INFLUENCE OF ETHANOL TO THE FUEL MIXTURE ON CHARACTERISTICS OF THE PETROL ENGINE

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Abstract: *The ecological effect was studied when using ethanol-containing fuel mixtures in gasoline engines. It has been established that with increasing the mass fraction of ethanol in the fuel mixture, the amount of carbon monoxide and oxygen emissions decreases in the exhaust gases, and the amount of carbon dioxide increases.*

KEYWORDS*: ETHANOL, FUEL MIXTURE, PETROL ENGINE.*

1. Problem Statement

Ukraine – is the largest European and world supplier food and coarse grains. An actual problem of harvesting agricultural crops was resolved and it's significantly reduced of yield losses past 5 years. Growing early grain crops occupy a special place in the sphere of crop production, yearly square of growing one is about 16 million ha. Around 6 million ha of them occupy winter wheat. Based on USA Agricultural Ministry data, in 2016 Ukraine placed the second place for yields of winter wheat in the World [1]. Nowadays even in the risk zone of farming, in condition of natural moisture deficit the yield of winter wheat at the level 7 t/ha, and maize – from 8 to 10 t/ha is normal. Food problem is solved within the country and today there are all premises for development of manufacturing fuel on petroleum origins. Among these fuels the bioethanol is particularly effective [2].

Today bioethanol relate to non-traditional kind of engine oil, but the first tests of its application refered to the end of XIX century, when there was no food operation of petroleum. But at the beginning of XX century it was crowed out by more cheaper mineral fuel (mostly, through improving cracking mechanism of petroleum). At that time turning to bioethanol caused by the range (number) of reasons: high and unstable prices for petroleum; not acceptable ecological condition; desire to the number of countries, including Ukraine, is to get independence of energy products' another countries ect. Despite the quite good an ethanol dimension, applying bioethanol in the modern internal combustion engine investigated not enough. Relevant article is continuation of works in this field [3, 4]; in it on the base of experimental tests provides the results of investigation the standard (mainly the mixtures ethanol and fuel) to characteristics of internal combustion engine.

Inverstigation analyse. The problem of applying bioethanol in the modern engines has following aspects: technological, economical, ecological and political. To consider them separately in the form of short empirical basis.

Technological aspects:

- material for manufacturing bioethanol are: in the north districts – bread corn, in the south districts – maize, wheat, sugar cane and other agricultures; generally bioethanol – is conserved sun energy, where are more sunshine, then manufacturing of eco-fuel effectively;

- nowadays mostly give attention to ethyl alcohol, but some firms rely on butanol;

- bioethanol has higher octane number (more then 100 units), but comparing with oil fuels one has lower heating value, from there lower engine power and high fuel consumer;

- in the modern standard and modified petrol engine usually used mix of bioethanol and fuel; this mixture identify as letter E (from the word ethanol) and number, showing content of ethanol in per cent (for example, E10 content 10 % of ethanol). Last time many firms (Sweden, USA) give attention to mixture E85 and synthetic ethanol, getting from petroleum;

- at the applying a fuel mixture E10 adoption of internal combustion engine almost is not needed, there are not problems with engine ingnition, but they are with engine ingnition when using the bio-fuel E100;

- in recent years, cars such as FFV (etal-nogibride) have been widely disseminated, which can work on any mixture of ethanol and gasoline; the conversion of the engines is not significant (an oxygen sensor, some gaskets and a program change in the on-board computer are added);

- ethanol and its mixtures with gasoline do not freeze, but sudden changes in temperature can result in the fuel system of water condensate, which at low temperature leads to the blocking of fuel lines and filters.

Economical aspects:

- production of bio-fuel became economically viable with a sharp increase in oil prices; today bio-fuel production met a worldwide requirements; the main economic effect is achieved through the rise of agriculture and the attraction investments in the country (for example, Japan's investments to Brazil's agriculture up to 2015 amounted to 13 billion US dollars);

- a waste product in the production of bioethanol is valuable feed additives; the cost of ethanol can be 0.40-0.45 euro per liter at the wheat price of 320 euro per ton;

- 2.6 tons of grain are needed for the production of 1 ton of bioethanol, and 2 tons of rapeseed for 1 ton of biodiesel. It should be noted that world grain production already lags behind the planetary needs in the production; with increasing bio fuels, this situation will be worsen (here the potential threat to production balances is more higher for oilseeds for biodiesel production than for grain crops for the production of bioethanol). On the other hand, if we limited or stoped the production of biofuels it might significantly affect solution of global energy costs and further environmental degrade (mainly to accelerate the global warming process);

- not always the production of bio fuels has economic motives; In the EU, for example, the main stimulant for the development of bio energy is reduced the emissions of harmful substances and only then reduced the dependence on energy carriers;

- there is a tendency in the world, and it is marked by many scientists that the bio fuels coming into direct competition with food.

Ecological aspects:

- at the combustion of bio fuel the emissions of greenhouse gases, carbon monoxide and hydrocarbons were reducing; carbon dioxide released during its burning is absorbed by plants, so the carbon balance of the planet remains unchanged; bio fuel is practically free of sulfur;

- the harmful emissions are observed 30% fewer at the using E10, mainly due to the bioethanol has oxygen (harmful emissions are simply afterburned)

- according to the Organization for Economic Cooperation and Development (OECD), the results of subsidizing biofuel production have been led to the expansion of sown areas from the forests, in addition farmers use toxic fertilizers and pesticides in growing grain and oil crops, which generally brings more harm to the environment than the use of gasoline ; And further "... concern for the development of clean fuels is due, rather than economic, to political motives, because it's allows the governments of developed countries to subsidize farmers ... ";

- according to experts from the University of Edinburgh, emissions from burning biofuels are more destructive for the Earth's atmosphere than emissions from the combustion of mineral fuels: 50 to 70% more greenhouse gases are generated (evidence is not provided);

- there are many arguments for and against the use of bio fuels; at the same time, all these arguments take place until the ecology of the region has reached a certain critical level; for many megacities this level is practically reached and for them the ecological imperative can cancel both the economic and the political imperatives come into effect. Therefore, now many countries are equating environmental security with national security.

Political aspects:

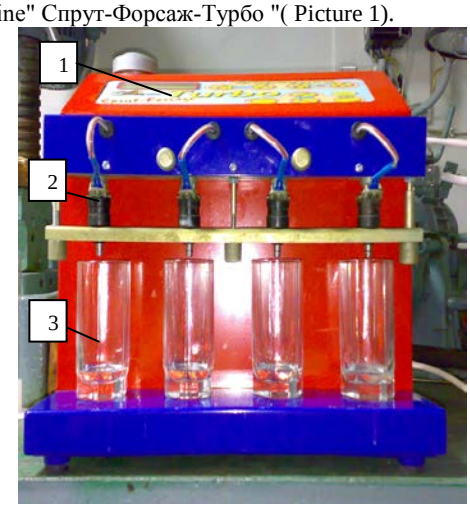
- these aspects are closely intertwined with economic and environmental aspects: with economic - it is primarily the support of farmers and the creation of a favorable investment policy, with environmental - is linked to the fact that environmental safety becomes part of national security. Therefore, it is not surprising that a number of legislative acts stimulating the production and use of biofuel have been adopted in the numerous leading countries in the world (USA, Germany, France, Sweden, etc.);

- The Ministry of Agricultural Industry of Ukraine in 2007 was initiated the tax incentives for producers of bio fuel. At the end of 2006, the Cabinet of Ministers of Ukraine approved a program for the development of biofuel production for 2007-2010; According to this program, by 2010, 100% of vehicles with internal combustion engines should be converted to bioethanol (not performed). Ukraine planned to build up to 2010 at least 20 biodiesel plants. The draft law "About the development of production and consumption of biological fuels" (No. 3158 of June 8, 2007) provides for all producers of gasoline the norms of compulsory consumption of bioethanol: in 2008 - at least 2%; In 2009 - 3%; In 2010 - 5%; In 2011 - 10%. Biofuel should be manufactured in accordance with the procedure established by law and complied with state standards. Biofuel can be used directly as fuel in its pure form, as a component for the production of other fuels or for mixing with traditional fuels. The state standard for biofuel was also developed: for biodiesel ДСТУ 6081: 2009, and for bioethanol - ДСТУ 7166: 2010.

Unfortunately, in the following years no development of biofuel production occurred. The reasons of this in the article, which will be not considered by us, because they are more political than economic. However, today in Ukraine there are extremely favorable conditions for the production of this type of fuel.

Formulation the objective of the study. The aim of present work is study an impact bioethanol on some characteristics of modern engine.

Research procedure. To determine the main characteristics of the engine during work with various mixtures of gasoline and bioethanol, known methods were used, the diagnostic complex " Спрут-Диагностик ", the gas analyzer " Инфракар М1.01", the stand for cleaning and adjusting the injectors of the gasoline engine" Спрут-Форсаж-Турбо "(Picture 1).



Picture 1. Stand «Спрут-Форсаж-Турбо»:
1 – control panel; 2 – injector;
3 – glass for the fuel collection.

The investigations were subject to:

- fuel mixtures of gasoline AE-95 and bioethanol E5, E10, E15 and E20;

- engine «Volkswagen» monoinjection type, with the number of revolutions of the crankshaft 1000 ± 15 rpm;

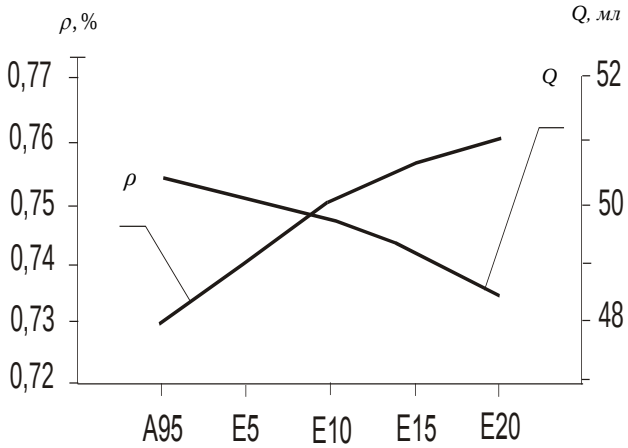
- The composition of the exhaust gases was determined by the gas analyzer Infrakar M1.01;

- the temperature of the exhaust gases was recorded in the exhaust manifold using a thermocouple;

- the temperature of the coolant and its rate of change was measured by the " Спрут-Диагностик " temperature sensor.

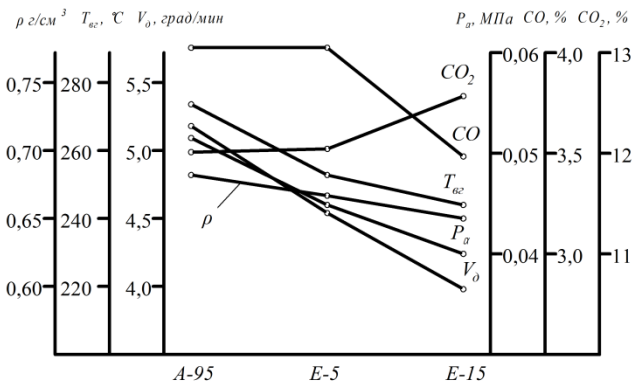
2. Tests result

It is found that the density of ethanol, which was used in the tests was equal to 0,77; and pure gasoline – 0,73 g / cm^3. Therefore, with an increase in the mass fraction of ethanol in the fuel mixture by 20% (E20), its density increased by 4% (Picture 2). As seen from the graph, the fuel injection amount is inversely proportional to the density. Thus, under identical conditions of the fuel (supply pressure was 0.5 MPa) to increase the fuel density difference between the amount of fuel A95 and E20, was 6%.



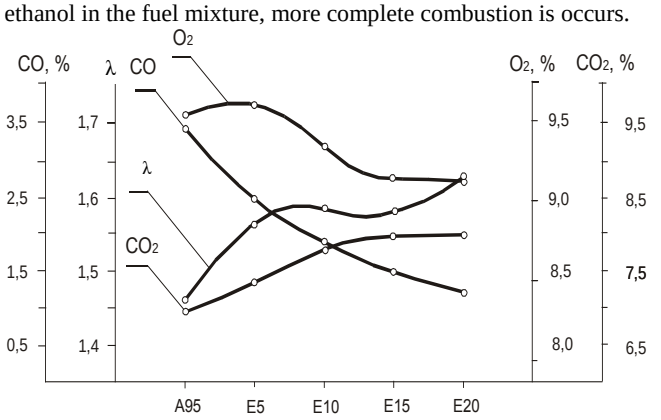
Picture. 2. Dependence density fuel-mixed ρ and the amount of fuel Q injected from its composition.

On the Picture 3 the main characteristics of engine and fuel mixture are showed (ρ – density of fuel mixture; $T_{вг}$ – temperature of exhausted gases; V_d – speed of engine heating rate till work mode; P_a – vacuum pressure in an exhaust manifold) dependence on the content of exhaust gases: carbon dioxide CO_2 and gas CO. As can be seen, with increase percentage content of bioethanol the engine warm-up speed V_d to work mode and temperature $T_{вг}$ of exhausted gases declined slightly; that's why we may talk about reducing the heat load on engine. Reducing of vacuum pressure P_a in the intake pipe with growing share of bioethanol may be connected with width reduction of oil film on the surface of cylinders, that in general reducing the width in the piston group; this may be due to density reduction in the fuel mixture (density of ethanol less then density of fuel).



Picture 3. The main characteristics of engine from fuel mixture

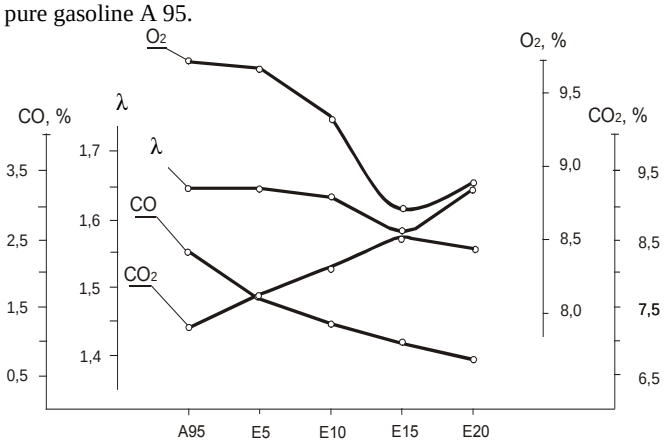
Analyzing the main environmental indicators of exhaust gases at a crankshaft rotation speed of n 1000 min-1, it was found that with an increase in the mass fraction of ethanol from 0 to 20%, carbon monoxide emissions decreased from 3.46 to 1.21% or 2.85 times (Picture 4). The amount of carbon dioxide increased by 15% respectively. This indicates that with the increase in the amount of ethanol in the fuel mixture, more complete combustion is occurs.



Picture 4. Dependence of carbon monoxide content (CO), carbon dioxide (CO_2), oxygen (O_2) and the excess air factor λ from the ethanol content (n = 1000 min^{-1}).

As can be seen from the graph, the amount of oxygen O_2 decreases, which, when ethanol is burned, takes a more active part in the afterburning of the ethanol-containing mixture. When all types of mixtures are burned, the excess air factor λ increases simbatically the proportion of ethanol.

With regard to the composition of exhaust gases, with a rotational speed of the engine crankshaft of 2000 rpm, the results indicate that the dependencies have a slightly modified appearance (Picture 5). So, the maximum of CO_2 in the exhaust gases falls on the mixture of E15 and further there is an insignificant decrease in this index. Compared to pure gasoline, with this mixture, the amount of CO_2 increased by 19%. However, even with the combustion of the E20 mixture, the amount of CO_2 decreased by 4%. In reverse proportion to the amount of CO_2 in the exhaust gases is the amount of oxygen O_2, the volume fraction of which decreases (with an increase in the proportion of ethanol), and in gases of the mixture E20 - slightly increased. Obviously, the excess O_2 does not enter the combustion reaction and is released separately. The amount of carbon monoxide CO is steadily decreasing and in gases of the mixture E20 it is 2.3 times less than in the exhaust gases of pure gasoline A 95.



Picture 5. Dependence of carbon monoxide content (CO), carbon dioxide (CO_2), oxygen (O_2) and the excess air factor λ from the ethanol content (n = 2000 min^{-1}).

The smallest value of the coefficient λ is also observed at the burning of mixture E 15. As can be seen from the dependence (Picture 5), a rapid increase in the amount of carbon dioxide occurs with an increase in the mass fraction of ethanol and a maximum which is in the E 15 mixture.

It should be noted that the engine performance was stable during working on all fuel mixtures.

4. Conclusion

1. Stable engine work on the fuel mixture E5 is possible without adaption of the fuel system, at the reduction of heat load to the engine; the dilution in the intake pipe is within the permissible range.

2. Engine work on the fuel mixture E15 has following features: educing the heat load to the engine by 12 %, reducing the vacuum pressure in the intake pipe by 18%, which can lead to malfunctioning of engine at the long term operation.

3. Ecological aspects: ecological effect was insignificant when the engine being worked on a mixture E5, but at the working on a mixture E15, the decrease in carbon dioxide CO2 by 12.5% was observed.

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