INFLUENCE OF CHOSEN PARAMETERS OF WATER FUEL MICROEMULSION ON COMBUSTION PROCESSES, EMISSION LEVEL OF NITROGEN OXIDES AND FUEL CONSUMPTION OF CI ENGINE

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Abstract

The microemulsion is the emulsion with dimension of molecules approx. micrometre and smaller. Such microemulsion of water and diesel oil creates new quality and lets on obtainment ecological and economic of effects, as well as eliminates the disadvantageous influence common emulsions, or unprofitable effects of the injection of water to inlet system of the engine, direct to combustion chambers, as well as the sequential injection of water direct to combustion chambers. The essence of apply of the microemulsion is also improve catalytic influence of small molecules of water on combustion process, what, beside decreasing temperature combustion gases, influences both emission level components of toxic combustion gases, as and the level of the specific fuel consumption. The paper presents different ways of microemulsion production, novel way of microemulsion production, which does not demand apply of mixers and suffers obtainment of microemulsion with the volumetric content of water in diesel oil do 40% under conditions of laboratory and stabile the microemulsion with content of water in diesel oil to 25%. Results of laboratory research involving basic parameters of the microemulsion and engine researches with measurements emission ingredients of toxic exhaust gases and fuel consumptions are presented involving basic parameters of the microemulsion and engine researches with measurements emission ingredients (NOx, soot, fuel consumption) of toxic exhaust gases and fuel consumptions are presented in the paper.

Keywords: *diesel engines, combustion processes, ecology, emulsion, microemulsions*

1. Introduction

The emulsion is the mixture two or the greater number of insoluble fluids. The microemulsion this is the emulsion with dimension of molecules approx. micrometre and smaller. Such microemulsion of water and diesel oil creates new quality and lets on obtainment ecological and economic of effects, as well as eliminates the disadvantageous influence common emulsions, or unprofitable effects of the injection of water to inlet system of the engine, direct to combustion chambers, as well as the sequential injection of water direct to combustion chambers. The use of the microemulsion influences favourably on reliability of the work of the engine, through elimination delaminating of components emulsion, what appears always at usage common emulsions of water and diesel oil. The essence of apply of the microemulsion is also improve catalytic influence of small molecules of water on combustion process, what, beside decreasing temperature combustion gases, influences both emission level components of toxic combustion gases, as and the level of the specific fuel consumption.

There are known four main ways of the delivery of water to combustion chamber of the engine: The injection of water to inlet system of the engine; direct injection of water to the engine by means of the separate injector; sequential injection of water and diesel oil; direct injection of the macroemulsion of water and diesel oil.

All well-known methods of the usage of water to delivery of the CI engine have beneficial influence on the emission level nitrogen oxides, however cause unfavourable influence connected with the growth of the emission level of hydrocarbons, Particulate matters and with the

enlargement of the individual fuel consumption. There cause also disadvantageous effects connected with the corrosive influence of water on essential elements of the engine. In turn the usage of the injection of water as such to the engine limits the utilization of these methods to stationary uses. The usage e.g. the injection of water conditioned of winter eliminates completely this manner of the feed of the compression-ignition engine under the circumstances. Applied in the country field tests of the macroemulsion to the feed of the compression-ignition engine did not give the beneficial effect because of the very small durability such emulsion cause with her stratification. Proposed solution of the use of the microemulsion of water and the derv eliminates inconveniences of previous methods. First of all will be the possible obtainment of the stable microemulsion in which will not appear the proper stratification for the macroemulsion. Besides the superiority of the microemulsion over any injection of water consists in the comfort of her usage and with effects with both bearing upon of the diminution of the emission level of components of toxic combustion gas, as and the individual fuel consumption. A besides new element of the usage of the microemulsion is the catalytic effect of water which does not appear at the injection of the macroemulsion and the injection of water. From above-favour the use of the microemulsion to the feed of the compression-ignition engine is in the country a new problem. Applied macroemulsions could not use the catalytic effect of small molecules of water, and the besides low durability of applied of the macroemulsion limited at us their use to the quickly carried out experiment.

2. **Ways of microemulsion production**

Basic problems connected with production of microemulsion of water and diesel oil refers to stabilities, costs additives, biodegradability of additives. Fundamental problems connected with the production of the microemulsion of water and diesel oil refers to stabilities, costs additives, biodegradability of additives. Basically is known two ways production of microemulsion: ultra sounds and turbulences with additives of suitable surfactants. There exists opportunity obtainment of microemulsion with content of water from 5 to 17% volumetric in diesel oil thru uses of the surfactant package and the special manner mixing.

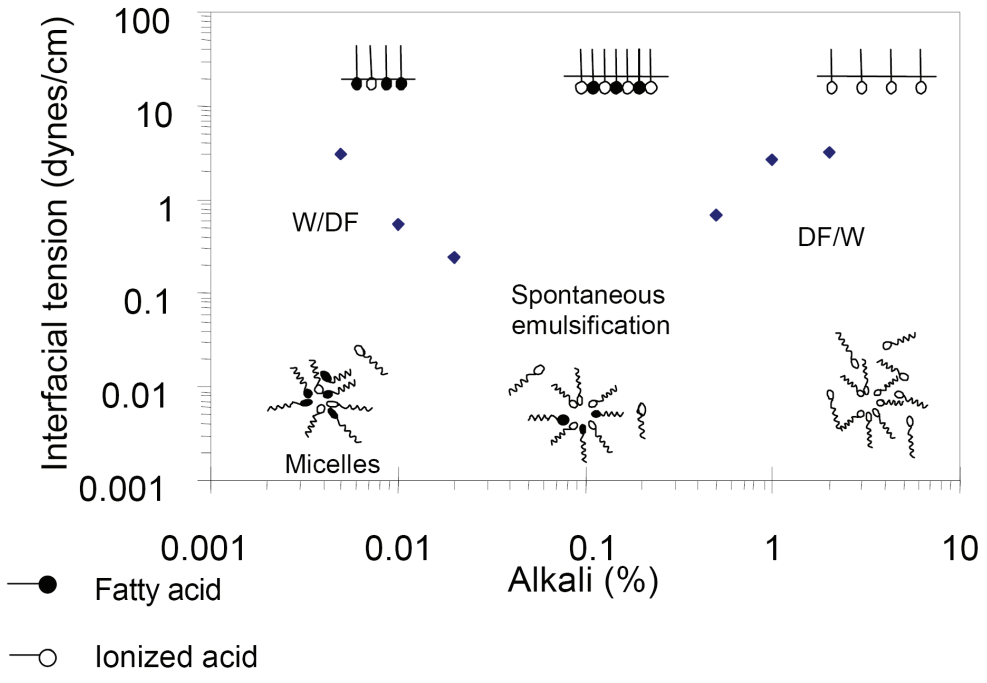

Fig. 1. Interfacial tension vs. function of the alkali concentration used (W- water, DF- diesel fuel) [15]

The surfactant package contains mixture of two surfactants. One of them is a lipophilic surfactant, such as fatty acid. Other surfactant is hydrophilic, such as the ionized form of the fatty acid. The ionization of the fatty acid is reached by the addition to the fuel of the high-pressure basic agent, such as the amine which promotes the formation of suitable carboxylate. By controlling relationship between fractions of the fatty acid and its carboxylate the ion, one can adapt the characterization of the surfactant package. Such microemulsions are thermodynamically constant, because the change in the free energy for process of the formation is lower than the zero. This condition is reached, when extreme low values included between two surfaces of the tension for the system are reached. By cautiously controlling of the mixture of surfactant by the addition of the suitable co surfactant in the required concentration, extreme low tensions included between two surfaces can be received. Microemulsions are created, using mixing device which contains static mixers, specially designed for this process. Water in microemulsions with diesel fuel, is prepared under conditions with above mentioned. Microemulsions are very constant products under static or dynamic conditions. In fact, they were stored, without observation of changes in their properties, for long periods (in excess of the year) at temperatures as high as 60°C. On the other hand, when these microemulsions were whirled at 10000 rpm for in excess of hour, no lamination of water was not perceived. In this instance, water to volume reference of surfactant was higher than 10. This low concentration of surfactant was reached because of favourable synergistic effect between surfactant active forming the surfactant pack. The positive cooperation is between two or more surfactants, when the value of the tension included between two surfaces of the mixture of surfactant is lower than tensions included between two surfaces of surfactant working separately and the value of the critical micellar concentration (CMC) of the mixture surfacant is lower than critical micellar of the concentration surfacant of working separately. In Fig. 1 change of the tension included between two surfaces for the system of the diesel, of the fatty acid, of water, of alkali, as function concentration alkali, are shown. This can be observed that it exists the compartment of the concentration of the rule at which extreme low tensions included between two surfaces are received. In this interval of the concentration, the spontaneous emulsification is reached. When the fatty acid dispersed in oil fuel phase (the diesel fuel) gets to the contact with alkali dispersed in the water phase which happens at oil fuel the interface of water, acid / base reaction is promoted and several carboxylate of ions is created. Both, not ionized molecules of the fatty acid and carboxylate of the molecule of the ion adsorbs at the interface of oil fuel/water. Is interval of the concentration alkali at which the concentration of adsorbed not ionized molecules of the fatty acid is approximately equal to concentrations adsorbed carboxylate ions.

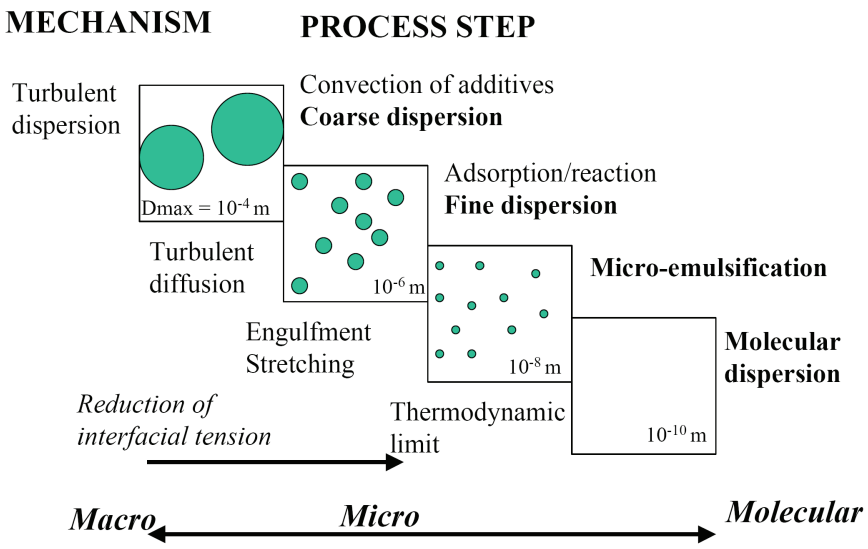

Fig. 2. Schema of microemulsion production

The cooperation among two surfacants comes in because of their interaction at the interface to oil fuel / water. The interaction which happens among the fatty acid and ionized acid is because of bonds of hydrogen, between hydrogen carboxylic of the group of acid and the atom of oxygen carrying negative charge of ionized acid. Under these conditions, highly compact absorbed the monolayer is generated, with great number of molecules of surfacant per unit the area included between two surfaces and therefore with the tension included between two surfaces low enough that to promote the spontaneous microemulsion formation. Process of the formation of water in diesel fuel, the step of mixing has very important part.

For production of fuel, this is necessary to have mixing device which can be able to generate turbulence flow which is homogeneous and giving to control intensity of the turbulence. Mechanism formation of microemulsion is shown in Fig. 2.

3. Novel way production of microemulsion

Microemulsions are thermodynamically constant, stabilized on the border of phases by compounds surface active, usually surfactants. Microemulsions differ from common emulsions transparency, low viscosity, big durability, and first of all with small dimensions of particles, within the range from approx. 10 nm to 200 nm. Microemulsions are characterized besides with very values of surface tension. Besides microemulsions have extra large area interaction of water in diesel oil and diesel oil in water. Components of the microemulsion are exactly dispersion, create the mixture close to the molecular mixture. This means that every molecule of the component of the phase dispersion is found in relative to its ambience phase of the second component. The preparation of the microemulsion according to applied method consists in bring in of the special component modified surfactants Invex. In opposition to the previous emulsification and the microemulsion this process does not demand mixers, or other special devices. Process of production of the microemulsion takes place in temperature of 40ºC. It consists in mixing diesel oil and Invex surfactant on these conditions, with the mechanical mixer during 30 minutes. Then suitable quantity of demineralised water to the founded concentration is moved in. The concentration of water carried out 10, 20 30 and 40%. After bring in of water, the received microemulsion was mixed mechanically during 30 minutes, then it was cooled to the ambient temperature. Stand microemulsion at the use of this method was obtained for the content of water carrying out of 25%. Microemulsions of content of water 30 and 40% were subject to cloudiness after 60 minutes. Microemulsions of the content of water to 25% are characterised with the thermodynamic stability.

3. Results of laboratory research

Basic laboratory researches of the microemulsion were carried out in reference to density, the ignition temperature, viscosity and the surface tension. The result of research for the microemulsion of content of water 10% are contained in Tab. 1.

Tab. 1. Test results microemulsion (10% water)

No.	Parameter	Result
1	Density at 15ºC [kg/m^3]	886.2
2	Temperature of Ignition [ºC]	64.5
3	Viscosity at 40ºC mm^2/s	9.457
4	Surface Tension [mN/m]	25.96

The result of research for the microemulsion of content of water 20% are contained in Tab. 2. Researches density were carried out in accordance to standard PN-EN ISO 12185:2002 standard, researches temperature of ignition, to standard PN-EN ISO 2719:2007 standard, researches viscosity, to standard PN-EN ISO 3104:2006 standard, researches surface tension, to standard PN-C-04809:1999 standard. Heat value of the microemulsion carried out 30.72 MJ/kg.

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Tab. 2. Test results microemulsion (20% water)

No.	Parameter	Result
1	Density at 15ºC [kg/m^3]	886.2
2	Temperature of ignition [ºC]	50.0
3	Viscosity at 40ºC mm^2/s	11.48
4	Surface Tension [mN/m]	24.09

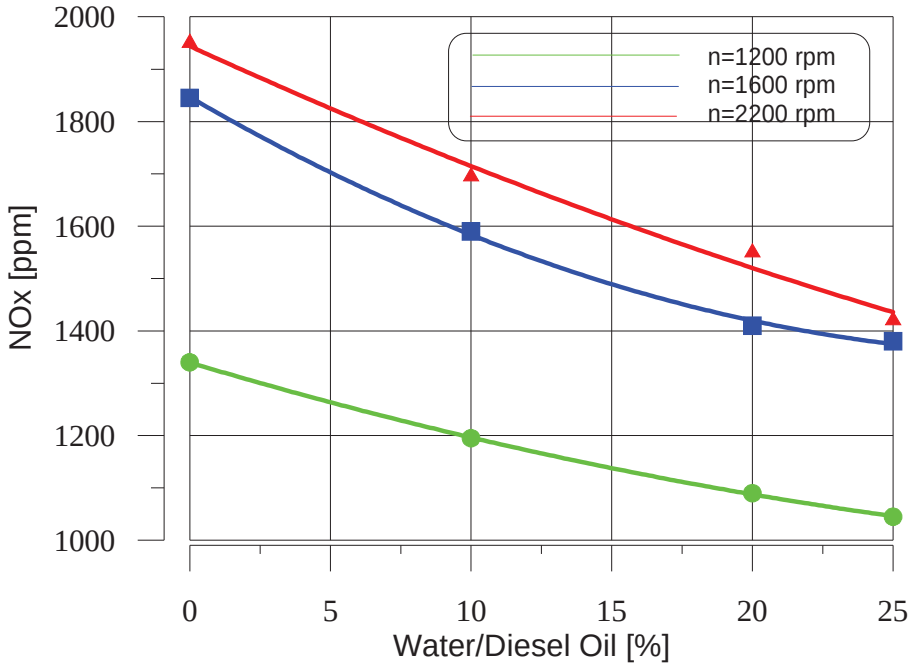

Fig. 3 Effect of water content in the diesel oil – water microemulsion on the emission of NOx

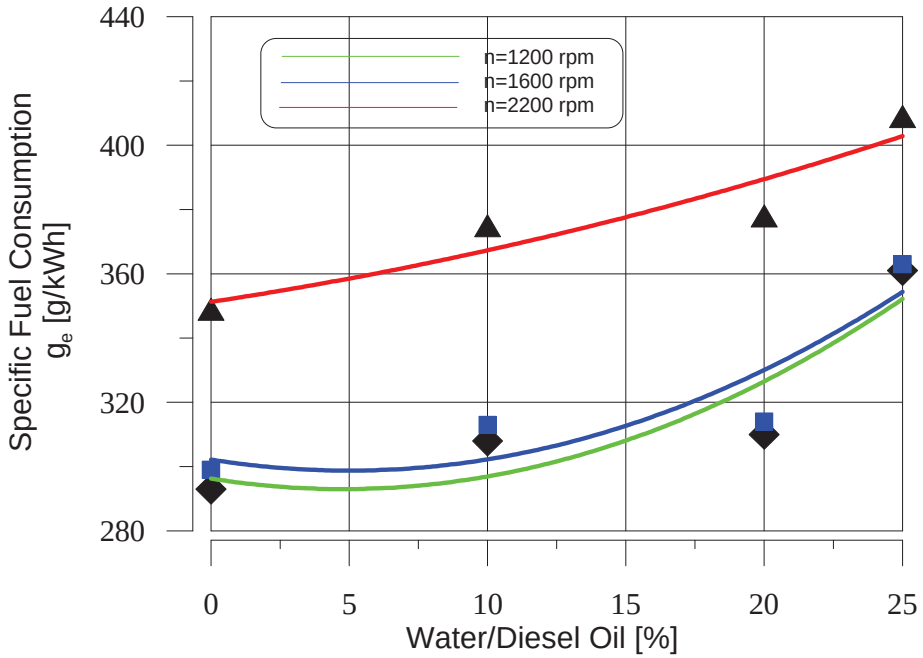

Fig. 4. Effect of water content in the diesel oil – water microemulsion on the emission of Specific Fuel Consumption

Typically, the use of water- fuel microemulsion in a diesel engine is connected with reduction in emissions of NOx. Fig. 3 shows emission level of NOx versus water content in microemulsion of water-diesel oil. As is clear from Fig. 3, linear decrease in NOx emissions was obtained with a water increase in microemulsion. Fig. 4 shows effect of water content in the fuel oil – water microemulsion on the emission of Specific Fuel Consumption. Fig. 5. shows effect of water content in the diesel oil – water microemulsion on the soot emission.

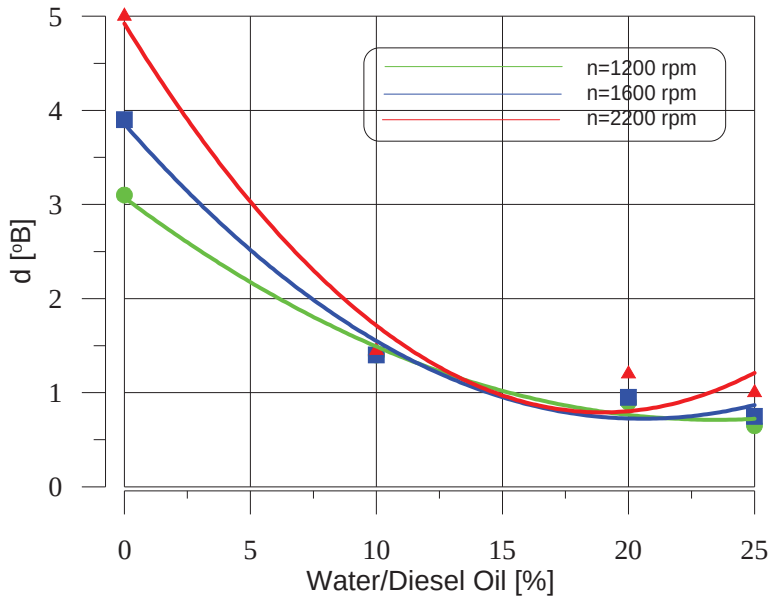

Fig. 5. Effect of water content in the diesel oil – water microemulsion on the soot emission

5. Conclusions

The microemulsion fuel stability at engine conditions is satisfactory based in the absence of fuel-water separation.

The diesel fuel microemulsions can significantly reduce peak opacity of in-service vehicles.

Due to the lower energy content of the diesel-water fuel microemulsion, the engine produced less power at full load, compared to base fuel. The reduction in power depends on engine speed.

Summarizing the results presented above can be stated generally positive impact of fuel-water microemulsion produced by preparation of the microemulsion according to applied method consists in bring in of the special component modified surfactants Invex on the combustion process and its results in the form of exhaust gas composition.

It therefore seems appropriate to a strong increase in the degree of dispersion of water droplets in the emulsion by applying the methods to obtain the size of water droplets on nanometric range. This should dramatically improve both the stability of emulsion and its influence on the chemical effects of combustion in diesel engine.

Simultaneous reduction in emissions is possible through the use of a stable emulsion, i.e. water-fuel microemulsion.

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