system, it was possible to quickly find damage that occurred due to exceeded emissions. Thanks to the use of the system, it has become possible not only to diagnose the vehicle in terms of engine operating parameters, but also to repair damaged elements and assemblies on a current basis [4].

As a result of the need for an improved system, the OBD II system was developed to diagnose engine performance parameters, in Europe called EOBD [7]. The characteristic feature of this system is its 16-pin connector (it has been normalized according to standards ISO 15031-3 / SAE J1962) [9], minimum two lambda probes and an approval label located in the radiator area of the car. An important issue is the fact that when the system was introduced to the European market, car manufacturers were required to install the connector in the vehicles. A significant advantage of this system is not only the detection of defects, monitoring and controlling vehicle's engine operation, but also informing about upcoming dates of replacement, repair, or technical examination.

We also hear about OBD III term more often. A car on-board diagnostic system fulfils the same functions as its previous versions. It has been improved with an automatic contact feature and information option (emergency services, vehicle workshops, etc.) [5]. It is possible due to full satellite control of the vehicle [2, 8].

3. Course of the study

The test was carried out in spring conditions, temperature of ± 2°C and barometric pressure in the range of 99-100 kPa. The examination lasted each time from 10.00 to 12.30, which allows minimizing the differences resulting from atmospheric conditions during the test. The speed at which the vehicle moved did not always corresponded to the permissible speed in a given place and time, and was adjusted to the speed of other road users. Course of this study is based on four test drives that had been made. Each of the tests examines other parameters:

- The type of routes driven in the city and beyond the city,
- Characteristics of the engine during normal driving and driving in sports mode.

In this way two drives will be obtained on the same route in the urban cycle in regular and sports mode, and two drives on the beyond the city route in the regular and sports mode.

The tested vehicle is the Audi Q5 from 2014. Engine parameters:

- 2.0 TDI engine,
- 190 HP engine power,
- Mileage 60,000,000 m,
- Tiptronic 8-speed gearbox,
- Vehicle weight 1800 kg.

Route in the city included nearly 11 km and included following streets (Fig. 1 a): Mariana Langiewicza Street – Józefa Sowińskiego Street – Racławickie Avenue – Krakowskie Przedmieście – Hugo Kołłątaja Street – Jana Hempla Street – Ignacy Mościckiego Street – Rusałka Street – Zamojska Street – Unii Lubelskiej Avenue – Lubelskiego Lipca Roundabout – Unii Lubelskiej Avenue – Romana Dmowskiego Roundabout – Podzamcze – Walecznych Street – Gen. Władysława Andersa Street – Mieczysław Smorawiński Avenue – Józefa Poniatowskiego Street – Józefa Sowińskiego Street – Mariana Langiewicza Street. Route beyond the city entering the Solidarności Avenue at the junction with Warszawska Avenue and drive in the direction of Warsaw up to 105.4 km DK 17 (Fig. 1 b).

4. Analysis of test results

During the measurements, the OBD II / EOBD recorder measured 19 following parameters: elements:

- Vehicle speed,
- Engine speed,
- Gas pedal position,
- Water temperature,

- Engine load,
- Air mass flow,
- Air temperature,
- Air intake pressure of the collector,
- Battery voltage,
- Proportion of the O2 sensor (B1-S1),
- The value of the sensor O2 intensity (B1-S1),
- Fuel rail pressure,
- Barometric pressure,
- Voltage of the control module,
- Relative position of dampener,
- Temperature of the ambient air,
- Accelerator D pedal position,
- Accelerator E pedal position,
- Dampener engine control.

Fig. 1. Route in the city and beyond [Google/maps]

The tester enables the diagnostics of all types of vehicles compatible with the OBD II / EOBD data transmission [1]. The travel time of regular and sports mode was similar.

During regular driving, it was less than 1740 seconds, exactly 1734 seconds with an average speed of 6.24 m/s. This gives a total of 10,822 m. The average engine speed was 1159.7 rpm. On the other hand, the average engine load indicated 41.22% with an average pressure of the gas pedal in 58.79%. The water temperature was in the range from 84 to 92°C, which gave an average of 90.96°C for the entire measurement. Driving the same route in the sports mode, the journey time was 1840 seconds at an average speed of 5.59 m/s. The distance that has been covered is 10,782 meters. The average rotational value indicated 1378.7 rpm. The engine load gave an average of 37.3% and the gas pedal was pressed at 60%. The water temperature remained at a similar level and equalled 91.15°C. The results of the measurements are shown on Fig. 2.

Duration of the rides does not differ a lot, and with the large variation of road conditions in the city, it can be assumed that the data did not differ in any way.

The distance travelled was similar but not identical. The difference was 40 m, which gives a change in the length of the route by 0.02%. This was caused by a slightly different movement of the car itself while driving (different widths of overcoming curves, variable overtaking frequency, or a slight measurement error).

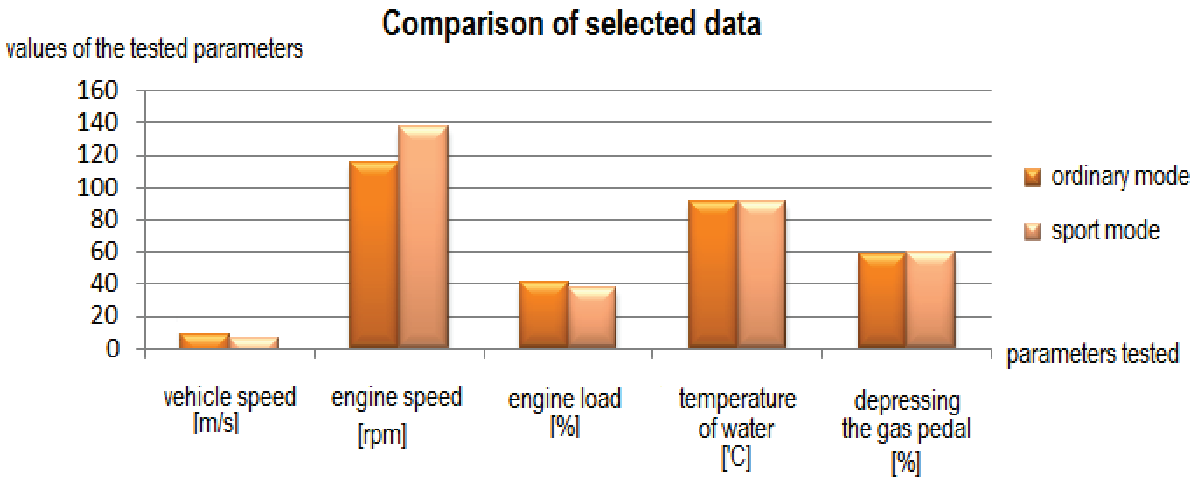

Fig. 2. Comparison of selected data (engine revolutions x10)

The average speed was higher when driving in regular mode and it was 6.9% more than sport mode. The engine load increased by 10.5%.

Engine speed value gave a large difference in measurements. During regular drive, the average was 1159.7 rpm and in the case of a sports mode it grew to 1378.7 rpm, which gives an increase of almost 19%.

Pressing accelerator pedal while driving the sports mode was slightly higher, which theoretically translated into slightly better dynamics of driving. This factor increased by 2% compared to normal driving. In addition, temperature of the water was at a similar level. During sports, driving it was only 0.19°C warmer, which translates into an increase of 0.2%.

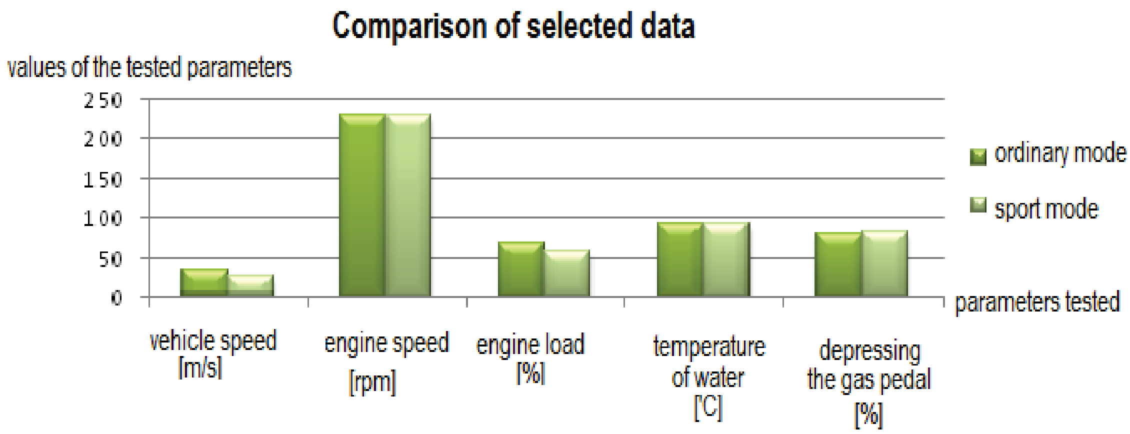

Fig. 3. Comparison of selected data (engine revolutions x10)

In case of travelling this route by car, the situation is as follows:

The whole route in one direction was approximately 39 000 m. While driving in regular mode, the car moved with an average speed of 37.75 m/s and the entire journey lasted just over 1033 seconds. The vehicle driven is 38.781 m during this time. The average value of engine revolutions were 2292 rpm during the test with a gas pedal pressing level of 81.5%. The engine load during the test was 68.2% and water temperature was on average at 92.7°C.

On the way back, driving in sports mode, the car moved at an average speed of 36.12m/s for 1081 seconds, which gave the distance of 39.218 meters. The average engine revolutions were 2298 rpm with 82% gas pedal pressing level. The engine load was at 59.5% and water temperature was 92.2°C. The results of the measurements are shown on Fig. 3.

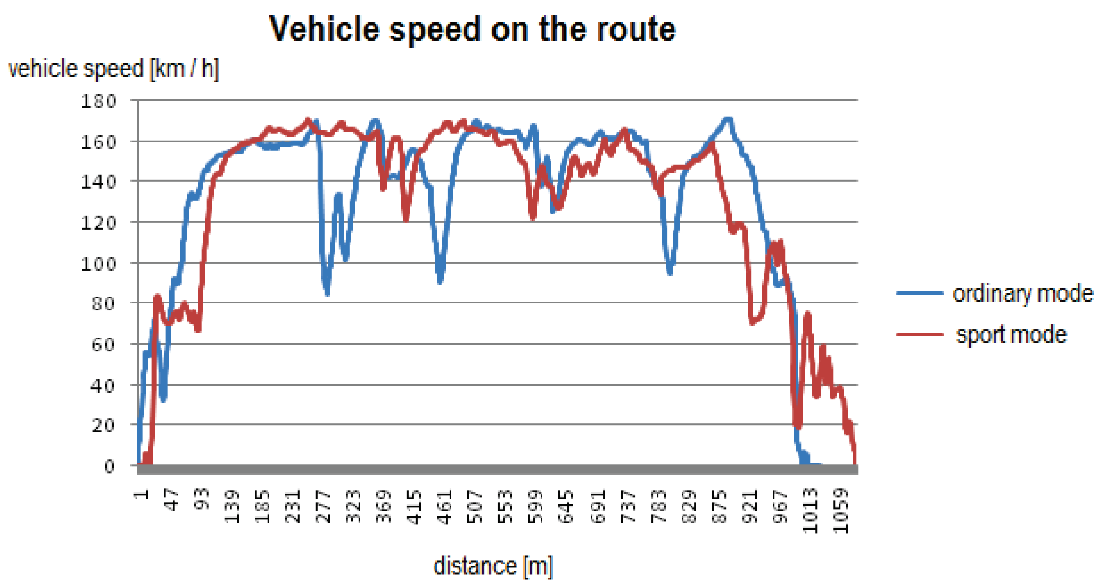

Fig. 4. Vehicle speed on the route

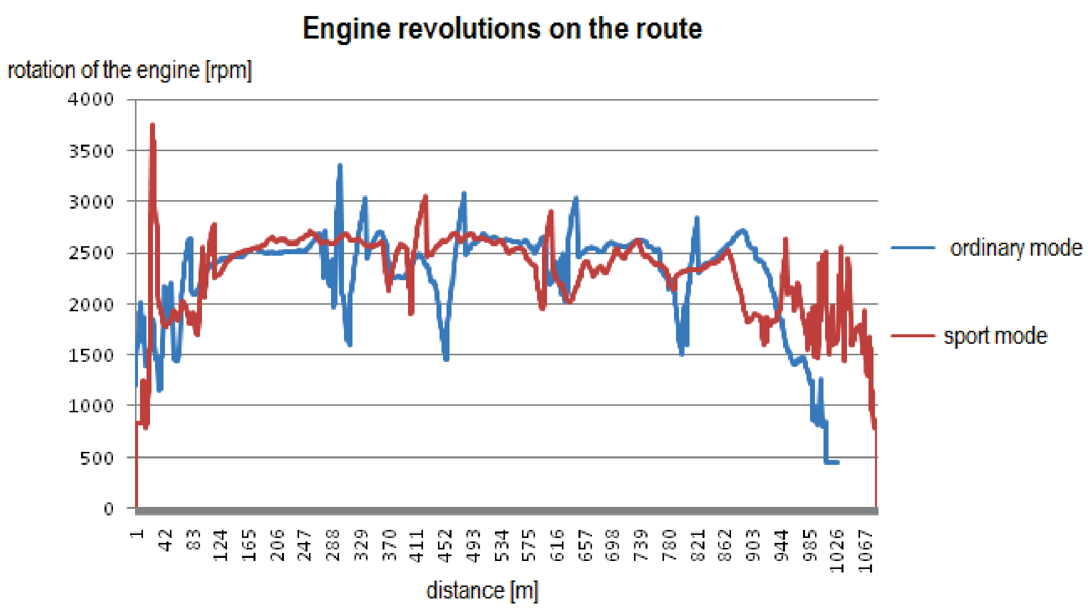

Fig. 5. Engine revolutions on the route

Comparing data from the Fig. 4 and 5, it can be read that when driving in sports mode, the car moved at a speed of 1.64 m/s more slowly, which gives a 4.5% lower value. The average number of engine revolutions in the regular mode of driving was by 6 revolutions smaller, which is a very small difference and gives approximately 0.3% of difference.

The parameter for pressing the gas pedal differed only by 0.5% and indicated a higher value when driving in the sports mode. A big difference can be seen in the case of engine load, as can be seen in Fig. 6. In the case of driving the vehicle in regular mode, it amounted to 68.2% and in the case of the second type of driving; it gave a value of 59.5%, which in direct comparison is by almost 15% greater. Water temperature was at a very similar level and differed only by 0.5°C.

The ideal fuel-air mixture is the stoichiometric one. In its composition for every 14.7 kg of air, there is one litre of fuel. In order for the car to be able to use the air the best way, it is necessary to have a properly functioning flow meter, which performs current and continuous measurements. Electrically controlled fuel injection works with it.

The fuel injection controller has built-in maps thanks to which, based on the data on the amount of air sucked in, air temperature and engine load, it tries to provide the amount of fuel so that it is as close as possible to the stoichiometric mixture. In the case of ZI engines, such mixtures are achieved, however, in the case of self- ignition cars, the engine usually works on slightly poorer fuel-air mixtures.

Several ways to calculate the amount of fuel engine needs. One of the types is the use of a dampener position sensor. Data is sent along with the air temperature to the controller, which calculates the air density and on the basis of it determines the appropriate fuel dose.

Another way to determine the right fuel dose is to measure the temperature of the air flowing through the pressure and the pressure in collection pipe.

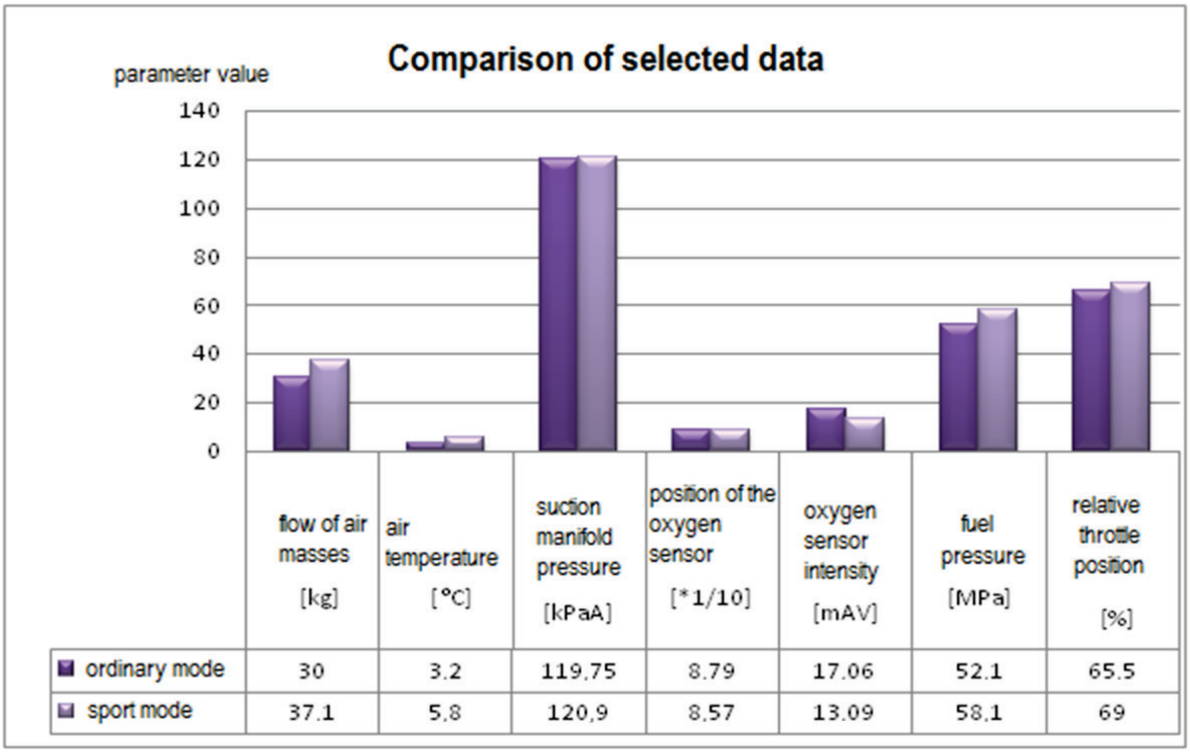

Fig. 6. Comparison of selected data

During the first ride, i.e. driving around the city in the regular mode, the car used 29.953 kg of air. The average temperature was 3.2°C. The pressure of the collection pipe during the test was on average 119.75 kPaA. The proportion of the oxygen sensor equivalent was 0.879 and the sensor intensity was 17.06 mAV. The average fuel rail pressure was 52134 kPa, while the relative dampener position was 65.5% on average.

The situation when driving No. 2, that is, city driving in sports mode looks like this: the car used 37100 g of air. The average air temperature was 5.8°C. The average pressure of the collection pipe was 120.9 kPaA. The position of the equivalent oxygen sensor was 0.856 while the sensor intensity oscillated around 13.09 mAV. The average pressure of the dosed fuel was 58121 kPa and the relative dampener position was 69%.

The previously presented data shows that comparing urban driving in regular mode in relation to sports mode, there are significant changes in some areas. Air masses, which were consumed during both rides, grow in the second drive by as much as 23.8%, which is a significant increase taking into consideration similar speed, and driving dynamics. The temperature of the intake air has also significantly changed in percentage terms and it is 81% different. However, considering the relatively low temperature in both cases, the difference is small and had a rather small impact on other parameters.

The average collection pipe pressure in both cases was very close to each other. The difference between No. 1 and No. 2 was just 1%. In case of less accurate measuring devices, such a value would be within the limits of measurement error, therefore it could be safely assumed that the pressure in both cases was identical.

The position of the equivalent oxygen sensor, i.e. lambda probe measurement, also fell in similar values, but the difference in both cases was already greater. In the first ride, we had the result of 0.879 and in the second 0.856, which gives us a difference of just under 2.7%. This is a similar result but it cannot be classified as the possibility of measurement error.

The average value of the oxygen sensor intensity differed from each other by 3.97 mAV, which translates into a reduction in the intensity of the second driving by an average of 23%. The percentage difference is high, however, taking into account the travel intensity spikes, sometimes exceeding 200 mAV, the better value is the direct difference given in mAV. Comparing this difference to the intensity jumps, we can see that there were not many discrepancies between these two rides and in general, they are very similar.

In the case of average fuel supply pressure, the difference was 5998 kPa and was higher in sports mode. This value translates into an increase of 11.5% compared to the first ride.

The relative position of the dampener has also grown in sports mode. The direct difference was 4.5%, but if you make a direct comparison between the first and the second value, the increase is 5.3%.

5. Summary

On the basis of previously presented data, we can draw many conclusions about how different subsystems work in the engine while driving and how their cycle changes depending on many factors that affect it. Thanks to OBD II / EOBD, we do not only deal with on-board diagnostics, but we also get the opportunity to check how our engine works during the ride [3].

Both in the graphs and from the data itself, it can be seen that the operating conditions of the engine change dramatically with almost every second of driving. Constant changes in loads, changes in the settings of various elements or changing road conditions force the vehicle to deal with many obstacles.

With the data presented, we can deduce which parts of the engine are more exposed than others are and can be exploited faster than the others can. Of course, the data presented is not complete and it is not possible to say everything from it, however, as simple from the technical point of view as measuring engine parameters using the OBD recorder's block allows us to observe the operation of the vehicle without interfering with it.

Driving the beyond city style, the speed, engine speed and engine load increase significantly. All the rest is the effect of these changes. When the car drives faster, there is more resistance, which requires more power to overcome them. In order for the car to get more power, it needs more energy and this one needs more fuel, which translates into higher demand for air, etc.

It would seem that the car traveling on the route is exposed to heavier working conditions; however, any manufacturer or the average user knows that driving around the city in a much worse way affects the technical condition of the vehicle. This is obviously not related to speeds or other engine parameters but to the variability of its operation. During urban driving, the engine is exposed to continuous and large changes in the engine's operation. In the case of city, driving the amplitude of the engine's rotation practically all the time on short sections ranged from 0 to 3000 rpm. In the case of driving around the city, the vast majority of the time, the turnover was in the range of 2000-3000 revolutions / min. In addition, city driving is usually associated with short distances, which is in turn associated with overcoming the majority of the route on a cold engine. During this test, the car worked from the beginning on a warm engine, but it is well known that working on cold engines is much more adverse.

Comparing just the regular mode to the sports mode, significant differences can be seen only in the case of city driving, which is characterized by a much greater variability of the engine's operation and other systems.

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