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ANALYSIS OF SELECTED OPERATING PARAMETERS OF ENGINE POWERED BY A MIXTURE OF BIOCOMPONENTS AND DIESEL OIL

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Abstract

Reaching of high parameters of a drive unit and low pollution of the natural environment is considered to be the most desired effect of motorization. The use of the additive in the form of fatty acid methyl esters to the diesel oil, assumes lowering of harmful fuel gases' emission and reaching high operating parameters of an engine, such as power and turning moment. Studies on the power output and the turning moment of an engine with self-ignition are presented in the study. The subject matter of the studies was a combustion engine with self-ignition of the power of 80 kW with the direct common rail system and turbo-compressor's supercharging and with electromagnetic injectors. The tested engine was powered with diesel oil and the mixture of fatty acid methyl esters and the diesel fuel, in proportions 10%, 30% and 50% with an improver, at the standard settings of the fuel injection controllers. The vehicle used for the testing purposes, has been singled out with respect to the specific features, such as: universality of its use as a means of transportation and the opportunity of modification of the injection parameters, resistance to possible unfavourable consequences resulting from the use of the fuel mixture. The studies were conducted on a chassis test house, at full engine's loading. The vehicle placed on the test house's rollers, was strapped with belts to the foundation, and then accelerated up to the specific speed and subjected to loading standing in place. In such a manner, the road conditions were simulated. The obtained results of the tests were subject to the statistical analysis. From their analysis it results, that application of the mixture lowers the engine's parameters to a degree unnoticeable at the time of its operation.

Keywords: *transport, means of transport, diesel oil, biocomponent, alternative fuels*

1. Introduction

The use of the alternative fuels for powering piston combustion engines is connected with high demand and decreasing natural resources. The raw materials most often used for powering engines of self-ignition are the transesterified plant oils. Raw plant oils are most of all produced for food purposes, what means that they do not meet the requirements of the standard DIN 51 605 and cannot be used as fuels for powering means of transport. Rape oil is the most often used material for production of fatty acid methyl esters (biocomponents). In the last decade, a remarkable growth of rape production has been recorded in Germany, France and Italy, as well as in Belarus and in

Ukraine. In Poland, the production of rape is concentrated in the region of Kujawy, Żuławy, Western Pomerania, Olsztyn, Lublin, Opole and Wroclaw. For power purposes, there are produced double improved varieties of rape of low content of erucic acid and glucosinolates [5].

In case of engines with self-ignition, the use of the rape oil in pure form is not possible due to their high coefficient of viscosity. In order to make it possible to use rape oil for powering diesel engines, they have to be modified by decreasing the coefficient of viscosity by [3]:

- diluting of plant oil with fuel of naphtha origin,
- their connecting with low molecular weight alcohols,
- distillation or other technological processes,
- chemical reaction leading to esters' release (transesterification).

Transesterification that is the reaction as a result of which there occurs the exchange of glycerol included in a fat molecule (triacylglycerol) into a low micromolecular aliphatic alcohols (methanol, ethanol, propane, butane), is the most often used treatment [5]. The transesterification process is most often conducted in the temperature 60-70ºC in the presence of a basic catalyst. In order to reach a high level of esters' conversion, there is used a high surplus of methanol which, after completion of the transesterification process, is distilled off and comes back to the process [7].

The fatty acid methyl esters formed in this process are mixed with the diesel oil, and in such a manner, there originates an alternative fuel for powering engines with self-ignition, commonly called biodiesel. In contrast to the diesel oil, biodiesel is a non-toxic use, and its use results in lowering of the release of harmful substances' emission to the atmosphere [1]. Biodiesel has better lubricating properties than the traditional diesel oil and extends an engines' life [2]. There are many pro-ecological arguments, which opt to this mixture's use, such as: no pollution of the atmosphere with sulphur compounds and the decrease of the volume of carbon dioxide emitted to the atmosphere.

Apart from ecological aspects of the means of transport, the remaining assessment criteria of their functioning quality are of significant importance [4, 8], which are expressed with the use of operating criteria, directly depending on fuel powering them. The most often encountered operating rates of the means of transport power units are power and turning moment. In the domestic and foreign literature, there have been found the studies concerning powering of high--pressure engines with fatty acid methyl esters [6]. The following parameters were subject to experimental studies: engine's performance, ecological properties, calorific value of fatty acid methyl esters, density, and viscosity of fatty acid methyl esters. The tests have shown a lower engine's performances for 7-8%, and lower drops of the engine's power as compared to the diesel oil, depending on the combustion system and properties of the ignition system, as a result of lower calorific value at simultaneous higher parameter of fatty acid methyl esters' density.

2. Methodology of the studies

Plant oils subject to the process of transesterification, commonly called biocomponents that were mixed in different proportions with diesel oil were the material used at the time of the studies. The mixtures II, III and IV are presented in Fig. 1.

Mixtures of diesel oil and fatty acid methyl esters have been prepared in planned proportions and appropriately marked, what is presented in Tab. 1. The improver that was used in connection with the mixture of 50% of diesel oil and I 50% of fatty acid methyl esters, was the agent enriching the cetane number and increasing the fuel's lubricating properties.

The subject matter of the studies was the engine with self-ignition with direct fuel injection performed with the use of the Common Rail system with the applied electro-magnetic injectors. The tested engine co-operates with a dual mass flywheel and with a turbocompressor of variable geometry of blades, what has an impact on the increase of generated performances and meets the stringent standards concerning combustion gas' emission. The drive unit, used in the tests, was not

Fig. 1. Mixtures of diesel oil and the fatty acid methyl esters

Tab. 1. Proportions of mixtures used for the studies

No.	Mixture's composition	Mixture's marking
1	Diesel oil	Mixture I
2	90% of diesel oil and 10% of fatty acid methyl esters	Mixture II
3	70% of diesel oil and 30% of fatty acid methyl esters	Mixture III
4	50% of diesel oil and 50% of fatty acid methyl esters with an improver	Mixture IV

equipped with diesel particular filter. The tested engine marked 1.6 HDi in 16 valves' version, has a timing belt which powers one distribution shaft and the second shaft collects the drive from the first one via a chain. In the subject matter of the tests, there has been introduced a modification of the supply system, what allowed for non-disruptive change of fuel feeding the engine. The changes covered in particular: the system of fuel transferring, installing of another fuel tank and changes in the computer's settings installed in a vehicle. Modifications in the vehicle did not directly interfere in construction of its drive unit; they only concerned its fittings and software. Adaptations connected with the fuel's supply to the engine, were based on connecting of an external fuel tank at simultaneous disconnecting of the fuel's supply from the factory's tank. No additional fuel filters as well as fuel pump were assembled. The fuel supply system was connected from the additional tank directly to the drive unit.

Studies of the operating parameters of a drive unit powered with the mixture of the diesel oil and the fatty acid methyl esters were conducted on the loaded chassis test house with the Eddy--current brake, presented in Fig. 2.

Fig. 2. View of the tested vehicle on the chassis test bed

In the loading chassis test beds, the drive from a vehicle's wheels is transmitted by the track rollers to the brake, and the obtained results concern operation of the whole drive system. The test bed used in the studies is designed for the control and checking of the power in the means of road transport and verification of the engine's operating parameters, in which the changes of the fuel injection controller's settings were made. The technical data concerning the loading chassis test bed used for the tests are presented in the Tab. 2.

Tab. 2. Technical data of the loading chassis test bed

Type of measurement	Inertia accelerated mode
	Loading mode, that is with fixed rotations for different loadings
	Accelerated mode controlled with a brake
Maximum speed	270 [km/h]
Size of the rollers	320 x 600 [mm]
Size of the test bed	3500 x 5600 x 350 [mm]
Mass of the test bed	2500 [kg]

The course of the tests performance depends on the scope of conducted tests and the determined testing purpose. In case of measurement of the effective output and the torque moment of a drive unit powered with the mixture of different content of diesel oil and the fatty acid methyl esters, the tests were conducted at full load. At the time of the measurement, the vehicle mounted on the test bed was brought up to the speed of 140 km/h. The obtained measurement results were automatically generated by the software in the tabular and graphical form. The direct results displayed in real time could be observed on the computer's screen, and these were the following ones: rotational speed of the engine, driving speed, adjusted engine's power, and adjusted torque moment, loading of an Eddy-current brake, temperature of the air choked by the engine and pressure of water steam in the air. In Fig. 3 there are presented the exemplary results, which are obtained at the time of the tests on the loading chassis test bed.

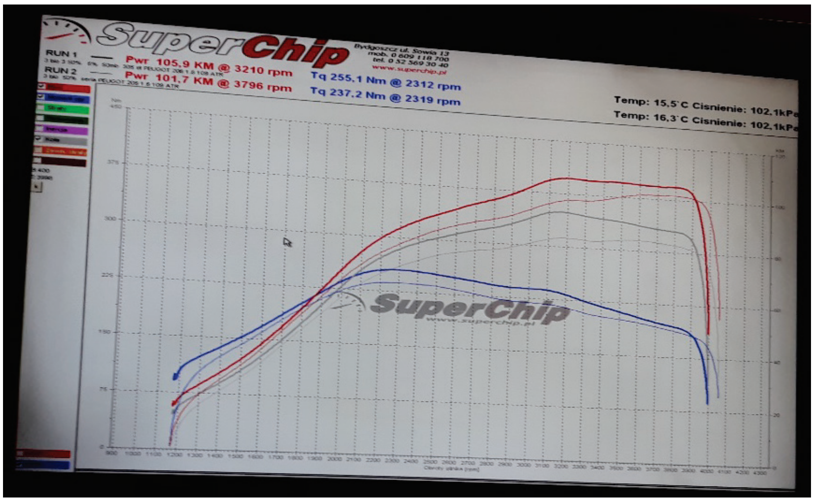

Fig. 3. Exemplary data from the chassis test bed displayed in real time

3. Results of the tests and the statistical analysis

The statistical analysis concerned 30 measurements of the net power and the torque moment of a power unit for the diesel oil, the mixture of 10% of biocomponent and 90% of diesel oil, mixture of 30% of biocomponent and 70% of diesel oil and the mixture of 50% of a biocomponent and 50% of diesel oil with an improver. The values of the basic statistics for all the analysed mixtures are presented in Tab. 3-4. In Fig. 4-5 there are graphically presented the values of the analysed statistics for the tested mixtures.

Tab. 3. Values of the basic statistics of the net power's measurements for the tested mixtures

Number of the mixture	I	II	III	IV
Average	100.94	101.49	100.15	99.97
Median	100.6	101.6	100.3	100.0
Standard deviation	0.96	0.56	0.83	0.31
Variation coefficient	0.009	0.005	0.008	0.003
Min.	99.4	100.4	96.3	99.4
Max.	102.8	102.5	100.8	100.4

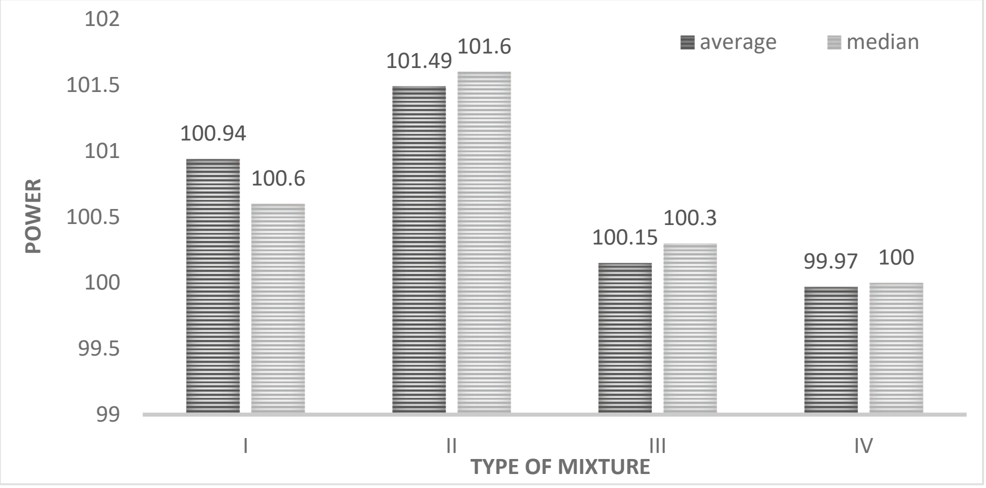

Fig. 4. Graphically presented the values of the analysed statistics for the tested mixtures

Tab. 4. Values of the basic statistics of the torque moment's measurements for the tested mixtures

Number of the mixture	I	II	III	IV
Average	238.88	246.87	233.59	237.26
Median	239.1	247.0	234.35	237.55
Standard deviation	1.56	1.61	2.90	1.26
Variability coefficient	0.006	0.006	0.012	0.005
Min.	235.5	244.6	228.3	232.2
Max.	241.6	249.4	237.6	238.4

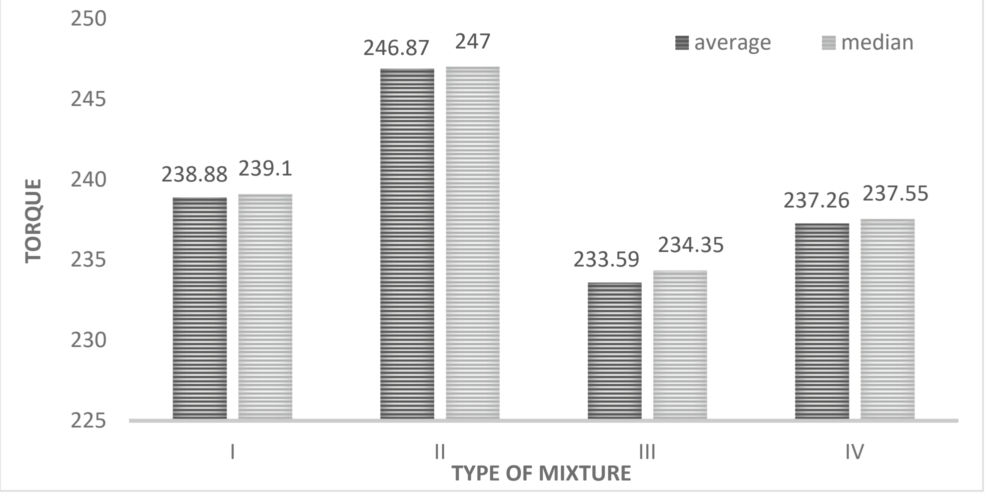

Fig. 5. Graphically presented the values of the analysed statistics for the tested mixtures

The statistical analysis of the table and the diagram shows, that the average value and the median are indeed statistically higher for the mixture II as compared to other mixtures. During analysis, attention should be paid to low coefficient occurring for the mixture IV, amounting to 0.003.

The statistical analysis of the table and the diagram shows, that the average value and the median is indeed statistically higher for the mixture II as compared to other mixtures. The most scattered values with reference to the average result were obtained for the mixture III, as provided for by the result of the standard deviation amounting to 2.9.

4. Summary and conclusions

The conducted studies showed that 50% of the share of the fatty acid methyl esters in the diesel oil lowers the motor's operating parameters for about 2% as compared to the parameters measured for the diesel oil. Use of the agent improving the lubricating properties and the cetane number to the mixture of 50% diesel oil and 50% of fatty acid methyl esters resulted in lowering of the power output and the turning moment for the standard settings of the fuel injection controller. The noticeable increase of operating parameters of the means of transport's drive unit was for the mixture of 30% of fatty acid methyl esters and 70% of diesel oil. The obtained results of the studies were conducted for the standard settings of the fuel injection's controller. They are the grounds for the operating parameters' verification for an engine powered with the mixtures of a diesel oil and a component, with the increase of the dosage of fuel and the drive unit's air charging up.

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