RESEARCH OF WATER-FUEL MICROEMULSIONS AS FUEL FOR DIESEL ENGINE

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Abstract

The combustion of fuels is and will be in the nearest future a basic way of acquiring the energy, among others, for transport purposes. Transport causes many threats for natural environment. It produces powders and particulates, together with many gaseous noxious substances and is also the source of noise and vibrations.

Sources of propulsion, applied in transport, are almost exclusively piston-combustion engines, among which the dominant role play self-ignition engines. In the light of well-known advantages of these engines, they were accepted as most beneficial sources of car vehicles' propulsion in nearest decades, provided they meet the requirements of the future legal regulations regarding the environmental protection.

The emission of nitrogen oxides (NOx) and particulate matters (PM) is a problem to be solved in modern engines. This constitutes so called targets conflict, consisting in excluding the alternative of both coefficients' decrease, in the way of regulation the set of an engine and the limiting emissions, permitted by the EURO regulations.

From among many different methods of limiting both the formation and emission of NOx, the method of the selective catalytic reduction (SCR) is universally applied. This method requires special installation with the catalyst and the reservoir intended for the „clinically" clean reductive measure.

In the aspect of constituting opinions regarding the need of reducing additional installations and media on board the vehicle, it seems that to supply the engine with fuel-water emulsion and especially fuel-water microemulsion becomes an interesting solution.

Keywords: *road transport, combustion engines, emulsion's fuels, air pollution, environmental protection*

1. Introduction

The man's activity in the area of gaining and processing of energy, as well as natural processes occurring on earth (fires, explosions of volcanoes), are at the bottom of continuous atmosphere polluting with the combustion products [1, 2]. The atmosphere pollution, arising directly from combustion processes cause, as the result of the interaction, the creation of new substances, often considerably more harmful than the compounds from which they arose [4, 7, 8, 9 10].

Commonly found as harmful for the natural environment, and first of all for the man, include:

- carbon monoxide, denoted with the symbol (CO),
- not burnt hydrocarbons, especially polycyclic aromatic hydrocarbons (WWA),
- volatile organic compounds (compounds of carbon, hydrogen, oxygen and nitrogen), such as aldehydes and acrolein, denoted with the common symbol (LZO),
- nitrogen oxides (nitrogen oxide NO and nitrogen dioxide NO_2), denoted with the symbol (NO_x),
- sulphur oxides, mainly sulphur dioxide SO_2,
- particulate matter, containing soot and toxic compounds of carbon, hydrogen and oxygen, such as aldehydes, acrolein and a-benzopyrene, denoted with the symbol (PM) [11,12].

Hydrocarbons and nitrogen oxides are carcinogenic, and carbon monoxide and sulphur dioxide – toxic. The sulphur dioxide, nitrogen oxides (mainly NO_2) and hydrocarbons, agglomerating in the atmosphere, come into the reactions under solar radiation, so called photoreactions, as a result of which a very threatening for the human health *the smog* emerges.

Except the above-mentioned toxic compounds, as a result of the fuels combustion a carbon dioxide (CO_2) comes into being, which is not a toxic compound, but causes the greenhouse effect, which in turn brings about the increase in the temperature of Earth and climatic changes [5, 6].

The level of emissions of nitrous oxides (NO_x) and particles matter (PM), permitted by the EURO regulations is introduced in Fig. 1.

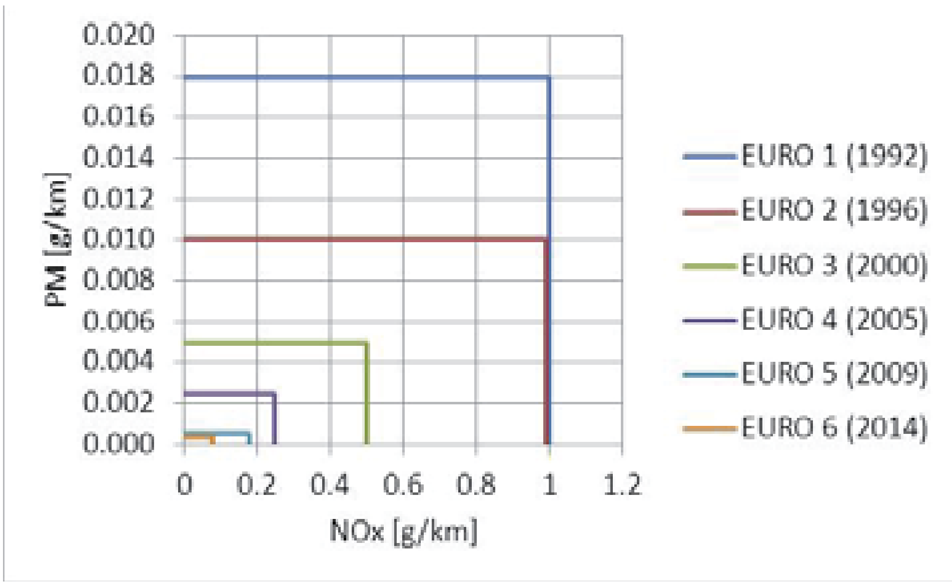

Fig. 1. EURO regulations in the area of NO_x and PM emission

2. Microemulsion production

Basic problems connected with the production of microemulsion of water and diesel oil refers to stabilities, costs additives and biodegradability of additives. Basically, two ways of microemulsion's production are known: ultra sounds and turbulences with additives of suitable surfactants. There is a possibility to obtain microemulsion with the content of water ranging from

5 to 17% volumetric in diesel oil thru uses of the surfactant package and the special manner of mixing.

For the production of fuel, it is necessary to have a mixing device, which can generate turbulence flow that is homogeneous and having the possibility to control the intensity of the turbulence. The formation mechanism of microemulsion is shown in Fig. 2 [3].

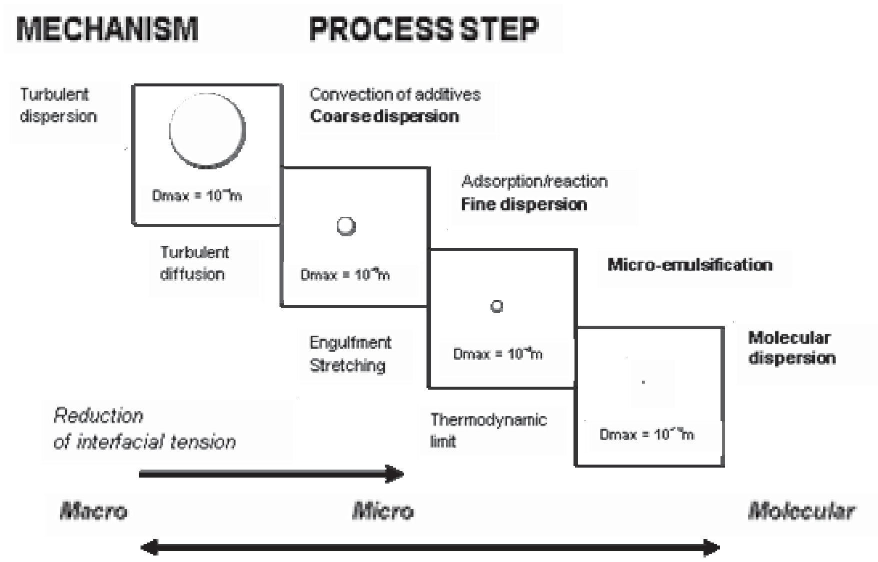

Fig. 2. Schema of microemulsion production [3]

3. Subject of study

The influence of the water-fuel microemulsion on the work of the combustion engine is defined by appointing the actual efficiency of the engine (denoted with η), the concentration of nitrogen oxides in the exhaust gases (denoted with NO_x) and smoke of the engine (denoted with S).

For the definition of applicability of the water-fuel microemulsion to feed the engines, samples of such fuel with 10% (10% water) and 20% (20% water) of the water content were prepared.

A natural consequence of the composition of the microemulsion is the change of basic properties with relation to diesel fuel (DF), i.e. the density and the heat value – the essential volumes for appointing the coefficients of the investigated engine's work.

Investigations of the “zero state" were carried out using the commercial diesel oil of the 0.83 g/cm^3 density and the heating value of 42 000 kJ/kg. The values of density and heating for the established concentrations of water, both calculated and measured, are presented in Tab. 1.

Tab. 1. Properties of investigated fuels

Fuel	Density, g/cm^3		Heating value kJ/kg
	Calculated	Measured	
DF		0.830	42000
10% water	0.847	0.887	Calculated 37800
20% water	0.864	0.890	Measured 33600

The differences in density of measured and calculated water-fuel microemulsion result from the fact that the participation and density (unknown) of emulsifier (surfactant) were not considered.

4. Research stand

The researches have been carried out with the research, one-cylinder engine of self-ignition with the symbol SB 3.1 and parameters presented in Tab. 2.

Tab. 2. Technical-operational parameters of the SB 3.1 engine SB 3.1

Cylinder liner diameter	127 mm
Piston stroke	146 mm
Stroke capacity	1.85 dm^3
Compression ratio	15.8
Power rating	22.7 kW
Rated rotational speed	2200 rpm
Maximum torque	117.7 Nm
Rotational speed of maximum torque	1400 rpm
Brake specific fuel consumption	220.3 g/kWh
Angle of beginning injection	26 [^{o} CA]

The engine was tested with the eddy-current-dynamometer of the NK 11 CVA type of the Heenan-Froude firm.
Investigations of fuel consumptions, underlying for the appointing of the engine efficiency were performed with the volumetric method.
Concentrations of NO_x were appointed with the analyser of the LCD type, PM 2000 model, the Pierburg GmbH Neuss FRG firm.
Smoke of the engine was analyzed by filter method with smokemeter of the AVL 415 type of measuring range 0 – 10 FSN (Filter Smoke Number), of AVL Austria production.
The schema of the research stand is introduced in Fig. 3.

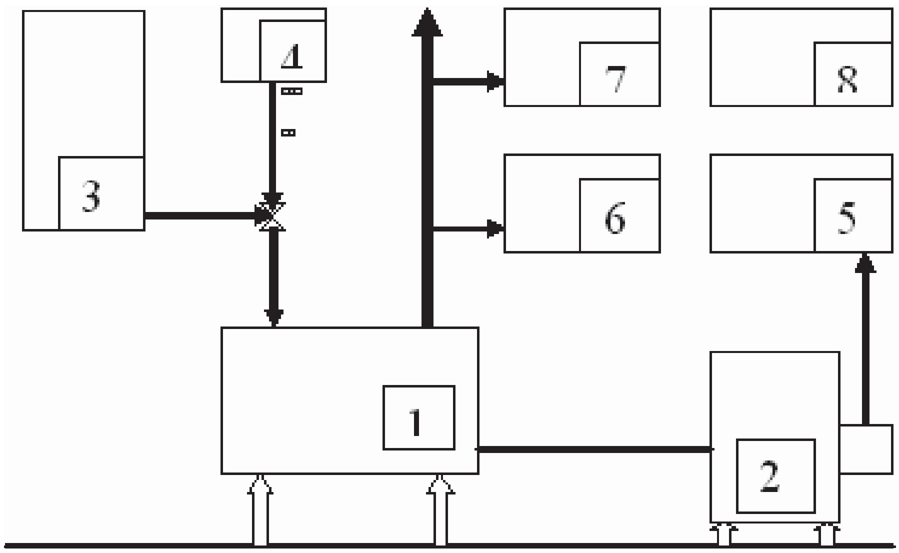

Fig. 3. The schema of the brake test bench: 1-Engine, 2- Load brake , 3-Supply of fuel oil, 4-Installation of the test fuel supply, 5-Measure rotational speed and torque, 6-Analysers of exhaust gases, 7-Smokemeter, 8-Measures of state of the environment

5. Test results

The investigated engine was fed with commercial fuel and water-fuel microemulsion, for given measuring values of the rotational speeds of the crankshaft, **n,** and the engine torque, **Mo.**

To illustrate the influence of water-fuel microemulsion on observed engine work indicators, Fig. 4, 5 and 6 introduce the comparative results of the efficiency η, concentrations NO_x and smoke of the engine S, which refer to the values appointed for the diesel fuel.

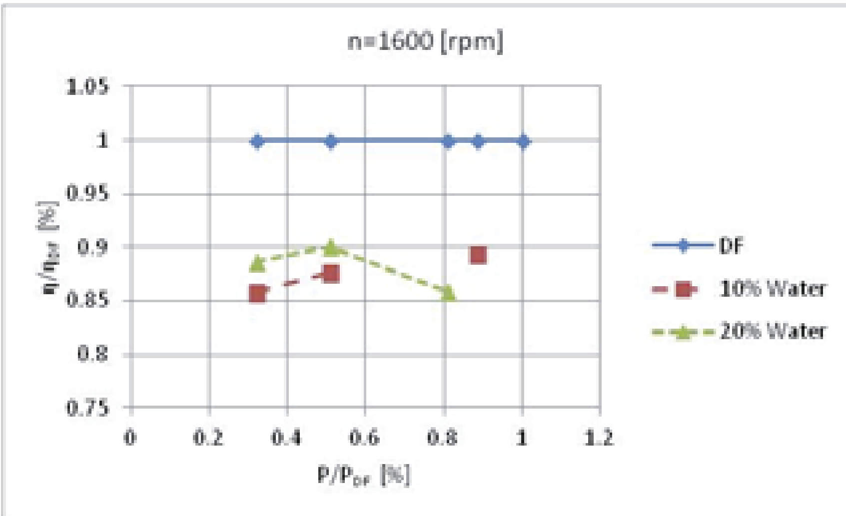

Fig. 4. Relative changes of value of the actual efficiency of the engine in the function of relative load variations for different fuels, at the rotational speed of 1600 rpm

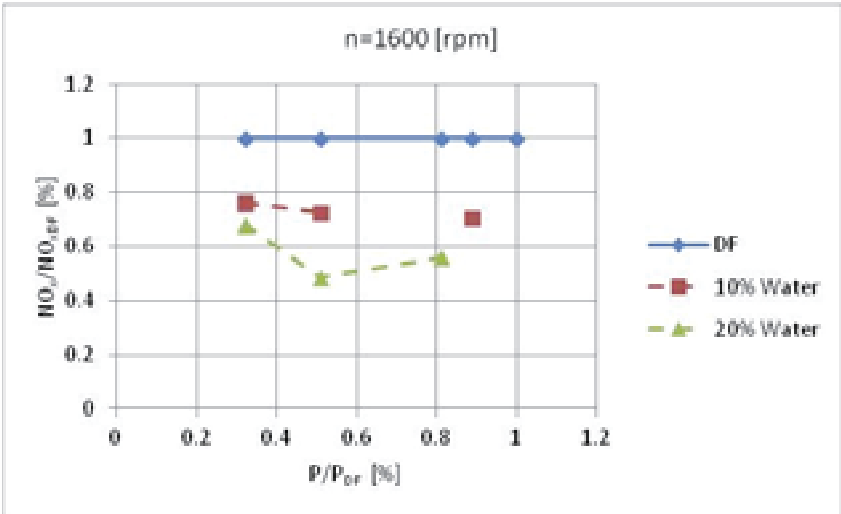

Fig. 5. Relative changes of value of the NO_x concentration in exhaust gases of the engine in the function of relative load variations for different fuels, at the rotational speed of 1600 rpm

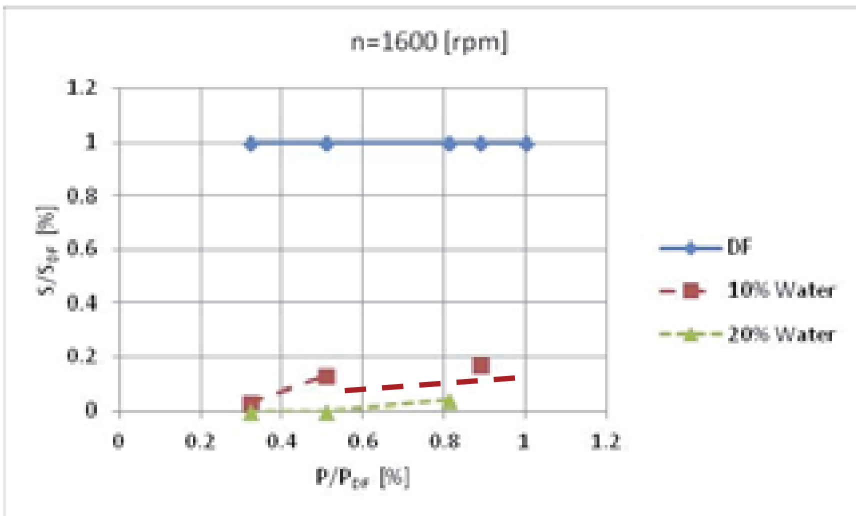

Fig. 6. Relative changes of value of the smoke of the engine in the function of relative load variations for different fuels, at the rotational speed of 1600 rpm

6. Conclusions

1 Investigated water-fuels microemulsions show their constant stability.
2 Investigations of proprieties of water-fuels microemulsions, carried out in the PKN Orlen laboratory, indicate locating of defined features outside the intervals of the values accepted for commercial fuels.
3 The greatest influence of investigated water-fuels microemulsions were observed on the smoke of the engine (90% lowers smoke of water-fuels microemulsions 20% water).
4 The concentration NOx in combustion gas surrenders to the decrease to 60% initial state.
5 The use of the water-fuels microemulsion causes the obvious decrease of the actual efficiency of the engine but in the smaller degree than the participation of water in the fuel.
6 Observed changes of indicators' values of the work and toxicity of the engine suggest the possibility of their optimization.

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