Noise emission research of diesel engine powered with mixture of diesel oil and methyl esters

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Abstract. Generation of noise by reciprocating internal combustion engines is the effect of operation performed by them. Modernization of fuel feeding the power unit makes it possible to limit the emitted sounds preserving the engine’s high operating parameters. The conducted studies concerned comparison of the noise emission generated by a combustion engine fed by diesel oil and a mixture of fatty acids methyl esters (bio component) and the diesel oil in proportions 10%, 30% and 50% of bio component additive, at standard settings of the fuel injection controller. The subject matter of the tests there was the combustion engine with self-ignition of the power of 80 kW with direct ignition common rail, assembled in a vehicle. Adaptation was performed in the selected means of transport making it possible to change quickly the feeding fuel. The test was conducted in the chassis bed. It results from the conducted tests, that the unit fed with the diesel fuel generates noise on the level of 123 dB. Increase of the bio component’s share in the diesel fuel results in the drop of noise emission by approx. 2%. It results from the conducted studies, that the use of the fatty acids methyl esters’ additives to the diesel oil does not decrease the performance of the power unit and contributes to limitation of noise’s emission emitted by that engine.

1. Introduction
Protection of the planet’s natural environment and the mining resources is one of the most important problems taken up by the authorities and the society. Exacted by the European Union additives in the form of the fatty acids methyl esters to the diesel fuel, allow to decrease consumption of the mining power sources. In the literature there are also known studies on the impact of noise generated by a mechanical factor on animal life. [3]. Application of biocomponent as the additive to the diesel oil, results in forming of biofuel for powering of compression-ignition engines [8]. Many producers pass the use of the diesel oil and biocomponent’s mixture as the engine fuel, not influencing negatively the modern engine’s construction. These are most of all mixtures determined as biofuel B5, B10 or B20, what means, that the maximum share of biocomponent in the diesel oil should not exceed 20%. Transesterificated plant oil, commonly called biodiesel, in contrast to the traditional petroleum fuel, is a non-toxic biodegradable substance, and its use results in a considerable decrease of harmful substances’ emission to the atmosphere, and it may be used everywhere where the diesel oil is used [1]. Additionally, biodiesel has much better lubrication properties than the traditional diesel oil and it significantly extends a motor’s life [2]: There are also many pro-ecological arguments in favour of biodiesel’s application, such as: no environment pollution with sulphur compounds and reduction of the CO₂ volumes introduced to the atmosphere. However, the use of biodiesel results in forming of for more
than 20% of nitrogen oxide introduced to the atmosphere. There also occur complications connected with biodiesel use, such as: reaching the required cetane number, solubility of plastics under the influence of biodiesel, change of physical properties, viscosity [7], under the influence of the temperature’s rise, requirements of the use of additional motor’s cooling sources, change of mechanical properties at negative temperatures, so-called gelling, [10].

Sound, generated by the acoustic wave travelling in the resilient centre, is the disturbance of density formed in the form of a longitudinal wave, accompanied by oscillations of the centre’s molecules [5]. The operating engine with self-ignition, apart from exhaust gases’ emission, is also the source of noise’s generation. Noise generated by the engine, is caused by the suction murmurs, effect of the mechanical engine parts’ and its fixtures’ contact, and most of all the fuel combustion process and its removal from the engine through the exhaust system [4]. The approximate values of the acoustic power generated by the engine’s parts, are presented in the figure 1.

![Figure 1. Exemplary values of the acoustic power’s selected engine elements](image)

Different types of sounds which are generated at the time of an engine’s operation may be distinguished. Due to the mode of forming, the following noises may be distinguished: mechanical, aerodynamical, gas dynamic and hydrodynamic [9]. During operation, the sound is generated not only from the elements cooperating with each other, there is also generated noise resulting from operation of the power unit systems, what is presented in figure 2.
Development of the technologies applied in motorization, allows for the improvement of the power unit operating parameters, including the reduction of the generated noise, what attributes to the decrease of the noxiousness for the natural environment.

2. Methodology

The material used in the tests there were the fatty acid methyl esters and the diesel oil. The proportions of the used mixtures are presented in the table 1.

| No. | Composition of the mixture                          | Mixture’s marking |
|-----|-----------------------------------------------------|-------------------|
| 1   | diesel oil                                          | I                 |
| 2   | 90% diesel oil 10% methyl esters of fatty acids     | II                |
| 3   | 70% diesel oil 30% methyl esters of fatty acids     | III               |
| 4   | 50% diesel oil 50% methyl esters of fatty acids     | IV                |

The tested material, apart from the diesel oil, there were the plant oil subject to the process of transesterification, that is the exchange of the chemically bound glycerin in a triacylglycerol molecule into the methyl alcohol added in the presence of a basic or acid catalyst, which are commonly called biocomponents. Figure 3 presents the exemplary mixtures of the diesel oil and the fatty acid methyl esters used for the tests.
Figure 3. Mixtures of the diesel oil and the fatty oil methyl esters [own study]

The object of the tests was the combustion motor with self-ignition of the power of 80 kW, with turbocompressor pressure charging, and with direct common rail injection and with the applied electromagnetic injectors, which is presented in figure 4. The tested power unit is used in vehicles of the allowable total weight up to 3.5 t. A vehicle used in the tests, has been singled out for the tests due to the following features: universality of its use as the means of transport and possibility of the injection parameters’ modification, resistance to possible disadvantageous consequences resulting from the use of the fuel mixture. In the tested object there was conducted adaptation of the feed system, allowing for non-invasive change of fuel powering the motor.

Figure 4. The tested power unit [own study]

Measurement of the noise generated by the power unit, was set with the use of a noise level’s measuring device with the built-in spectra analyser, meeting the requirement consistent with the standard IEC 61672-1:2002 and IEC 60651, view and the block diagram of the objective noise meter is presented in the figure 5.
Figure 5. View and the block diagram of the noise level’s measuring device [own study based on 9]: microphone, 2. amplifier with a discrete adjusted voltage divider, 3. type of operation’s changeover switch, 4. set of band filters, 5. set of correction filters, 7. ancillary systems.

The rule of the objective noise meter’s operation is based on the research of the acoustic signal, which in the form of a pressure wave reaches the capacitor microphone of linear frequency characteristics. At the time of the electric capacity’s testing, which is connected with the membrane’s oscillations they are processed into the correct voltage changes. The signal formed in such a manner, reaches the amplifier and then to the output signal through the filtering systems. Reaching the output system by the signal, allows for reading out of the measurement result on the device’s digital display. Setting of the acoustic parameters for a power unit powered with the mixtures of the diesel oil and the fatty acid methyl esters took place with the use of the survey method for determining of the acoustic power’s level of an engine’s noise. This method consisted in calculation of the corrected acoustic power level and the acoustic power level in frequency bands on the basis of the pressure’s acoustic level in the frequency bands and the noise level measured with the use of the correction filter. The measurement area, the scheme of which is presented in figure 6, should form a closed area around the engine, to reflect sound, and be in the distance of 1 m from the tested unit and on the height equal to the installed engine. Prior to commencement of the intensity of the level of the sound emitted by the engine, the environment’s noise level was measured, this activity was repeated also after the test’s completion. The measuring device was calibrated prior to the tests’ commencement with the model sound source. The measurement was for the maximum engine’s revolutions.
3. Results of the tests

The obtained measurements’ results have been subject to statistical analysis and presented in the form of a chart in figure 7. The results presented in the chart are the average from 30 measurements conducted during testing of operating parameters on the chassis test house.

Based on the conducted statistical analysis it may be noticed, that the level of noise generated by an engine in case of the engine’s powering with fuels of the content of up to 30% of biocomponent, have not statistically significantly differ among themselves. It was only for 50% of fatty acid methyl esters’...
additive in the diesel oil when there was measured a statistically significant drop in the noise level and for 1.4 dB lower than in case of the engine’s powering with the fuel of the biofuel’s contents of 30%.

4. Summary
Based on the conducted tests of the noise level in engines powered with the mixtures of diesel oil and the fatty acid methyl ester sit was found, that the increase of the biocomponent’s contents above 30% results in the decrease of the emission of the noise’s level generated by the power unit. The conducted tests showed lowering of the noise level for about 1.4 dB for 50% mixture of the diesel oil and the fatty acid methyl esters. Lower contents of biocomponent in fuel did not result, in the tested case, of any statistically significant noise level’s lowering. From the results obtained in the course of the conducted test sit may be concluded, that the additive of biocomponent to the diesel oil has a positive effect on emission of the noise generated by a power unit, what has an effect on the natural environment and affects the human being’s health.

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