OPERATING AND ENVIRONMENTAL TESTS OF BIOFUEL MICROEMULSIONS AT A SMALL BIOMASS-FUELLED POWER PLANT *

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Microemulsions are multicomponent liquid systems of two or more immiscible liquids stabilized by surfactants and an additional component. Externally, microemulsions are a transparent or slightly cloudy liquid due to the dispersed phase droplet size reaching from 1 to 100 nm [1].

The use of fuel microemulsions in comparison with traditional fuels allows to reduce the level of harmful emissions, increase combustion efficiency, and save hydrocarbon fuel. The use of microemulsion fuel allows reducing the temperature of exhaust gases by 20–60%, reducing emissions of particulate matter by 40–77%, nitrogen oxides and carbon monoxide by 70–75% [2]. Another advantage of water-diesel microemulsions is the possibility of their use in diesel engines and power plants without major modifications to fuel supply systems, in contrast to the method of direct injection of water into the combustion chamber [3]. One of the methods for improving environmental and power characteristics is the use of biofuel.

Biofuels have high potential for the energy sector and internal combustion engines, as they can be produced from a wide range of available resources (oils, fats, agricultural waste, etc.). The benefits of using biofuels include: reduced particulate matter, carbon neutrality, reduced greenhouse gas emissions, waste management, energy and economic security, less dependence on petroleum resources. With the global trend towards renewable energy and reduction of carbon emissions, biofuels can be considered as the best choice for the transport and energy sectors [4]. Due to the non-renewability and depletion of petroleum resources, biofuel has become an inevitable choice as an alternative. However, despite the extensive understanding of fuel microemulsions, an important aspect remains the assessment of the performance of small power plants using microemulsion fuels. This study provides a comparative analysis of the combined atomization, combustion and exhaust emission characteristics of rapeseed oil-based biodiesel microemulsions in a swirl burner equipped with an optically accessible combustion chamber and exhaust gas recirculation system. In particular, the features of the combustion process are determined, as well as the hydrodynamic and kinematic characteristics of an atomized gas-liquid flow of biofuel droplets from rapeseed oil produced through an environmentally sustainable approach - transesterification in a nanomembrane reactor.

To prepare fuel microemulsions (MEs), we used the diesel fuel, DF (EURO, class 3, type I-III (winter)), fatty acids methyl esters (FAME) of rapeseed oil (produced from refined rapeseed oil), distilled water (W) with a specific electrical conductivity not more than 5 μC/cm, Neonol AF 9-6, isononylphenol poly(ethylene glycol) ether (PEG-6, industrial, PJSC Nizhnekamskneftekhim, Russia) as a surfactant, and 2-ethylhexanol (industrial, Sibur-Himprom corporation, Russia) as a co-surfactant.

The fuel microemulsions were prepared by mixing the components in glass test tubes. Volumetric ratios of the components were used. The investigated MEs were stabilized by a mixture of the surfactant and cosurfactant at a volume ratio of 9/1.

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