Agronomy Research **12**(2), 307–314, 2014

Effect of E85 fuel on performance parameters, fuel consumption and engine efficiency – Škoda Fabia 1.2 HTP

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Abstract: This article deals with the effect of the E85 fuel on the performance parameters, specific fuel consumption and engine efficiency of a spark ignition engine Škoda Fabia 1.2 HTP and it is related to the article Effect of E85 Fuel on Harmful Emissions – Škoda Fabia 1.2 HTP. The measurement was performed on a test bench using a test cycle that simulates real traffic conditions and simultaneously the external rotation speed characteristics were measured. Three variants were chosen for burning E85 fuel. The first one was the usage of the E85 fuel without modifications on the engine control unit (variant 1 – E85), the second one was the usage of the E85 fuel with prolonged time of the injection by 28% (variant 2 – E85+) and the last third variant was the reference fuel petrol Natural BA95 (variant 3 – N95) for comparison. The results of the measurement showed a non-negligible decrease of the engine torque and power for both variants using E85 fuel. Further, there was a considerable increase of the specific fuel consumption for variants 1 and 2 (E85, E85+). Engine efficiency for the driving cycle increased for variants 1 and 2 (E85, E85+) approximately by one percent. For the external rotation speed characteristics the engine efficiency increased approximately by 5% for variant 1 – E85 and approximately by 2% for variant 2 – E85+.

Key words: E85 fuel, performance parameters, fuel consumption, engine efficiency.

INTRODUCTION

The increase in the usage of bioethanol as a fuel in Europe is significant (up to 15% annually) (Beran, 2011). The reason could be the European Parliament and the European Council, which adopted the so called action plan concerning with the issue of biofuels in transport. In the action plan the strategy for achieving the planned 20% substitution of conventional liquid motor fuels with alternative fuels by 2020 is defined (Šebor et al., 2006). Furthermore according to the European Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequent repealing directives 2001/77/EC and 2003/30/EC the target is a 20% share of energy from renewable sources and a 10% share of energy from renewable sources in transport (EU Directive 2009/28/EC; Hromádko et al., 2009; Beran, 2011; Pirs & Gailis, 2013). The second reason could be the dependence of Europe on the imported crude oil products. European OECD countries were dependant on the imported crude oil in the year 2007 from about 65% and by 2030 the dependence could increase up to 83%. The transport in Europe is dependant on the crude oil products from about 98% (Šebor et al., 2006; IEA, 2009; Gnansounou, 2010). France is the major consumer of bioethanol in Europe with a 5.41% share of bioethanol on the market (in Sweden it is 5.14%) (Gnansounou, 2010).

The most used fuel with higher share of bioethanol is the E85 fuel, which is made from 85% bioethanol and from 15% petrol. In comparison with the petrol the E85 fuel has lower energy content and higher density, it also has higher share of oxygen and therefore lower stoichiometric ratio. Furthermore it has a higher heat of evaporation, lower Reid vapour pressure, higher octane number and therefore an option of using higher compression ratio than petrol (Pumphrey et al., 2000; da Silva et al., 2005; Laurin, 2006a; Laurin, 2006b; Šebor et al., 2006; Mužíková et al., 2010; Hromádko et al., 2011; Küüt, et al., 2011). Taking into account new technologies of its production (second and third generation bioethanol) it could be a perspective alternative fuel which reduces the content of released greenhouse gases and the dependence on the crude oil (Varga et al., 2003; Liu & Shena, 2008; Sánchez & Cardona, 2008; Hromádko et al., 2009; Goh & Lee, 2010; Hromádko et al., 2010).

There are 2 possible variants of the E85 fuel use in the spark ignition engine. The first one is the engine customized directly for using of E85 fuel. For this engine the compression ratio can be increased up to 15:1 because of high octane number of the E85 fuel (RON 110) (Laurin, 2006a; Laurin, 2006b). The second variant are the Flex-Fuel vehicles (FFV). These vehicles can be operated with any mixture of E85 fuel and petrol. FFVs are the most used in Brazil, from the European countries in Sweden. (Laurin, 2006a; Kamimura et al., 2008; de Melo et al., 2012).

The purpose of the experiment was to verify the effect of the E85 fuel on performance parameters of the engine, specific fuel consumption and engine efficiency. According to the other experiments in this field (Čupera & Polcar, 2011; Küüt et al., 2011; Vojtíšek-Lom & Mazač, 2011; de Melo, 2012; Pirs & Gailis, 2013) the following assumptions can be established. The engine torque and power will be lower due to unmodified engine, specific fuel consumption can be higher due to the lower energy content of the bioethanol share in the E85 fuel and the engine efficiency could be higher. For experiment the test cycle, which simulates real traffic conditions, was used. Furthermore, for detection of the maximal values and progression of the engine torque, power and specific fuel consumption, the external rotation speed characteristics were measured.

MATERIALS AND METHODS

The whole experiment was performed on the test bench of the Department of Vehicles and Ground Transport at the CULS Prague.

For the experiment an electric-swirl dynamometer V125 with construction IP23/ICW37 was used. The reaction from the dynamometer was captured via a tensometric sensor with nominal load 2kN and merged mistake 0.5% of the nominal load.

The measurements were performed on the engine Škoda Fabia 1.2 HTP. This engine is a three-cylinder atmospheric in-line four stroke engine, it has overhead cams with 2 valves per cylinder. Max. power is 40 kW at 4,750 rpm, max. torque is 106 Nm at 3,000 rpm and the compression ratio is 10.3:1.

The measurements were performed for the following variants. The E85 fuel without modifications of the engine control unit (variant 1 – E85), E85 with prolonging of the time of the injection (variant 2 – E85+) and Natural BA95 (variant 3 – N95). For prolonging of the time of the injection for the second mentioned variant an additional control unit plugged between ECU and injectors was used. That means that the input for this unit are the impulses for the injectors sent by ECU and the additional unit is extending them by preset period in percentage and is sending them to injectors. In the case of the variant 2 (E85+), the prolonging of the time of the injection was by 28%.

For communication with ECU the diagnostics system VAG-COM was used. This system was primary used for reading values from ECU, such as rotations, load of the engine (in percentage) and the air-fuel equivalence ratio.

The test cycle was acquired from real traffic by recording values from the OBD diagnostics system of the vehicle and the length of the cycle is 330 sec. The whole cycle is characterized by the dependence of the position of the gas pedal on the time of the driving cycle (Fig. 1). During the cycle the values of the torque and rotations of the engine are not the same for all variants of the used fuel (Figs 2 and 3). The reason are the different performance parameters of the engine as a result of different heating values of the used fuels.

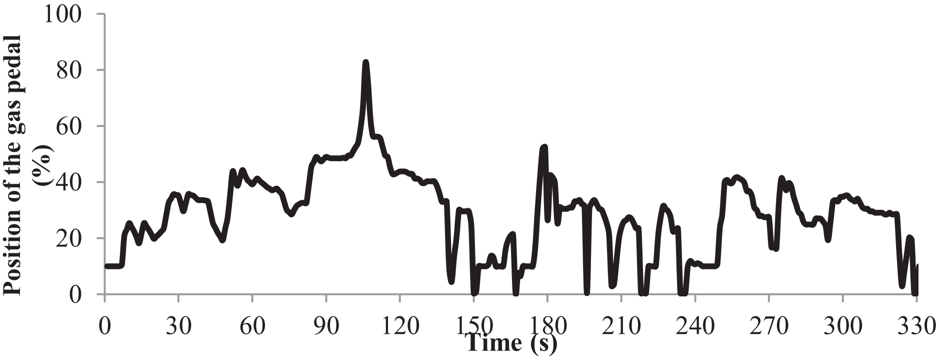

Figure 1. Progression of the position of the gas pedal during the test cycle.

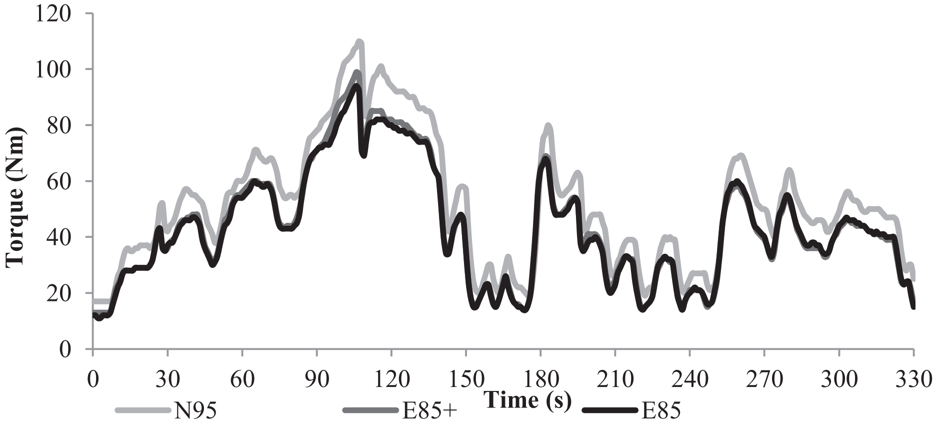

Figure 2. Progression of the torque during the test cycle.

Furthermore, on the above mentioned dynamometer the external rotation speed characteristics were measured for each variant of the used fuel. The position of the gas pedal was on 100% and by increasing torque the rotations were decreased. In every predetermined measurement point the measured parameters were stabilized.

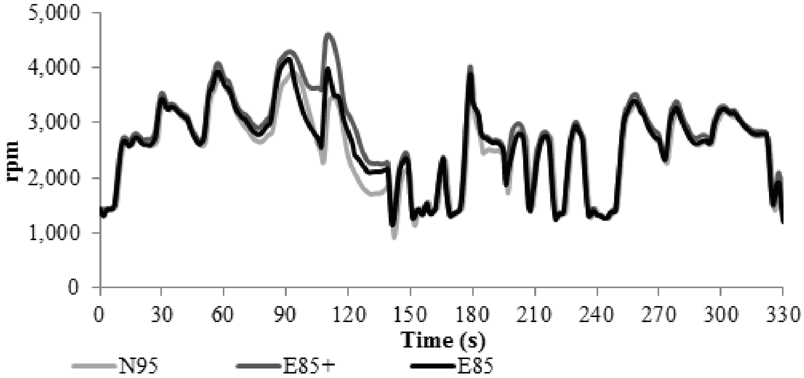

Figure 3. Progression of the rotations during the test cycle.

All measured parameters are logged with frequency of 1 Hz into a DBF file on the hard drive of the computer. These measured data were further processed using MS Excel.

RESULTS

The fuel consumption was evaluated for the whole cycle cumulatively. For the driving cycle with variant 1 (E85) 469.2 g of fuel was consumed, with variant 2 (E85 +) 512.6 g of fuel was consumed and with variant 3 (N95) 380.1 g of fuel was consumed. From these data it is evident that with variant 1 and 2 the fuel consumption increased. With simultaneously decreased performance parameters of the combustion engine, the specific fuel consumption increased by 40%.

To be possible to express the engine efficiency, for each variant of the fuel the heating value and density was specified. The resulting values reached during the whole driving cycle are listed in Table 1.

The engine efficiency increased approximately by one percent. Specifically for variant 1 (E85) the efficiency increase is 1.1% and for variant 2 (E85+) the increase is 1.0%.

Table 1. Summarized results of the measuring using the driving cycle

Variant	Specific fuel consumption ($g\ kWh^{-1}$)	Specific fuel consumption (%)	Efficiency (%)
E85	402	141.4	30.3
E85+	404	142.2	30.2
N95	284	100	29.2

The external rotation speed characteristics for each variant are showed gradually in Figs 4, 5 and 6.

In Fig. 4 the progression of the performance parameters and specific consumption of the engine with variant 1 (E85) is shown. Compared to variant 3 (N95) the decrease of maximal engine power by 10.7% and maximal torque by 7.8% and the increase of the specific fuel consumption by 23.2% can be seen. The measurement of this variant always concluded with an error of the ECU, which was reporting too poor mixture, both in the case of the measurement of external rotation speed characteristic and in the case of the driving cycle.

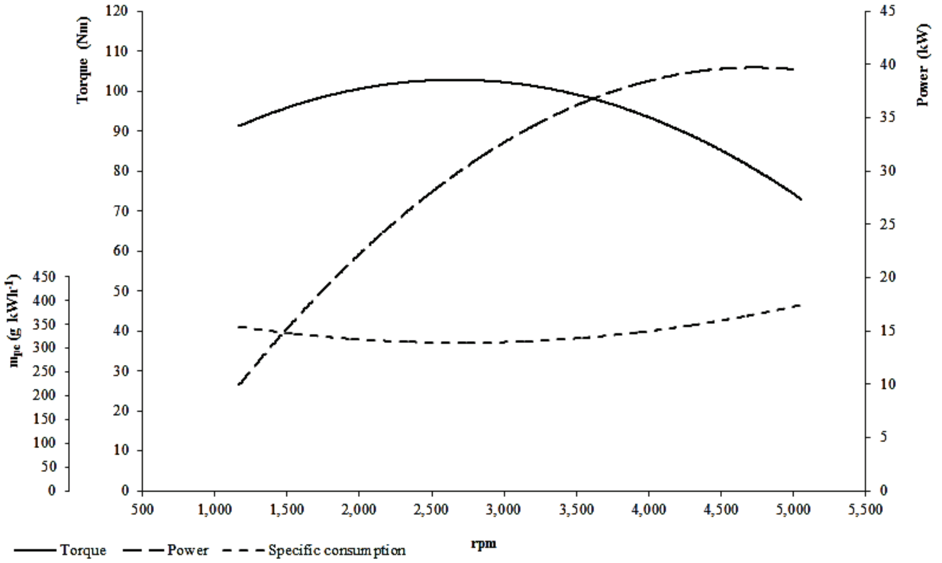

Figure 4. External rotation speed characteristic for variant 1 – E85.

In Fig. 5 the external rotation speed characteristic for variant 2 (E85+) is shown. Again, the decrease of the maximal engine torque (by 4.3%) and power (by 9.7%) can be seen, but not as significant as for the variant 1 (E85). If the negative effect of this variant on the emissions, described in the paper Effect of E85 Fuel on Harmful Emissions – Škoda Fabia 1.2 HTP, would be neglected, the engine was working properly. It is also confirmed by the fact, that after measuring this variant, the ECU was reporting no error message.

The external rotation speed characteristic for variant 3 (N95) is shown in Fig. 6. This variant was used as a reference one. Especially, significantly lower specific fuel consumption compared to the variants 1 and 2 (E85, E85+) can be seen.

During the measurement of the external rotation speed characteristics, both variants using E85 fuel (E85, E85+), showed a significant increase of the combustion engine efficiency compared with the variant 3 (N95). Variant 1 (E85) showed the highest engine efficiency, as expected. This can be explained, among others, by a poor mixture combusted in the cylinders. For variant 2 (E85+), where the mixture was richer than for variant 3 (N95), the better efficiency can be explained by a better combusting because bioethanol is a simpler hydrocarbon than the petrol, which is a mixture of hydrocarbons, therefore combusting E85 produces less intermediates. Furthermore, bioethanol contains significant share of oxygen (34.7%).

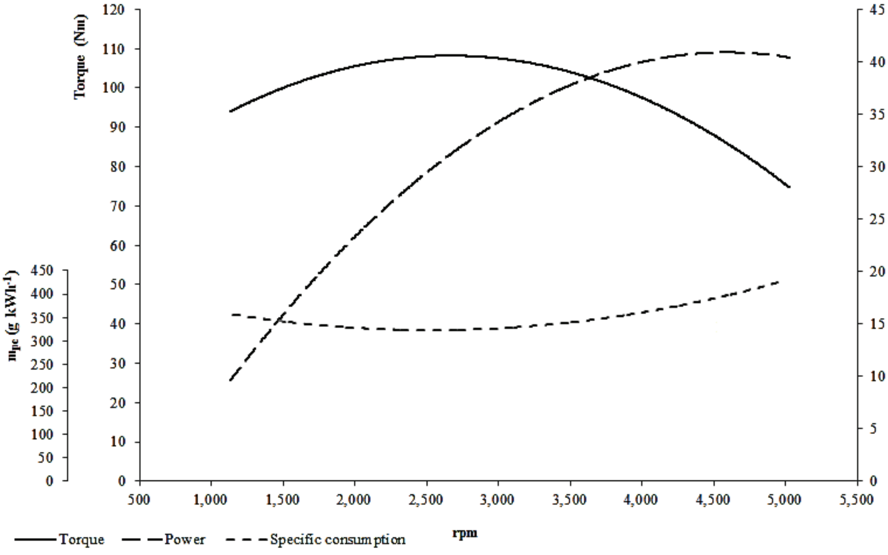

Figure 5. External rotation speed characteristic for variant 2 – E85+.

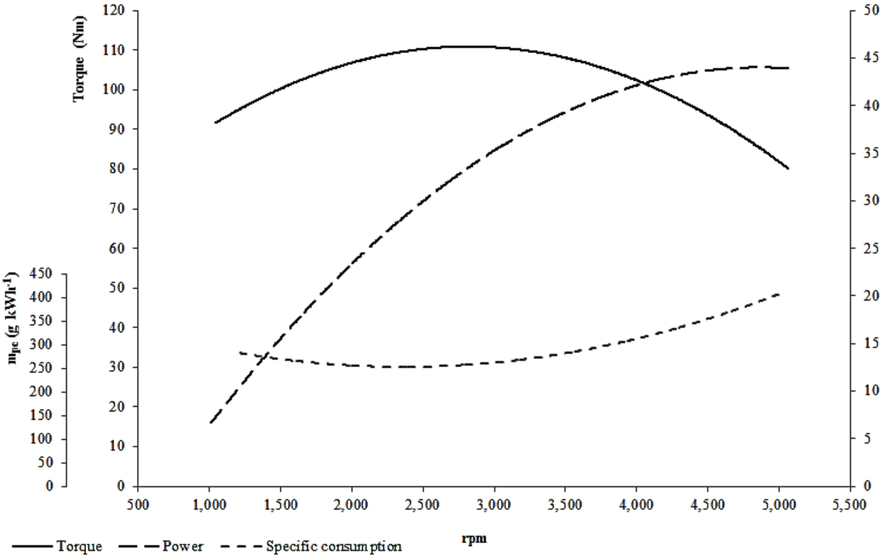

Figure 6. External rotation speed characteristic for variant 3 – N95.

Table 2. Summarized results of the external rotation speed characteristics

Variant	Torque		Power		Specific fuel consumption		Efficiency
	(Nm)	(%)	(kW)	(%)	(g kWh^{-1})	(%)	(%)
E85	107	92.2	40.7	89.3	343	125.37	35.6
E85+	111	95.7	41.2	90.4	379	138.41	32.2
N95	116	100	45.6	100	274	100	30.4

In Table 2 it can be seen that for both variants using E85 (E85, E85+) the engine power decreased approximately by 10%. The torque decreased for variant 1 (E85) approximately by 8% and for variant 2 (E85+) approximately by 4%. Specific fuel consumption increased, as expected, for variant 1 (E85) approximately by 23.2% and for variant 2 approximately by 35.8% compared to the variant 3 (N95). The E85 fuel achieved success during evaluation of the engine efficiency. The engine efficiency increase by 5.2% for variant 1 (E85) and approximately by 1.8% for variant 2 (E85+) can be seen. In real traffic, probably, it would not be possible to reach these values. Furthermore, permanent operation of variant 1 (E85) is not possible because even after repeated measurements the ECU was reporting an error message indicating too poor mixture.

CONCLUSION

From the viewpoint of the measurements using the driving cycle it can be claimed that the use of the E85 fuel brings the specific fuel consumption increase approximately by 40% (variant 1 – E85 by 41.1%, variant 2 – E85+ by 42.2%) compared with variant 3 (N95). But the engine efficiency increased by cca 1% (variant 1 – E85 by 1.1%, variant 2 – E85+ by 1.0%).

As can be seen in Table 2, for both variants using E85 (E85, E85+) the engine power decreased approximately by 10%. Specific fuel consumption increased, as expected, for variant 1 (E85) approximately by 23.2% and for variant 2 approximately by 35.8% compared to the variant 3 (N95). The E85 fuel achieved success during evaluation of the engine efficiency. The engine efficiency increase by 5.2% for variant 1 (E85) and approximately by 1.8% for variant 2 (E85+) can be seen.

To conclude, despite the weaknesses of the E85 fuel, such as aggressivity on the sealing elements and lower performance parameters, it is possible that in this fuel a key to the future can be. It can be combusted with a relatively small interference in the fuel system of the combustion engine (mainly prolonging of the time of the injection) and by usage of this fuel the better combusting efficiency can be achieved.

Paper was created with the grant support – CZU 2013:31150/1312/3108 – Progressive rear axle concept for Formula Student.

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