EXAMINATION OF THE EFFECTS OF WATER PRESENCE IN FUEL ON TOXICITY INDICES OF A COMPRESSION-IGNITION ENGINE

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Abstract

For many years research has been conducted on using water added to the process of combustion in a compression-ignition engine (by injection to the suction manifold, disintegrated in the manifold by ultrasounds, injection to the cylinder or in the form of emulsion) in order to improve the engine's operating indices and reduce its smoking and toxicity. The study presents the effects of adding water to fuel on selected toxicity indices of exhaust gases, and puts forward the problem of technical usability of a water solution of hydrogen peroxide for the discussed purposes.

The effect of water proportion in fuel on the change of the engine smoking, concentration of NOx in exhaust gases in the function of water proportion of water injected, concentration of NOx in the function of rotational speed for standard fuel and emulsion fuel, the effect of water proportion in the emulsion fuel on the relative value of the engine torque, concentration of CO in exhaust gases in the function of the engine load for different water proportions concentration of NOx in exhaust gases in the function of the engine load for different water proportions, specific fuel consumption in the function of the engine load for different water proportions are illustrated in the paper.

Keywords: *water, combustion engines, air pollution, fuel, emulsion, environmental protection*

1. Introduction

Adding water as a method of controlling the parameters of the engine's operation and emission of gas black and toxic compounds in exhaust gases has been examined for many years [1-8]. Coming back to or continuing this research results from not fully recognized mechanisms of water's impact on processes taking place in the cylinder.

2. Analysis of experimental dates

The effects of water presence in the engine cylinder, introduced there by different means, are shown in figures from No. 1 to 5.

Changes of concentration of nitric oxides in waste gases (Fig. 2, 3, 6) explicitly inform about the positive effects of water presence. The quality evaluation of this phenomenon is shown in Fig. 6, presenting the value graphs of concentrations of nitric oxides in the function of the engine load and water content in the fuel. According to expectations, the degree of lowering the NO content reached the highest values for the highest water proportion in the fuel. There is also a visible tendency to reduce the content of nitric oxide in exhaust gases at small engine loads.

Using fuel in the form of water emulsion makes it possible to reduce, controllably, the emission of NO_x in exhaust gases, and in addition, the increase in CO concentration should not pose a problem in engines equipped with a system of catalytic cleaning.

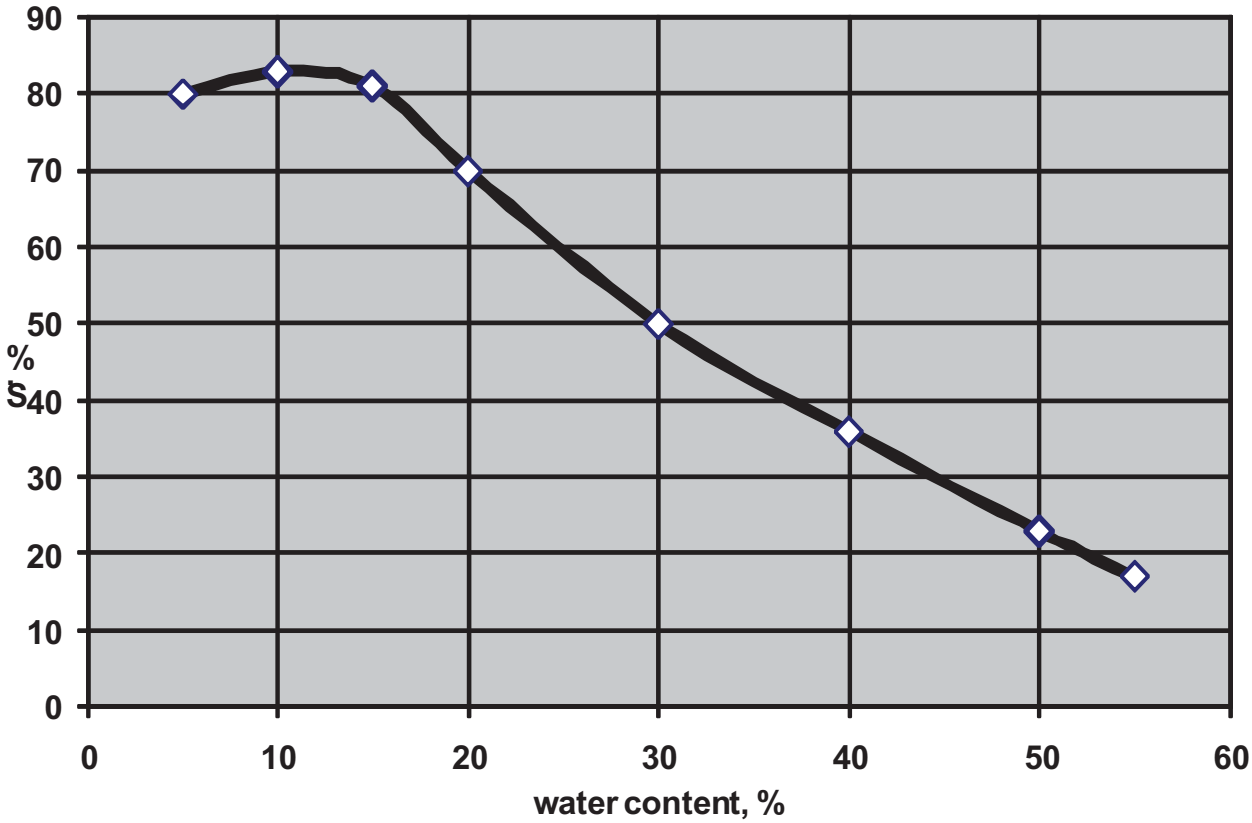

Fig. 1. The effect of water proportion in fuel on the change of the engine smoking [1]

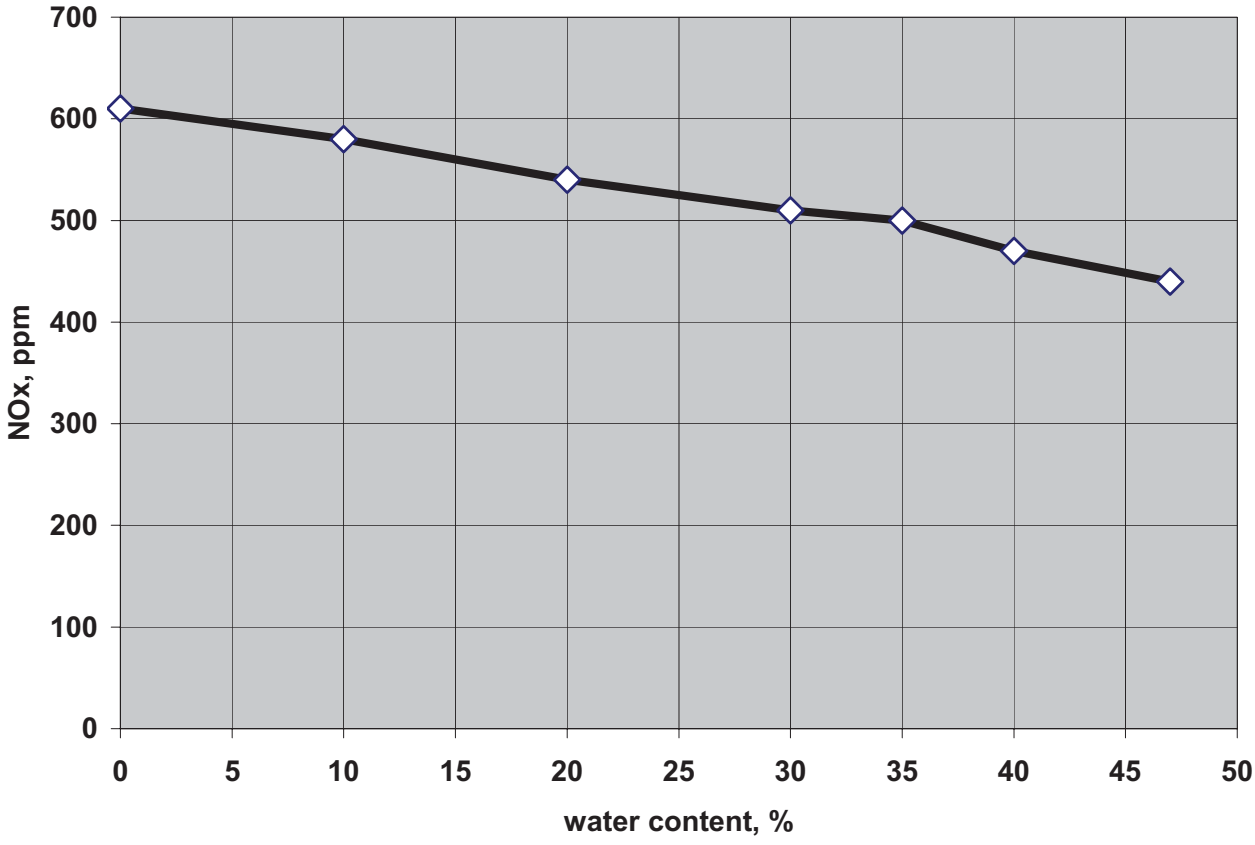

Fig. 2. Concentration of NOx in exhaust gases in the function of water proportion of water injected to the suction manifold [6]

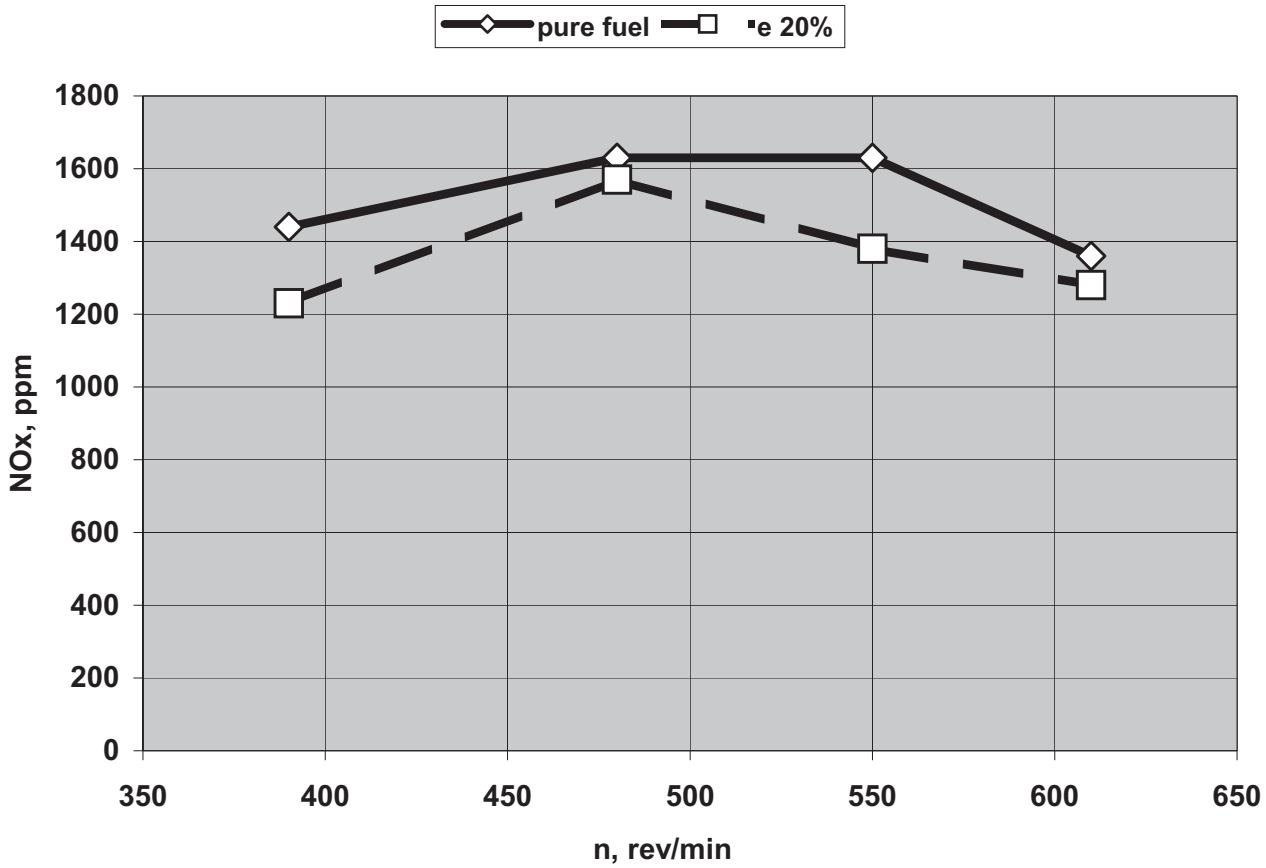

Fig. 3. Concentration of NOx in the function of rotational speed for standard fuel and emulsion fuel of 20% water content [8]

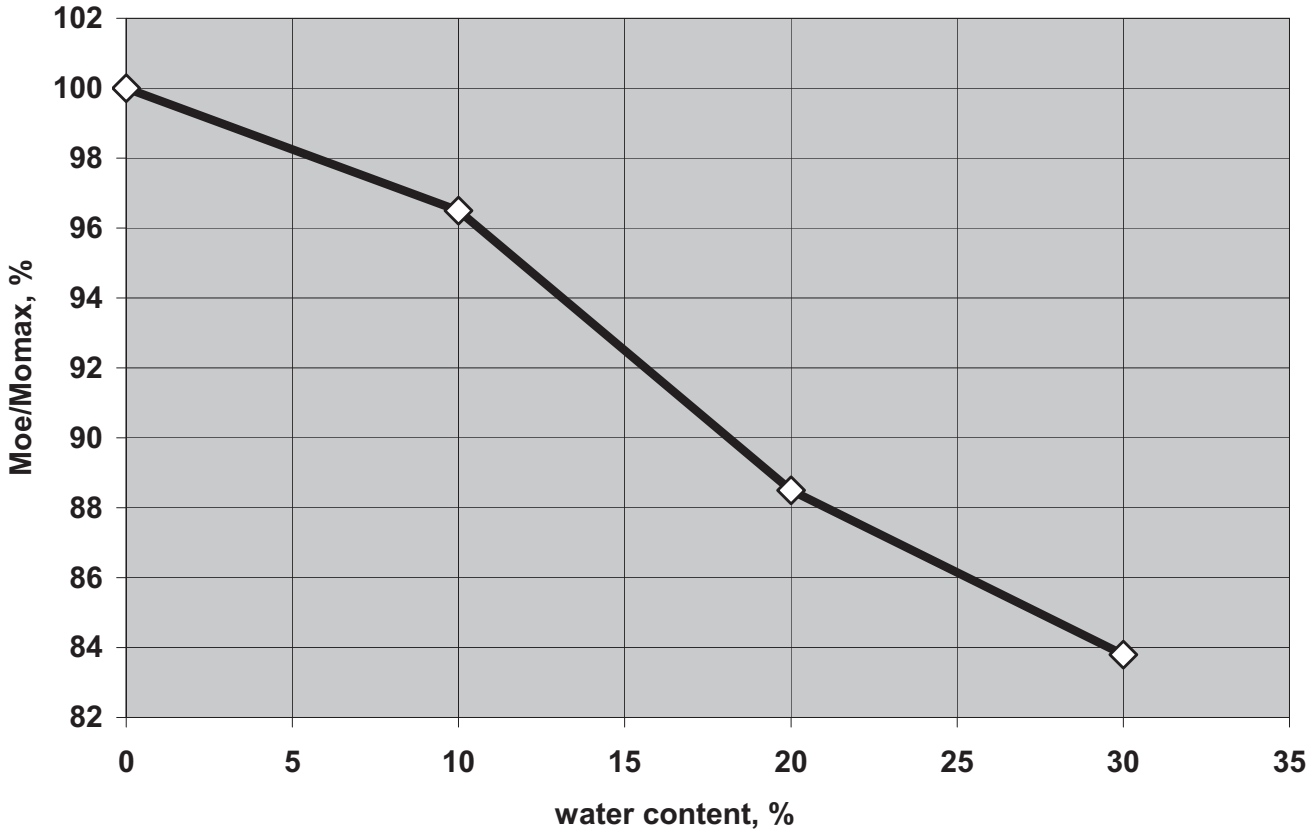

Fig. 4. The effect of water proportion in the emulsion fuel on the relative value of the engine torque

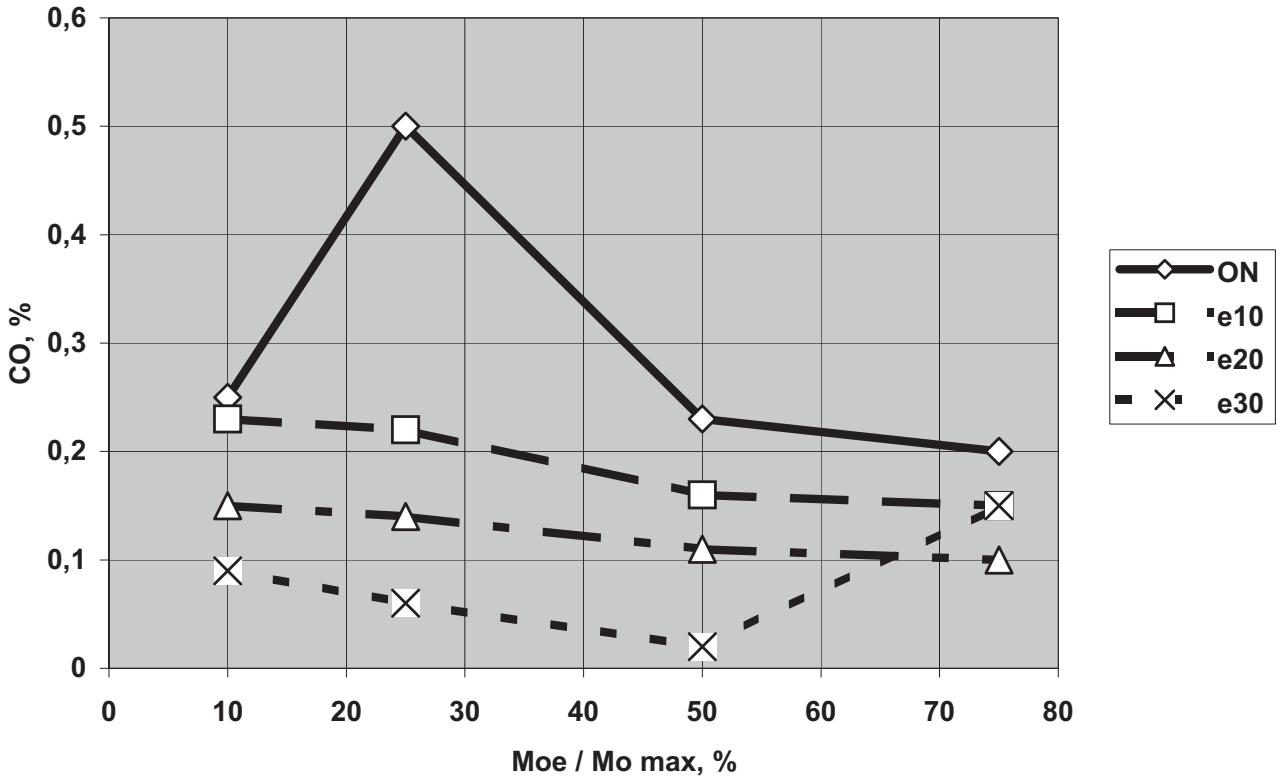

Fig. 5. Concentration of CO in exhaust gases in the function of the engine load for different water proportions in the emulsion fuel: ON – diesel oil, e10 – 30 emulsion fuel of water content 10-30%

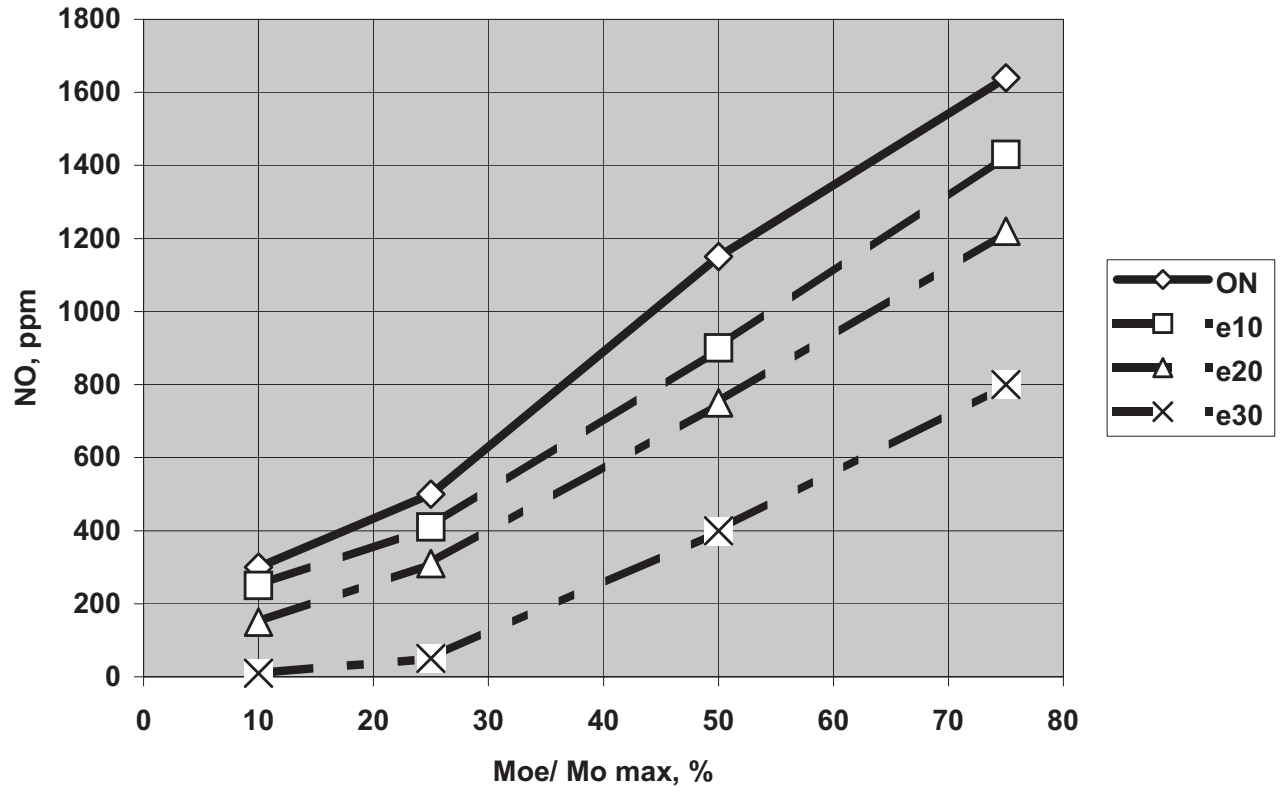

Fig. 6. Concentration of NO_x in exhaust gases in the function of the engine load for different water proportions in the emulsion fuel: ON – diesel oil, e10 – 30 emulsion fuel of water content 10 – 30%

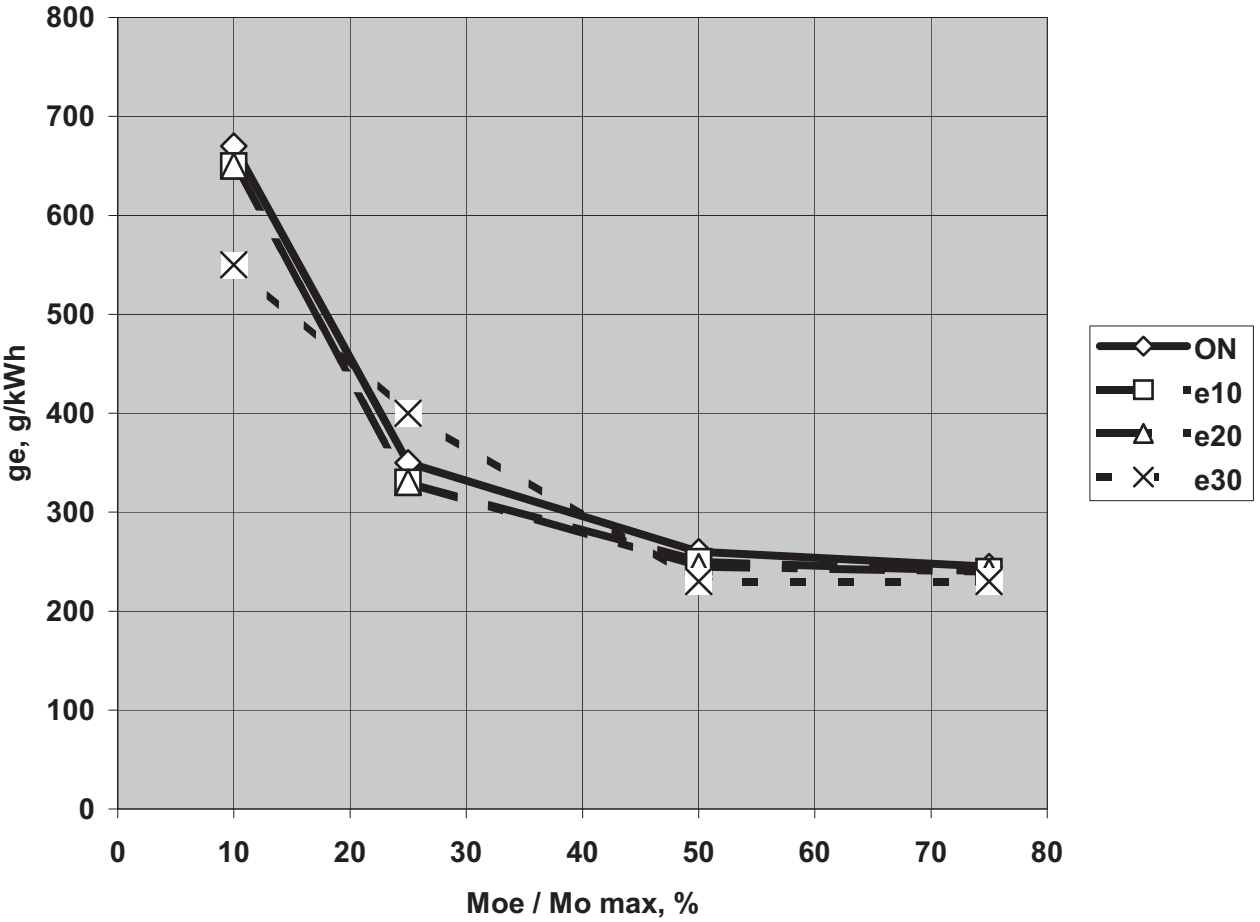

Fig. 7. Unit fuel consumption in the function of the engine load for different water proportions in the emulsion fuel: ON – diesel oil, e10 – 30 emulsion fuel of water content 10 – 30%

It was stated that the use of fuel in the form of water emulsion slightly decreases unit fuel consumption, which shows the increase in the process efficiency. Distinct decrease in the maximum values of the engine torque, accompanying the process of introducing water to the cylinder (after all causing a decrease in the fuel energy value) limits the usability of this method to power transmission systems having torque surplus.

Apart from the water molecule where there is one atom of oxygen to two atoms of hydrogen, we also know a compound of oxygen and hydrogen in which there is one atom of oxygen to one atom of hydrogen. This compound, of the chemical formula H_2O_2, is called hydrogen peroxide H-O-O-H.

It is an example of a chemical compound in which there is a chemical bond between atoms of the same element i.e. oxygen. A water solution of hydrogen peroxide (3%), is commonly known as *hydrogen peroxide solution* (a mild oxidizing agent), and a 30% solution – *perhydrol* – a strong oxidizer used in industry as an oxidizing agent.

Solutions of concentrations below 35% are durable, but in concentrations above 65% they are dangerous because H_2O_2 of this concentration explodes in contact with many organic compounds. Moreover, H_2O_2 is used as an oxidizer in rocket propellants. Hydrogen peroxide is an unstable compound and even in room temperature it self-decomposes, giving off oxygen:

$$2H_2O_2 \rightarrow 2H_2O + O_2.$$

The fact there is an additional atom of oxygen in the water molecule makes it possible to ask a question about the usability of such a medium in the aspect of the considered modification of fuel for a wide spectrum of combustion engines used in different areas of business.

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