Impact of the content of alcohol in petroleum on the level of an unsupercharged engine's noise

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Abstract. The results of the studies conducted on the chassis dynamometer for a vehicle powered with a spark-ignition engine are presented in the study. The tested vehicle was equipped with an unsupercharged engine. There was tested the noise level of the engine powered with ethyl alcohol at variable settings of the fuel injection. In the course of the tests, the dose of fuel was increased within the range from the manufacturer's settings respectively by: 5%, 10%, 20% 30% and 50% of the nominal dose, and the ignition advance angle with reference to manufacturer's settings was increased respectively by 0° and 3°. It was found, that the noise level for the engine powered with ethanol decreases together with the increase of the fuel's dose, (up to about 110% of the nominal dose), and then increases. At the same time, the increase of the noise level for the increased value of the ignition advance angle was found.

1 Introduction

Because of the environment protection necessity, looking for alternative energy sources for machines and vehicles, constitutes the subject matter of interest of numerous research centres, as well as companies dealing with production of engines. One of the manners to reduce arduousness for the environment, are electric drives or use of alternative fuels comprising components originating from renewable sources. These fuels should allow for operation of engines without the negative impact on their durability and ensure comparable performance just as in case of powering with traditional fuels [1]. In the conditions of the Central and Western Europe, popular is production of ethyl alcohol from organic biomass. These may be wastes from forest or agricultural production, as well as municipal wastes [2,3], or plants cultivated specially as a raw material for biofuels' production. Important are also possibilities and costs of ethanol obtaining. In the costs of production, a considerable share, apart from the prices of raw material, there have energy outlays and raw-material's processing [4].

For engines with self-ignition, bioesters are such an additive [5]. In case of diesel engines with spark ignition, the alternative for fuels of connate origin, are among the other alcohols. They may be combusted independently or – what happens most often – as an additive to petroleum. For that purpose, both the ethyl alcohol, as well as other alcohols are used, in particular the methyl and butyl alcohol [6].

Alcohols, as fuels, are most often characterised by a lower calorific value, but also a higher-octane number. Moreover, for the course of the combustion process, they require lower volume of oxygen than the fuels of connate origin. Properties of the selected alcohols are presented in the table 1. For most of the currently used engines, use of slight alcohol additives, does not cause any negative results. At the territory of the European Union, in most of the countries the additive of ethyl alcohol in the volume of 5% to petroleum is used. Such an additive, apart from decreasing of the connate

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fuels resources’ consumption, in most cases influences neither the composition of the combustion gases’ composition nor the power and the engine’s turning moment. According to different studies, only the additive of alcohol in the volume above 30%, results in the decrease of the content of harmful compounds in exhaust gases. [7, 8,9].

Table 1. Selected properties of petroleum, ethanol and methanol.

Name/parameter	Density in 15 ⁰ C [kg·m ⁻³]	Research octane number	Motor octane number	Boiling point [⁰ C]	Calorific value [MJ·kg ⁻¹]	Heat of evaporation [kJ·kg ⁻¹]
Methanol	795,6	107	91	64,7	19,9	1100
Ethanol	793,2	108	92	78,3	26,8	910
Petroleum 95	720- 775	95	min. 85	215	41,0	380

Limitation of connate fuels’ resources and improvement of the exhaust gases’ composition occurring as a result of ethyl alcohol combustion, results also in changes in the noise level emitted by engines. It is very often connected with the lower noise level connected with the power-supply system (reduced flow of the air), as well as smaller volume and speed of the combustion gases outflow.

2 Materials and methods

In the tests, there was used the vehicle Fiat Panda, powered with 8-valves engine with spark ignition and multiport fuel injection. The engine at manufacturer’s settings and powering with petroleum E 5, reached the power 61,8 KM (47,2 kW), and the turning moment 100,5 Nm. The course of power and turning moment at manufacturer’s settings, is presented in the figure 1.

Fig. 1. Course of the power and turning moment in the tested engine at manufacturer’s settings and powering with fuel E5.

Prior to measurements, in the engine the engine oil and oil filter, air and fuel filters were replaced. The vehicle was immobilized on rollers. Powering with fuel was connected passing over the original fuel tank. A special tank of the capacity of 5 dm³ was used for that purposes. The engine was heated up to the moment of reaching by the cooling liquid the temperature 75⁰C. In the room of the test house, at the time of the tests conducting, there prevailed the temperature of 15⁰C and the pressure was 100,4 kPa. The view of the vehicle at the testing stand with the connected external tank, is presented in figure 2.

Fig. 2. The view of the vehicle at the testing stand with the connected external tank.

In the vehicle there was replaced the factory’s control computer into an universal one, with the option of free settings’ programming. The manufacturer’s software was installed, and the course of the power and moment was checked again. The programming computer was connected. View of the vehicle and the programming computer at the test stand is presented in figure 3.

Fig. 3. View of the vehicle at the test stand with connected modifying computer.

The noise level was measured with the use of the integral noise level measuring device HD 2010UC. The measuring device has been assembled at the distance of 1 m from the engine, at the front of the vehicle. The measurements were conducted for alternately changed engine’s settings. The view of the measuring device is presented in figure 4. In the control computer’s software, the reaction to readings of the knock sensor has been turned off. The diagram of the engine’s settings is presented in the table 2.

Table 2. Diagram of the engine’s settings.

Fuel dose	Ignition lead	
Manufactur er’s setting	manufacturer’s	-

Fuel dose 105%	manufacturer's	+3 ⁰
Fuel dose 110%	manufacturer's	+3 ⁰
Fuel dose 120%	manufacturer's	+3 ⁰
Fuel dose 130%	manufacturer's	+3 ⁰
Fuel dose 150%	manufacturer's	+3 ⁰

Each measurement was repeated three times. At the time of the measurements' conducting, the ambient temperature and atmospheric pressure was controlled.

Fig. 4. View of the noise level measuring device HD 2010UC.

The obtained results were subject to statistical analysis. Mean values are presented at the diagrams 5, 6 and 7.

4 Analysis of the results and conclusions

The results obtained as the effect of the conducted researches, were subject to statistical analysis with the use of the STATISTICA programme. Occurrence of statistically significant differences were disclosed both depending on the fuel dose, as well as the

ignition advance angle. The mean values of the noise level for the manufacturer’s setting of the ignition advance angle is presented in diagram 5.

Fig. 5. Noise level for the manufacturer’s value of the ignition advance at the increasing ethanol dose.

For the manufacturer’s and increased by 5% doses, there has been found the statistically essential noise level. At the dose’s increase by more than 10%, the noise level lowered almost by 20 dB, not changing significantly at the further dose’s increase. Based on the observations conducted during the researches it should be assumed, that lower ethanol doses were combusted in a detonation manner. It resulted from the stoichiometric air excess at the time of the ethyl alcohol combustion, having a smaller demand for air for combustion.

For combustion of fuel at the increased by 3° ignition advance angle, the increase of the noise level was found. At the nominal dose, increased by 0 5% and 10%, the noise level did not differ between them significantly statistical. At the fuel doses increased by 20, 30 and 50%, there was found statistically significant increase of the noise level up to the value comparable with the measurements for the nominal setting of the ignition advance angle and lower fuel doses.

Fig. 6. Noise level for the manufacturer’s value of the ignition advance at the increasing ethanol dose.

The mean noise level emitted during the engine’s operation for the nominal ignition advance angle, had the value by 3 dB lower, than for the angle increased by 3°. The dependence is presented in diagram 7.

Fig. 7. Mean noise level for the nominal and increased value of ignition advance.

At the increasing dose of fuel, the mean noise level reached the lowest value at the fuel dose increased by 10% as compared to the nominal value. Both for the lower and higher volume of fuel, the noise level has essentially statistical higher value.

Course of the values of the noise level is presented in figure 8.

Fig. 8. Mean noise level depending on the volume of the fuel dose

Value of the noise level for the fuel doses for 20, 30 and 50% higher than the nominal ones, did not differ essentially statistical between themselves.

The value of noise at the increasing fuel dose, both at the nominal ignition advance angle and at the increased one was compared. It was found, that the lowest value the noise level was reached at the dose increased by at least 10%. It did not significantly statistically increase at the doses higher by 20, 30 and 50% than the nominal one. However, for the ignition advance angle increased by 3° with reference to the nominal one, the doses higher by 20, 30 and 50% resulted in the noise level's increase. The measured values for 20, 30 and 50%, did not essentially statistically differ between themselves.

Fig. 9. Mean level of noise for the nominal and increased value of ignition advance

As mentioned already, in the methodology of the studies, in the vehicle the control of the knock sensor's control was switched off in the engine. The increase of the noise level at low fuel doses, was caused by detonation fuel combustion in the excessive air volume. In case of the fuel dose's increase, the noise level originally dropped and then raised, what could have been caused by the increased volume of combustion gases and their increased outflow speed.

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