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AN ANALYSIS OF THE POSSIBLE IMPROVEMENT IN THE EMISSION LEVEL FOR THE COMPRESSION IGNITION ENGINES FUELLED WITH RAPE OILS OF THE DIFFERENT EXTENT OF PROCESSING

Abstract: Main subject of this article is an analysis of the possible improvement in the emission level of toxic compounds for the compression ignition engines fuelled with biofuels. In order to this rape oils of the different extent of processing were used – fatty acid methyl esters (FAME) and unprocessed rape oil (URO) – obtained results were referred to the conventional fuel.
A change in the design parameters of the nozzles used while fuelling the engine with bio-fuels, significantly affect the quality of spraying the rape oils and thereby improve their indexes of emission. In connection with that, influence of holes' number i_r as well as diameter of holes d_o on emission were examined in article.
The results of examinations presented in this paper have confirmed a chance of an effective improvement in emission of toxic compounds formed while fuelling the compression ignition engine with bio-fuels.

l. INTRODUCTION

In order to improve fuel and air mixing in combustion chamber it is common in new constructed systems to use a nozzles which have more and more number of holes. Additional fuel jets allow for better fuel propagation in combustion chamber. Increasing of holes number has results in increasing of fuel flow section from nozzles. That is why it is necessary to remember about decreasing of diameter in each hole of nozzle. All of this parameters should be strictly adjusted to combustion chamber – decreasing of hole's diameter results in growing speed of fuel jet [1]. Such long stream cause on fuel drops hitting on chamber wall. This phenomena has negative result on toxic compound and soot emission.

Other problem which is directly related to toxic compounds emission are physical and chemical fuel properties [2].

In this paper a problem of the toxic compounds emission refers to the rape fuels of a different extent of processing. Thereby this paper discusses levels of emission from the engine while fuelling it with:

- Fatty acid methyl esters of rape oil (FAME);
- Unprocessed rape oil (URO).

The obtained results are referred to the diesel fuel (DF).

2. RESEARCH METHOD

Effect of a spraying holes number i_r in a spray nozzle, and thereby an effect of their diameters d_o on the toxic compounds emission achieved in diesel engines has been examined in the article. During research two spray nozzles were used (Table 1). First of them had a higher number of output holes (spray nozzle 7), however, at the same time a diameter of each hole was smaller in relation to the holes of the second spray nozzle (spray nozzle 3). The changes in dimensions and levels of toxic compounds emission for both design solutions of the spray nozzles have been analyzed.

Table 1. Constructional parameters of spray nozzles used during investigation

number of nozzle	types of nozzle: S-nozzle with hole sac, BS nozzle without hole sac	number of holes	diameter of holes (mm)	types of outlet canals: W – cylindrical, S – conical	diameter of needle ending (mm)	type of needle performance: chop on 0,2 mm, conical on 95°
3	BS	7	0,18	W	2,1	95°
7	BS	8	0,225	W	2,1	95°

Examinations were executed on compression ignition research engine. Research stand which was used during investigations consists following elements:

- compression ignition research engine with AMX 210 eddy current brake,
- common rail type mobile injection system,
- electronic system – Control CR,
- system AVL INDISET 620 which allows for registration of fast changing pressures inside combustion chamber,
- toxic compounds analysers: Testo 360 type, AVL Smoke Meter 415S.

The most important elements of a test stand are presented in figure 1. The SB 3.1 four-stroke, one-cylinder test engine connected to the AMX 210 eddy current brake was used. The engine cylinder head was developed from the one of the SW-680 engine, and the water jacket of the cylinder housing was adapted from the respective water jacket of that unit. The application of the sectional camshaft made the control of the variable camshaft timing possible. The permissible rotational speed of the engine was 2500 rpm.

Research engine was adequately adapted for performing the tests on a modern mobile injection system of a common rail type, equipped with a Bosch high pressure pump allowing to obtain the pressure value of 200 MPa. The applied pump was driven by a timing belt with the use of a motor with output power of 1.5 W. The regulation of the engine rotational speed, and thereby the regulation of the injection pressure as well, was possible owing to the use of the ac/dc inverter. The whole system was arranged on a portable frame. The advantages of the developed system are its portability and a possible application in the different engines.

The developed and built electronic unit is given a name Control CR. This system is intended for controlling the operation of injectors for the one-, two-, or four-cylinder engines. The injection process can be programmed and realized independently of the combustion engine. The system-engine coupling can be realized only by signals coming from the crankshaft and cylinder TDC position sensors. These signals are being used for a cyclic triggering of the programmed injection process.

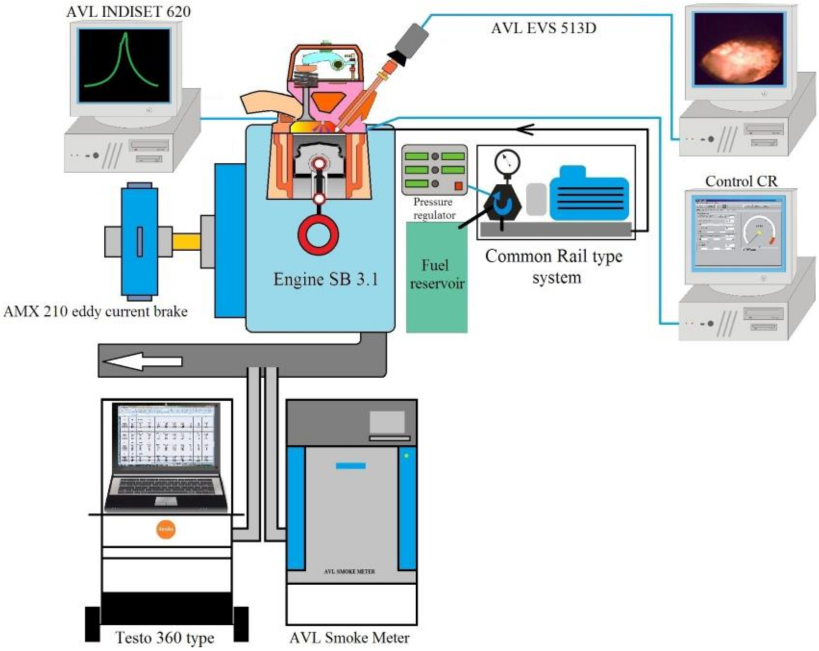

Figure 1. The arrangement of the most important elements of a engine test stand

During application of Control CR system it is possible to inject a dose of fuel in any position of the crankshaft. That is why the performance of gas pressure in a working cylinder p_{cyl} of the engine must have been monitored. For that reason it was necessary to use a system for measuring fast varying engine parameters and a data acquisition – system AVL INDISET 620.

Fuel injection was performed thanks to the application of the electromagnetic injector of the common rail Bosch 0 445 110 131 type.

3. INVESTIGATION’S RESULTS

After performed investigations two aspects were evaluated. An effect of the applied type of fuel and also an effect of the geometry of the applied spray nozzles on the levels of toxic compounds emission in exhaust gas have been examined. The conclusions are drawn on the basis of combination of both approaches.

Emission of toxic compounds that is CO, HC, NOx as well as smokiness of exhaust gases was examined depending on the engine load, applied fuel and kind of the applied nozzle. For each measurement the measuring time was the same in order to maintain a comparative sense of the investigations.

First observed change was related to emission of carbon monoxide. Concentration level of CO was lower for conventional fuel, the highest concentration was observed during URO combustion. Middle values of emission was registered for engine during FAME fuelling. This tendency was observed for whole range of loads (fig. 2). Carbon monoxide emission level was falling while load was expanded.

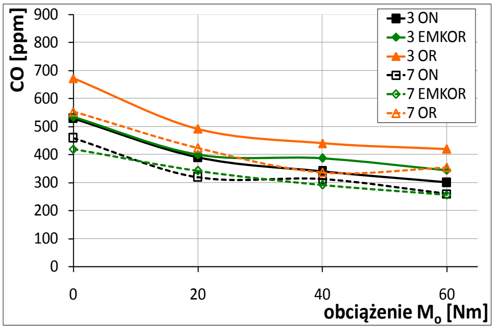

Figure 2. Changes in CO concentration for diesel fuel and biofuels while using spray nozzle 3 and 7 as a function of the engine load

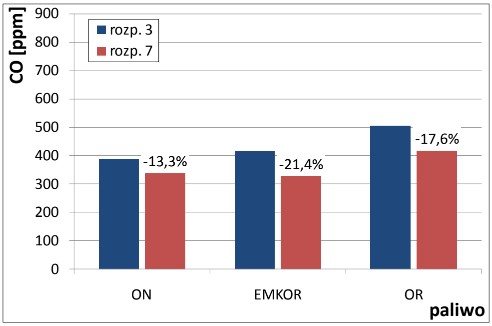

Figure 3. Comparison of middle CO concentration for diesel fuel and biofuels while using spray nozzle 3 and 7

Considering type of nozzle, it was observed that using of nozzle with higher number of output holes in which at the same time a diameter of each hole was smaller, cause that the middle level of carbon monoxide emission was lower. Such regularity was observed for each of fuel used in engine (fig. 3). For conventional fuel decrease amount 13.3%, for FAME – 21.4%, while for URO it was only 17.6%

Analysis of emission proved that there was not visible changes in hydrocarbons level while using of nozzle 3 and nozzle 7.

Such changes were registered during nitrogen oxide emission analysis (fig. 4). The lowest values appear during diesel fuel using, the highest for unprocessed rapeseed oil. Middle values were observed for fatty acid methyl esters of rape oil (fig. 5). There were some differences in relation to CO emission concerning of load trend line - for each fuel NOx emission level rises together with load rising. Taking into consideration type of spray nozzle, it was observed, that for all of the fuels nitrogen oxide level was falling when nozzle 7 was used. Differences in NOx concentration level were similar for DF and FAME – there was decrease for 35,1 and 33,5%. Less favourable effect was obtain for unprocessed biofuel – decrease in realtion to nozzle 3 was 24,6%.

According to [3] – on NO emission the most important influence have temperature and mixture composition. Such statement was very good confirmed during this part of investigation.

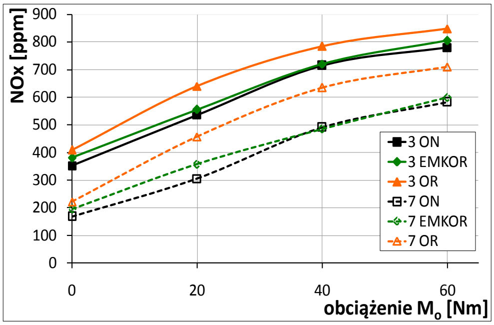

Figure 4. Changes in NO_x concentration for diesel fuel and biofuels while using spray nozzle 3 and 7 as a function of the engine load

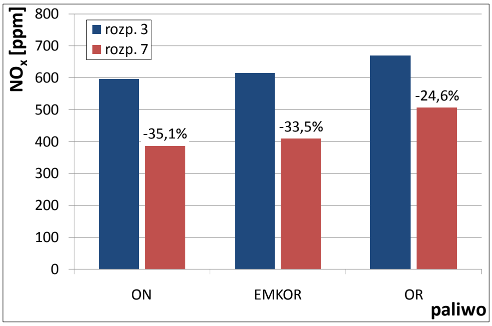

Figure 5. Comparison of middle NO_x concentration for diesel fuel and biofuels while using spray nozzle 3 and 7

Also for smokiness analysis repeating regularity was observed (fig. 6). Decreasing of smokiness level while using of spray nozzle with higher number of output holes has been observed. In relation to spray nozzle 3, application of nozzle 7 permits for considerable decreasing of smokiness. For conventional fuel it was 48,8% for FAME – 47,2% and for URO – 30,6% (fig. 7).

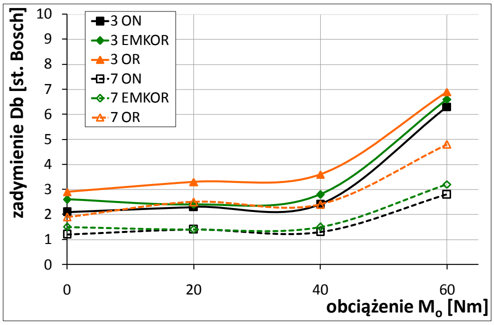

Figure 6. Changes in soot emission for diesel fuel and biofuels while using spray nozzle 3 and 7 as a function of the engine load

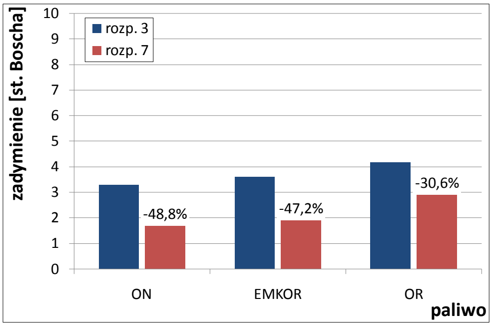

Figure 7. Comparison of middle soot emission for diesel fuel and biofuels while using spray nozzle 3 and 7

4. CONCLUSIONS

The obtained results concerning emission of toxic compounds and smokiness prove that there is a possibility of an effective limiting the negative effects of biofuels application in case when the spray nozzle of a right design solution is used.

Nozzle with higher number of output holes in which at the same time a diameter of each hole was smaller cause better spraying. Better fuel and air mixing leads to decreasing in CO, NOx emission in exhaust gases, as well as smokiness decreasing.

It was not observed visible change in case of hydrocarbons emission level analysis.

LITERATURE

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