

UDC 621

## EXPERIMENTAL STUDIES OF DIESEL FUEL PREPARED FROM OIL PRODUCT WASTE

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**Introduction.** The high share of sulfur and high sulfur oil in hydrocarbon stocks and the steady increase in the consumption of their refined products, where sulfur content is strictly regulated, are urgently looking for new cost-effective technologies to reduce total sulfur in primary and secondary petroleum products as well as in the refining stage [1, 2]. Sulfur-containing compounds negatively affect many performance characteristics of petroleum products: automotive fuels reduce stability, sensitivity to additives, increase carbonation and corrosivity. Sulfur-containing compounds adversely affect the operating systems of many petroleum products, sulfur-containing compounds are also active catalytic poisons in many refining processes, and their long-acting catalysts for poisoning are irreversible [3]. The hydrotreating process is widely used to remove sulfur compounds from hydrocarbon fractions, in which the destruction of organic sulfur compounds occurs through the formation of hydrocarbons and hydrogen sulfide [4, 5]. By improving the catalysts and equipment, optimizing the conditions of the hydrotreating process, it is possible to obtain motor fuels that meet the strictest standards [6], but the hydrofining capacity has almost reached the limit and is up to 0.001 % by weight of sulfur in petroleum products. This method is not economically viable [5] and inefficient. As a result, the search for new, non-traditional methods of desulphurisation from fuels, for example as an alternative to hydrogen treatment, can be considered as hydrogen-free methods for the removal of sulfur compounds with the most promising oxidative desulphurisation. A modern alternative to hydrodesulfurization is ultrasonic desulfurization

**Methodology.** The petroleum product obtained from JUMPS – diesel – was prepared for experimental research in order to determine its performance in comparison with standard diesel (Supply chain) and treated ultrasonic cavitator, together with H<sub>2</sub>SO<sub>4</sub> and NaOH solutions. Experimental studies were performed in the JUMPS laboratory with the existing equipment and using the developed tools and chemical preparations H<sub>2</sub>SO<sub>4</sub> and NaOH solutions. Microscopic examinations of the samples were performed in the laboratory of KTU Institute of Mechatronics using a microscope NIKON with a video camera Pixelink PL-A662 and a computerized analysis program NisElements. Performance fuel tests were performed on a four-stroke four-cylinder direct injection diesel engine with a displacement of

1,91 dm<sup>3</sup> and an 18:1 compression ratio with a common rail fuel injection system (FIAT 1.9 JTD8V). The motor was loaded and the torque was measured with a three-phase asynchronous 110 kW electric dynamometer. Torque measurement accuracy  $\pm 1$  Nm. The load was varied from minimum to maximum at constant 1 800 rpm.

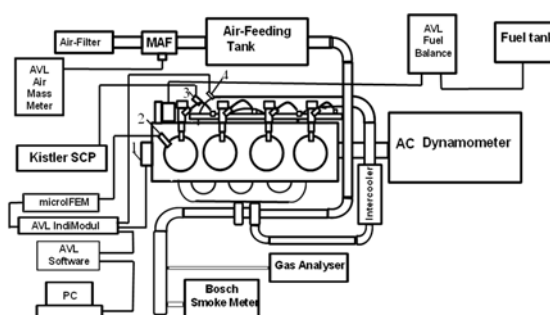


Figure 1 – Engine test bench diagram:  
1 – AVL encoder; 2 – cylinder pressure sensor;  
3 – injector control signal sensor;  
4 – boost pressure sensor

Mass fuel consumption was measured with an AVL fuel balance measuring device with an accuracy of  $\pm 0,12$  %. Air consumption was measured with an AVL air mass flow meter mounted upstream of the air receiver to reduce airflow pulsations. Accuracy of air flow measurement  $\pm 0,25$  %. The engine coolant temperature was maintained between 80 and 85 °C.

The crankshaft speed was measured with an AVL rotation angle encoder 365 C attached to the engine crankshaft with a measurement accuracy of  $\pm 0,1$  min<sup>-1</sup>.

To analyze the combustion process of the engine, individual and 100 indicator cycles summarized were indicated, i. e. pressure variation diagrams in the cylinder. Indicator diagrams were recorded by recording measurement data every 0,1 degree of crankshaft rotation angle using AVL indication and data visualization equipment. The pressure was measured by a piezoelectric uncooled AVL pressure sensor GU24D (measuring range 0–280 bar) built into the head of the first cylinder, connected to a MOCROIFEM piezoelectric signal amplifier. Pressure measurement accuracy  $\pm 0,1$  bar. The gas pressure in the cylinder, crankshaft angle, fuel pressure, and injector needle travel signals continued to be fed to the AVL IndiModul 622 display system connected to a personal computer with AVL IndoCom Mobile software display. A summary indicator diagram

of 100 engine operating cycles was used to analyze the engine operating process and calculate the heat release rate.

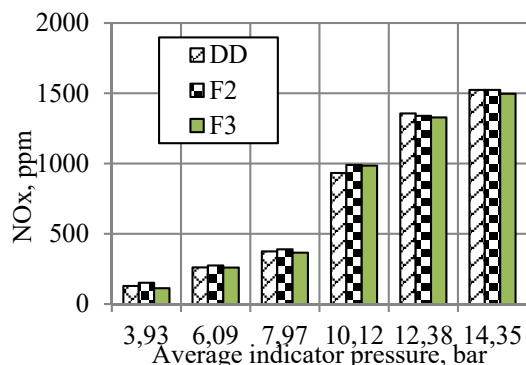


Figure 2 – Influence of fuel on NOx emissions

In diesel engine combustion, the main part of NOx emissions (80–90 %) consists of NO. The rest is NO<sub>2</sub>. The formation of NO is highly dependent on the amount of combustible mixture prepared during the spontaneous ignition delay period and burned in the first combustion phase. Comparing the influence of fuel type on NOx emissions (Figure 2), it can be observed that at low and medium loads, these changes correlate with the changes in the spontaneous ignition delay period (Figure 2). At high load, F2 fuel use resulted in lower NOx emissions despite a longer ignition delay period.

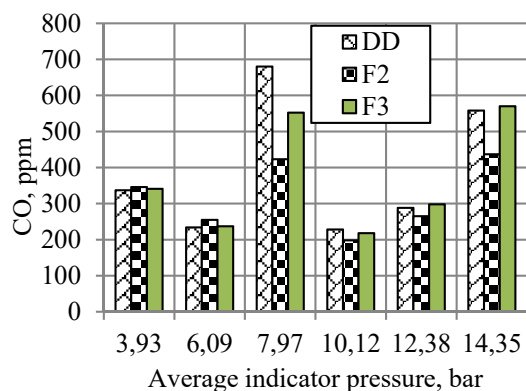


Figure 3 – Influence of fuel on CO emissions

Carbon monoxide (CO) emissions are affected by the presence of a locally fatter combustible mixture (with a lower excess air ratio) in the combustion chamber. As shown in Figure 3, CO emissions were lowest at medium and high loads using F2 fuel. Using F3 fuel, CO emissions were obtained close to carbon monoxide emissions using standard diesel fuel.

The smoke of the combustion products is the highest obtained using standard diesel fuel. In all load modes, with the engine running on F2 and F3 fuels, the opacity (optical transparency) of the flues was lower. This can be explained by the longer ignition delay period (Figure 4.), during which a larger

amount of homogeneous mixture is formed, resulting in a smaller share of diffuse combustion.

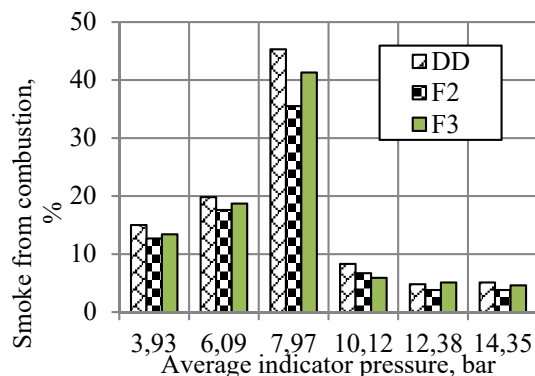


Figure 4 – Influence of fuel type on flue gas smoke

**Conclusions.** The best results for diesel clarification and acidity were obtained when the diesel was mixed mechanically with sulfuric acid, and after the initial clarification, the introduced NaOH was mixed mechanically and with a cavitator. The duration of the auto-ignition period of the ultrasonic-treated fuel F2 was obtained closer to that of standard diesel fuel. The comparative costs of the tested F2 and F3 fuels were obtained analogous to the costs of standard diesel. The total nitrogen oxide (NOx) emissions from the engine running on ultrasonic F3 fuel were lower than when running on F2 fuel. The smoke of the flue gas with F2 and F3 fuel is lower than with standard diesel.

#### References

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