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Measurement of Impact of Air Filter Cleanness on a Change of Engine Speed Characteristics

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Abstract The paper is focused on the impact of clogged air filter on a change of speed characteristics of spark-ignition engine 1.4 MPI, 16V, 74 kW. The clogged air filter can cause deterioration in engine charging. Less air means the possibility of burning smaller amount of fuel, and thus less energy brought to the engine. This should cause a change in the size of engine torque and its power.

Keywords air filter, engine torque, inlet manifold, engine power

JEL R40

1. Introduction

The role of air filter is to absorb impurities that could cause wear of engine above the permissible extent [6]. The internal combustion engine for its operation needs to intake a certain amount of air. How much fuel is injected into engine depends on the amount of intake air. It is ideal for spark-ignition engines to maintain air-fuel ratio λ close to 1. However, the intake air must be free of any mechanical impurities that would cause faster engine wear. These impurities are absorbed by filter and they deteriorate the air flow through filter. This leads to deterioration in engine charging. In order to maintain optimum air-fuel ratio λ, a smaller amount of fuel injected into cylinder can be used. The result during fuel combustion is less released heat and lower engine power. The aim of measurement is to find the impact of clogged filter on a change of speed engine characteristics. The paper offers results of measurements of both, vehicle with new unclogged filter and vehicle with clogged filter after driving 60 000 km. Both results are shown as a graph.

2. Methodology

Vehicle description

- Vehicle: Škoda Fabia 1.4 MPI, 16V, 74 kW, 1390 cm^3.
- Number of forward gear is 5 [1].
- There were used new filter and clogged filter with driving 60 000 km for measurement, see Figure 1.

Figure 1 Filters used during measurement

Measuring device description

For measurement, it was used a dynamometer MAHA MSR 500 V, Figure 2. The accuracy is ± 2%. During measurement, humidity, pressure and air temperature are being recorded and the computer is communicating with an electronic control unit. The computer records actual data from engine, especially its temperature and revolutions. The device is also able to measure a vehicle with four-wheel drive, with maximum axle load 2 500 kg and maximum power 1 000 kW, with drawbar pull max. 7 000 N. Maximum speed of measurement is 210 km.h-1.

Figure 2 Dynamometer MAHA MSR 500 V

Measurement procedure

Before measurement, new air filter was inserted into inlet manifold and visual inspection of completeness of inlet manifold was conducted followed by verification of air intake system tightness and checking of tire inflation. After checking, the vehicle was set on cylinders and secured against displacement by means of belt tensioners. The engine control unit was connected to computer of measuring device. The vehicle identification, fault memory checking, measurement parameters setting and devices calibration were conducted. After that came the measurement of speed engine characteristics itself, in the 4th gear. The measurement was carried out at full pressing on accelerator pedal with full-open throttle. Finishing of the first measurement was followed by replacement of new filter by clogged filter and the measurement of speed engine characteristics was carried out again. At the end, the measurement result was printed in the form of a graph, see Figure 3.

3. Measurement results

The measurement result can be seen in the graph, Figure 3. Thick lines are curves of new filter; thin lines are curves of clogged filter.

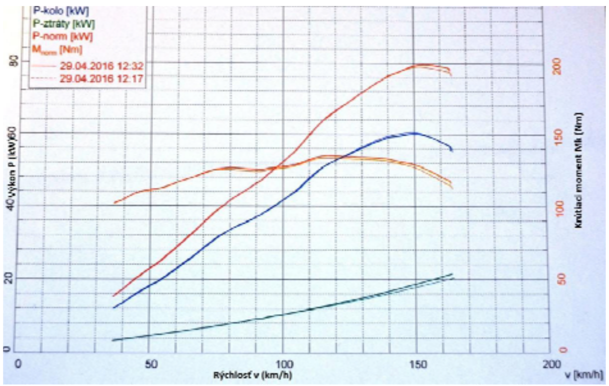

Figure 3 Measurement results

Engine power curves, in red, have the same course in both filters in the speed range from 37 km.h-1 almost up to 149 km.h-1. From speed 149 km.h-1 up to the end of measurement, speed of 164 km.h-1 stands the power curve measured using a clogged filter slightly below the power curve measured using new filter. Maximum difference is almost 2 kW.

The course of engine torque depending on a vehicle speed as well as engine revolutions is the same in the range from 37 km.h-1 up to 78 km.h-1. The engine with clogged filter has at the higher speeds the lower torque. The decrease of engine torque became evident almost at the mean engine revolutions. It can be assumed that it is a consequence of deteriorated engine charging caused by clogged air filter. Maximum difference is 1.8 Nm.

Measured differences are relatively low. There is no assumption that they could be seen by the driver owing to their placement in engine revolutions which are usually not used. The reason of low differences is the offset of change in the permeability of filter for engine control electronics. In the inlet manifold, there is a pressure sensor which sends the data to engine control unit [4]. The control unit on the basis of intake air pressure, its temperature and flow velocity assesses the air quantity and converts to it the adequate amount of fuel that is adjusted through the interference of injection length. The correct composition of fuel mixture with air is also checked by lambda probe [2]. Lambda probe is placed in the exhaust pipe and evaluates the amount of unburnt oxygen in exhaust gases. In the case of too rich or too lean mixture, the engine control unit adjusts the injection length as well as the composition of mixture.

The change of intake and exhaust resistance leads to the change of engine pressure conditions for which the timing of intake and exhaust valves is proposed. From that, it can be assumed that even in the case of removing of inlet manifold and in-taking air right from throttle body, it would lead to cutting down of engine power and torque [2]. The reason is the setting of control unit in vehicle design and making formulas and values stored in the control unit. The resistance and losses in the manifold with using of serial air filter is also taking into account. It would lead to decrease of power loss, if the values in control unit were changed by diagnostic equipment.

More significant changes in engine speed characteristics due to clogged filter could be presupposed in an older type of vehicle without air weight, or without pressure meter in manifold, and without lambda probe [2]. The increased resistance in inlet manifold, and thus lower air flow could cause rich mixture and lower engine power and torque. These changes would produce higher fuel consumption and they would adversely affect the vehicle emissions [3].

The measurement results can be also applied into consideration about suitability for using of sport filter. The low differences in values indicate the pointless in changing serial for sport filter due to increasing of engine power for regular operation. The result would be only an increased

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engine noise since the serial filter acts also as a silencer [2]. In the case of using low-quality sport filter, there is a risk of intake of increased number of dust elements which cause when mixed with oil an excessive wear of moving engine parts.

4. Conclusion

The aim of measurement was to determine the impact of clogged filter on speed engine characteristics. The clogged filter causes deteriorated charging of engine. The measurement result is that the engine torque became lower almost at mean engine revolutions and a noticeable decrease of engine power became evident almost at maximum power engine. The change of these parameters will evince in worse vehicle dynamics and weaker acceleration. More clogged air filter would mean more evident decrease of engine power than our measured 2 kW decrease. The vehicle would not reach its maximum speed specified by the manufacturer. The clogged filter will be probably reflected in the increased vehicle consumption [2].

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