INVESTIGATION of EFFIENCY OF CONSUMING ETHANOL OF DIESEL ENGINE

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Abstract

Renewable resources, searching for alternative energy and its application in motor vehicles became particularly urgent now, when oilfields are approaching to their depletion and prices of hydrocarbon fuel are permanently growing. One of renewable energy sources is ethanol that may be produced upon the existing conditions in Lithuanian as well. Consuming alternative fuel in internal combustion engines of motor vehicles that are applied to use fuel made of fossil oil causes various technical problems. When pure alternative fuel is consuming, one meets into collision with expensive and complicated changes of structure of the engine and its control (fuel supplying) systems. Seeking for reduction of the above mentioned expenses and simplified exploitation, the usual fuel is partially replaced by the alternative one. The problem arises in using a supply system for introducing the fuel applied for extra supply of ethanol to the air, sucked into Diesel engines combustion chambers. The issues related have been discussed in the presented paper.

Key words: *ethanol, biofuels, internal combustion engine, Diesel engine, comparative fuel consumption.*

1. INTRODUCTION

Renewable energy sources have caused great interest from the time the first automobile appeared in the world. Yet, the search for the alternative energy and the ways of its application have never been that important in the automobile transport as they have recently become [1, 2] due to the exhaust of fuel sources and its increasing prices. Ethanol is one of the renewable energy sources, which can be recently produced in Lithuania.

Consumption of alternative fuel in the internal combustion engines of an automobile causes different problems as they are meant to work on the fuel made from the oil. A very expensive and complicate alteration of the engine construction and its control system is required when using the pure alternative fuel. This is why the change of the regular fuel into the alternative one is limited due to the possibilities to simplify the vehicle exploitation and decrease of expenses.

The problems, caused by using the extra fuel supply system are analysed in the work. The system is adapted for the extra supply of ethanol into the air inlet of a diesel internal combustion engine [3]. While using the system for different experimental tests, the results of the experiments were noticed to have lack of high precision. The research proved the case that ethanol temperature was increasing in the fuel tank when the system was in process therefore, the ethanol density was changing. It could affect the changes on the amount of ethanol ejected.

2. REFERENCES REVIEW

It has been known that the main imperfections of the ethanol as the fuel of diesel engines are the following: low cetane number, high specific heat and inflammation temperature, low lubricate and low corrosion resistance [4, 5, 6, 7]. The difference of properties between the ethanol and fuels containing alcohol does not only influence the combustion process but also requires the reconstruction of the engine and its systems.

Light fuels contain more aromatic hydrocarbons whereas the structure of the molecules is cyclic, that is why high-octane fuels (petrol, alcohol) have the lower molecular mass, higher thermal stability and lower spontaneous combustion in comparison to Diesel.

Ethanol in comparison to diesel fuel contains some oxygen atoms and the temperature being more steady significantly decreases the fumigation of the combusted materials and the amount of incompletely combusted products; both the lower viscosity of alcohol and the surface tension power influence better ejection and the difference between the thermal properties increases the vaporisation, as well as the formation and burning of the combustible mix. Yet, the high inflammation temperature of the alcohol fuel and low cetane number does not allow using pure ethanol in a diesel engine in absence of its constructive changes.

The specific heat of liquid ethanol is higher, and the one vaporised- lower, the diffusion coefficient is higher of both the liquid and vapour ethanol in comparison to diesel, thus on the account of the properties mentioned above, the ejected ethanol should be better pulverised, heated and vaporised than diesel. Yet the high temperature of alcohol vaporisation makes the vaporising and combustion of the droplets complicate, especially when the possibility for using the heat of the air or the heated parts of the engine is limited. Therefore, during the supply of the alcohol directly to the cylinders of the engine together with the diesel, the period of inductivity increases when compared to the alcohol supply through the intake system [8].

Due to the low cetane number ethanol is very slow in combustion due to the compressed air, because its self-ignition temperature is 693°C, whereas that of diesel fuel is (473- 493) °C. Yet if the air and fuel mix is ready in the intake collector, after the inlet of a certain portion of diesel, the combustion of the mix takes place in the combustion chamber, with no flame spread, the combustion being instant therefore the process becomes more economic in comparison to the diesel combustion.

While constructing the supply systems for the ethanol supply one must take into account the solidity / resilience of the vapour and the corrosion activeness. Due to the higher solidity of the vapour cavitations phenomena may occur, which usually become evident in the low-pressure system. The alcohol is a hydroscopic material, therefore the humidity is absorbed from the surrounding, and its accumulation causes the corrosion of the parts [9].

In ethanol and air mix combustion more moles occur than in diesel combustion, therefore the work load increases. On the other hand, triatomic gas is more susceptive to the heat, which will be taken from the working unit present in the cylinder, thus decreasing the temperature in the combustion chamber.

The Hiroshima University made research in methanol and diesel fuel extra supply to the pump collector in a diesel engine. Experiments were completed by one-cylinder engine S/D=130/135, ε=15,5, V_h=1,86 l engine revolutions n=600 min^{-1}. Electromagnetic spray was used for methanol and/or diesel supply, fixed in the distance of 490 mm from the intake valve. Cyclic amount of the injected fuel was being changed from 0 to 150 mg/cycle with no replace of the main fuel (diesel), injected into the main chamber, cyclic rate, which made 70 mg/cycle. The temperature of the pumped air was changing within 293- 523 K. Compression cycle temperature was measured in thermal pores while pumping the extra fuel to fix the situation of the main fuel during the combustion in case the engine was rotating but not started. The research proved that the extra-injected diesel much more shortened the duration of inductive period than methanol. During the methanol supply the work noise increased, while the diesel did not increase any noise.

The research proves that alcohol amount during its supply to the diesel engine must be controlled according to the engine work mode for gaining high ecologic and economical effect because in case of small loads and idle running the work of the engine is not possible due to the unstable running of the engine. In case of increase of the workload from the medium mode, the alcohol amount must be decreased due to the increased noise of the work. The instant control of the fuel ratio is not possible in case of the supplied mix of alcohol and diesel. To avoid the undesirable phenomena the double fuel supply system must include the electronic control.

Finally, the following can be stated: when the diesel engine works on fuel with a low cetane number, the fuel consume and maximum pressure of combustion decrease p_z, but the phase of inductive combustion Δi increases, the heat is relieved more intensely and the noise is increased $\Delta p/\Delta\tau$; the temperature T_z in the combustion process increases, yet, the fumigation and the amount of solid particles in the combusted materials decrease in comparison to the basic diesel engine; the efficiency coefficient slightly increases due to the micro-explosion of alcohol droplets.

3. EQUIPMENT FOR THE EXPERIMENTS AND THE METHODS OF THE RESEARCH

For setting the influence of ejected ethanol on temperature a specific stand was established, Fig.1. The scheme of the stand is presented below, Fig. 2. with its operability has been described.

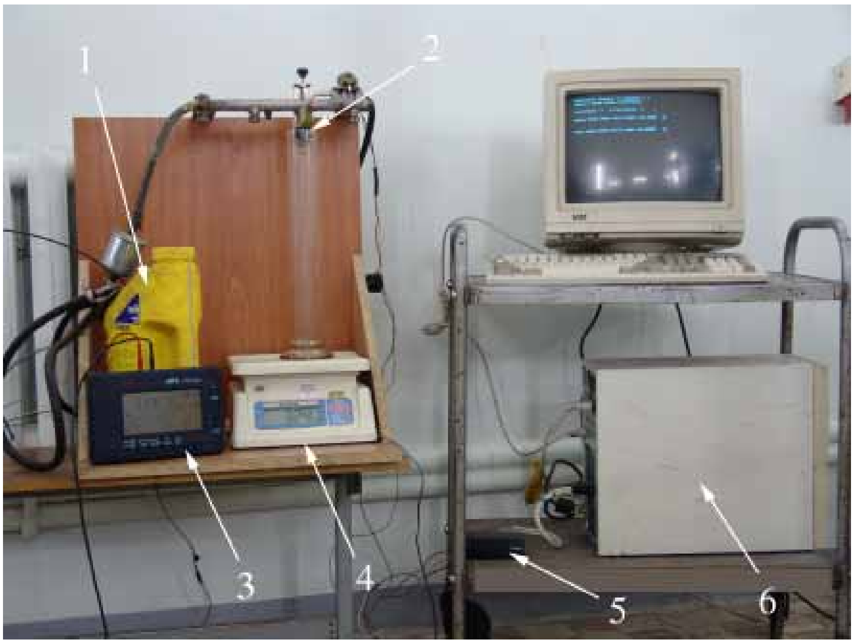

Fig.1. Stand for measuring the amount of the ejected ethanol:1 – fuel tank; 2 – electromagnetic nozzle for ethanol; 3 – temperature gauge; 4 – electronic scales; 5 – impulse generator, 6 – PC

Ethanol is pumped from the fuel tank 5 (Fig.2) by the electric pump 4 through the filter 3 to the fuel distribution pipe 2, which is joined to the electromagnetic injector valve 1. The reduction valve 7 maintains the constant fuel pressure in the pipe. The modes of pump operability are set by personal computer 9 and sent to the impulse generator 6. The impulses of a sufficient power control electromagnetic pump.

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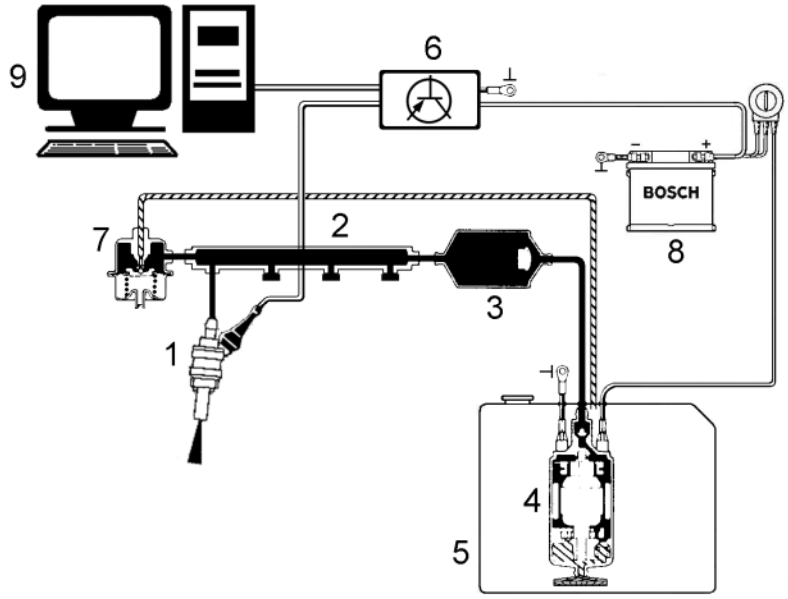

Fig. 2. Scheme for measuring the amount of the ejected ethanol: 1 – electromagnetic pump; 2 – fuel distribution pipe; 3 – filter; 4 – electric pump; 5 – fuel tank, 6 – impulse generator; 7 – fuel pressure valve; 8 – battery element; 9 – personal computer

For the initial experiment to complete a pump of one mode operation was chosen of 15 ms as open one and 5 ms as closed. The mode was chosen according to the optimal operability modes of intake system set by automobile manufacturers. It satisfies the engine operability in a medium workload. While making the changes in the mode the extra amount of the fuel was taken into account, which would be 2-4 times lower in comparison to the engine operability in one- type fuel. It was also estimated that the system used only one pump for ethanol intake into all the four cylinders of the engine.

The device *AVL DiScope 865* was used for measuring the ethanol temperature in the tank throughout the experiment. The ethanol was pumped into the test-mixer and weighed on the electronic scales *SK-5000*, where one step equals 1 g. It took ~70- 80 s for one estimation. The duration was decided on purpose as the ethanol temperature was not changing in more than 0,2-0,3°C from the beginning to the end of the measurement.

4. EXPERIMENTAL RESULTS

The results gained after 80 measurements, whereas after the calculations the diagram was made together with the equations giving the most precise results of the experiment. Fig.3 shows the results of the experiment estimated by the second-degree polynomial function:

$$y = 0{,}0001 \cdot x^2 + 0{,}0003 \cdot x + 0{,}8148 . \qquad 1$$

The function is accurate enough in the results gained, as the high value of R^2 meaning shows $R^2 = 0{,}7997$.

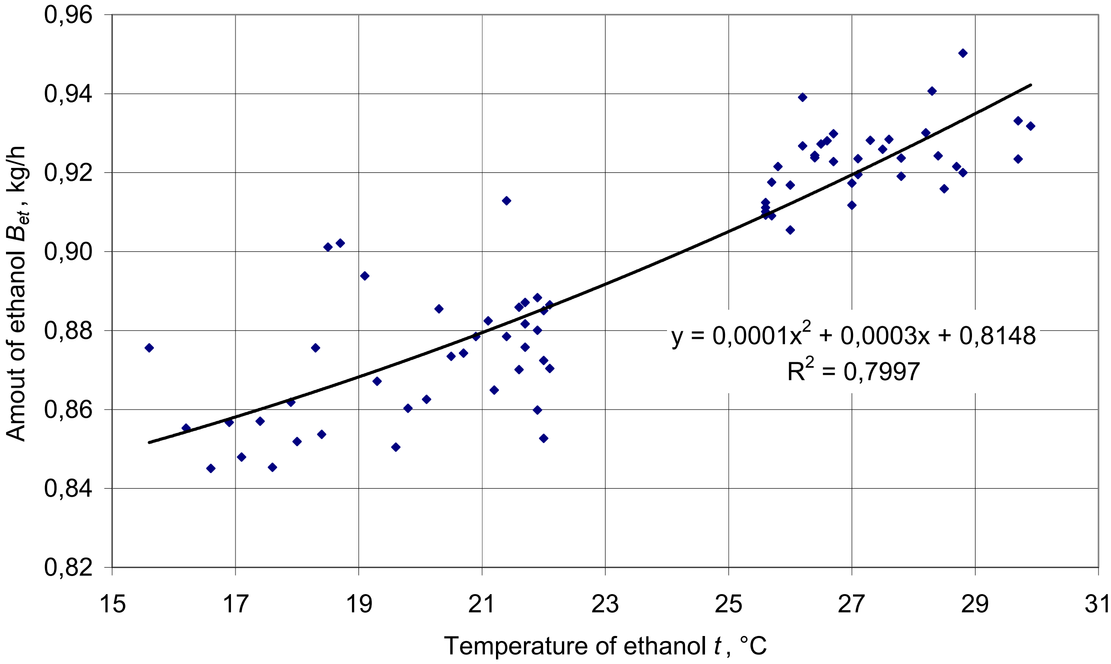

***Fig. 3. Influence** of the ejected ethanol on temperature described by the second-degree polynomial*

The results of the experiment have been tried to describe by the linear function (Fig. *4*.):

$$y = 0{,}0064 \cdot x + 0{,}7461\,. \qquad 2$$

The results have been accurate enough, as $R^2 = 0{,}7958$.

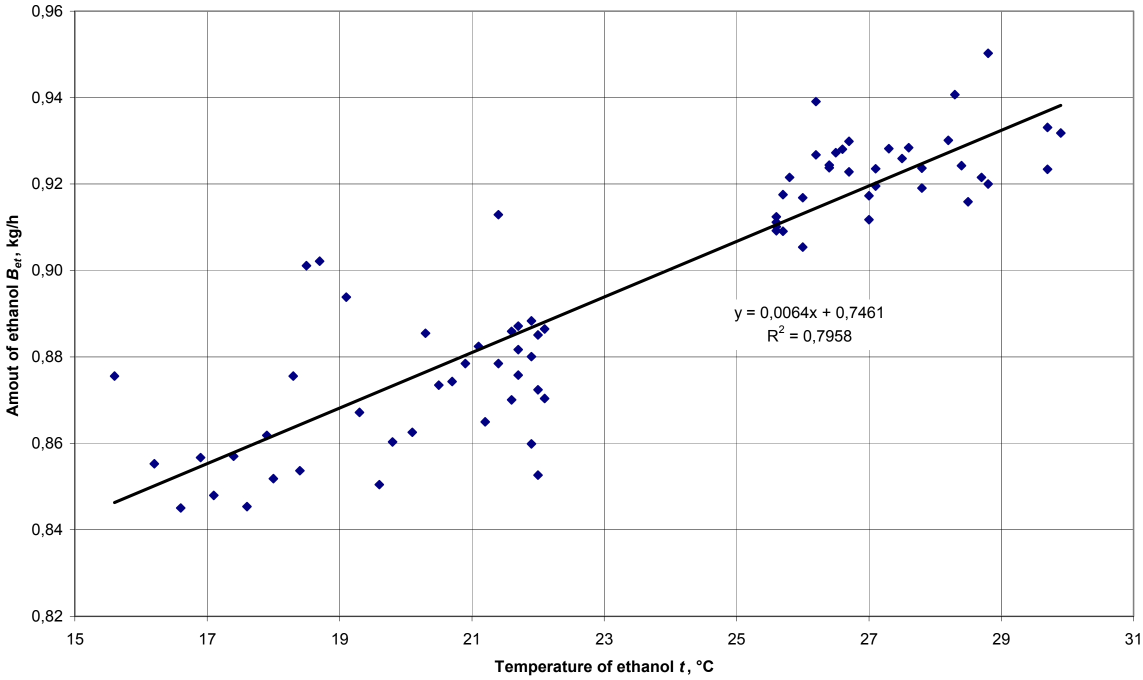

Fig. 4. Direct influence of the ejected ethanol on the temperature

The experiment caused to think it over, because the results were expected different. Before the experiment the increase of ethanol temperature was expected to result in the decrease of its amount, because the density increase due to the temperature the less mass of the liquid could go through the exhaust port within the same duration of the opening. Therefore, the results encourage developing the comprehensive research.

5. CONCLUSIONS

1. The amount of the ejected ethanol depends on its temperature: the higher the temperature, the bigger ethanol volume.
2. The volume of the ejected ethanol subject to temperature can be defined by the polynomial of the second degree $y = 0{,}0001 \cdot x^2 + 0{,}0003 \cdot x + 0{,}8148$, or the less precise (the more relevant form in this case) linear function, $y = 0{,}0064 \cdot x + 0{,}7461$.
3. The data of the experiment completed motivates for further development of the research, which could enable in setting the more precise reliability and find out its cause.

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