INFLUENCE OF COMPOSITION OF GASOLINE – ETHANOL BLENDS ON PARAMETERS OF INTERNAL COMBUSTION ENGINES

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Abstract

The purpose of this study is to investigate experimentally and compare the engine performance and pollutant emission of a SI engine using ethanol–gasoline blended fuel and pure gasoline. The results showed that when ethanol is added, the heating value of the blended fuel decreases, while the octane number of the blended fuel increases. The results of the engine test indicated that when ethanol–gasoline blended fuel is used, the engine power and specific fuel consumption of the engine slightly increase; CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases in some engine working conditions; and CO_2 emission increases because of the improved combustion.

1. Introduction

Ethanol has been known as a fuel for many decades. Indeed, when Henry Ford designed the Model T, it was his expectation that ethanol, made from renewable biological materials, would be a major automobile fuel. However, it is not widely used because of its high price. But as a fuel for spark-ignition engines, ethanol has some advantages over gasoline, such as better anti-knock characteristics and the reduction of CO and UHC emissions. Although having these advantages, due to limitation in technology, economic and regional considerations, alcohol fuel still cannot be used extensively. Since ethanol can be fermented and distilled from biomasses, it can be considered as a renewable energy. Under the environmental consideration, using ethanol blended with gasoline is better than pure gasoline because of its renewability and less toxicity.

Looking forward for Lithuania to become a member of the EU it is very important to use much bigger amount of renewal fuel. Based on economic and environmental considerations in Lithuania, we are interested in studying the effects of ethanol contents in the ethanol–gasoline blended fuel on the engine performance and pollutant emission of a SI engine.

2. Literature review

Ethanol (C_2H_5OH) is a pure substance. However, gasoline is composed of C_4–C_{12} hydrocarbons, and has wider transitional properties. Ethanol contains an oxygen atom so that it can be viewed as a partially oxidized hydrocarbon. Ethanol is completely miscible with water in all proportions, while the gasoline and water are immiscible [1]. This may cause the blended fuel to contain water, and further result in the corrosion problems on the mechanical components, especially for components made of copper, brass or aluminum. To reduce this problem on fuel delivery system, such materials mentioned above should be avoided [2]. Ethanol can react with most rubber and create jam in the fuel pipe. Therefore, it is advised to use fluorocarbon rubber as a replacement for rubber [3]. On the combustion characteristics, the auto-ignition temperature and flash point of ethanol are higher than those of gasoline, which makes it safer for transportation and storage. The latent heat of evaporation of ethanol is 3–5 times higher than that of gasoline; this makes the temperature of the intake manifold lower, and increases the volumetric efficiency. The heating value of ethanol is lower than that of the gasoline. Therefore, we need 1.6 times more alcohol fuel to achieve the same energy output. The stoichiometric air–fuel ratio (AFR) of ethanol is about 2/3 that of the gasoline, so the required amount of air for complete combustion is lesser for alcohol.

Sustaining a clean environment has become an important issue in an industrialized society. The air pollution caused by automobiles and motorcycles is one of the important environmental problems to be tackled. Since using ethanol–gasoline blended fuels can ease off the air pollution and the depletion of petroleum fuels simultaneously, many researchers [4, 5, 6] have been devoted to studying the effect of these alternative fuels on the performance and pollutant emission of an engine. Palmer [7] used various blend rates of ethanol–gasoline fuels in engine tests. Results indicated that 10% ethanol addition increases the engine power output by 5%, and the octane number can be increased by 5% for each 10% ethanol added. Abdel-Rahman and Osman [8] recently had tested 10%, 20%, 30% and 40% ethanol of blended fuels in a variable-compression-ratio engine. They found that the increase of ethanol content increases the octane number, but decreases the heating value. The 10% addition of ethanol had the most obvious effect on increasing the octane number. Under various compression ratios of engine, the optimum blend rate was found to be 10% ethanol with 90% gasoline.

Bata et al. [9] studied different blend rates of ethanol–gasoline fuels in engines, and found that the ethanol could reduce the CO and UHC emissions to some degree. The reduction of CO emission is apparently caused by the wide flammability and oxygenated characteristic of ethanol. In the study of Palmer [7], he indicated that 10% of ethanol addition to gasoline could reduce the concentration of CO emission up to 30%. Alexandrian and Schwalm [10] showed that the AFR has great influence on the CO emission. Using ethanol–gasoline blended fuel instead of gasoline alone, especially under fuel-rich conditions, can lower CO and NO_x emissions. However, using ethanol–gasoline blended fuels increases the emission of formaldehyde, acetaldehyde and acetone 5.12–13.8 times then those from gasoline. Although the emission of aldehyde will increase when we use ethanol as a fuel, the damage to the environment by the emitted aldehyde is far less than that by the poly-nuclear aromatics emitted from burning gasoline. Therefore, using higher percentage of alcohol in blended fuel can make the air quality better [11] in comparison with gasoline.

From the literature review, we understand that alcohol–gasoline blended fuels can effectively lower the pollutant emission without major modifications to the engine design. Moreover, the ethanol can be made from biomasses. These factors make it appealing to us in Lithuania. We therefore use engine test facilities to investigate the effects of 10% ethanol–gasoline blend fuels on the engine performance and pollutant emission.

3. Investigation methods

Experimental apparatus includes three major systems, i.e., the engine system, power measurement system and exhaust measurement system. Tests were carried on in the laboratory by using Toyota Corolla (produced in 1994). The engine characteristics of this car are displayed in Table 1.

The engine output power is metered by the performance tester made by MAHA (LPS 2000 Series). In the experiment, the concentration of CO, CO_2 and HC in the exhaust gas are measured by the analyzer of AVL DiGas 465 with pre-calibration. The sampling of exhaust gas is taken of the exhaust pipe without the catalytic converter. Due to the pulsed characteristics of the engine, we always take 5 measurements to average the data for each operating condition.

Table 1. Technical characteristics of the engines tested

Characteristics	Value
Type of engine	4 E-FE DOHC 16V
Volume V_h, cm^3	1332
Compression ratio ε	9,8
Power P_e, kW	65 (6000 min^{-1})
Torque M_s, Nm	124 (5000 min^{-1})
Fuel system	fuel injection, MPI, (D-Jetronic) TCCS
Fuel (Octane rating)	95 RON
Ignition system: distributor	TCCS – II, Toyo Denso

The properties of the used fuels and blend in the experiment are displayed in Table 2.

Table 2. Properties of fuels

Properties	Ethanol	Petrol	E10
Density (kg/m^3 at 20°C)	789	790	790
RON	108	95.2	98.9
Heating value (MJ/kg)	27.0	44.0	41.8
Carbon (wt %)	52.20	86.60	83.16
Hydrogen (wt %)	13.10	13.30	13.28
Oxygen (wt %)	34.70	0.03	3.50

The experiments were carried out under the following conditions: a throttle valve is at 100% opening; the emissions measurements were carried out at engine speeds 1500, 2500, 3500, 4500, 5500 and 6500 rpm.

4. Results and discussions

Ethanol contains an oxygen atom in its basic form; it therefore can be treated as a partially oxidized hydrocarbon. When ethanol is added to the blended fuel, it can provide more oxygen for the combustion process and leads to the so-called "leaning effect". Owing to the leaning effect, CO emission will decrease tremendously; HC emissions will also decrease under some operating conditions, though the engine power slightly increases.

Fig. 1 The dependence of the engine power on revolutions, when we use fuel and E 10 blend, is displayed. It may be seen that due to better combustion conditions and lower temperature in the intake manifold the engine power increases when ethanol is added.

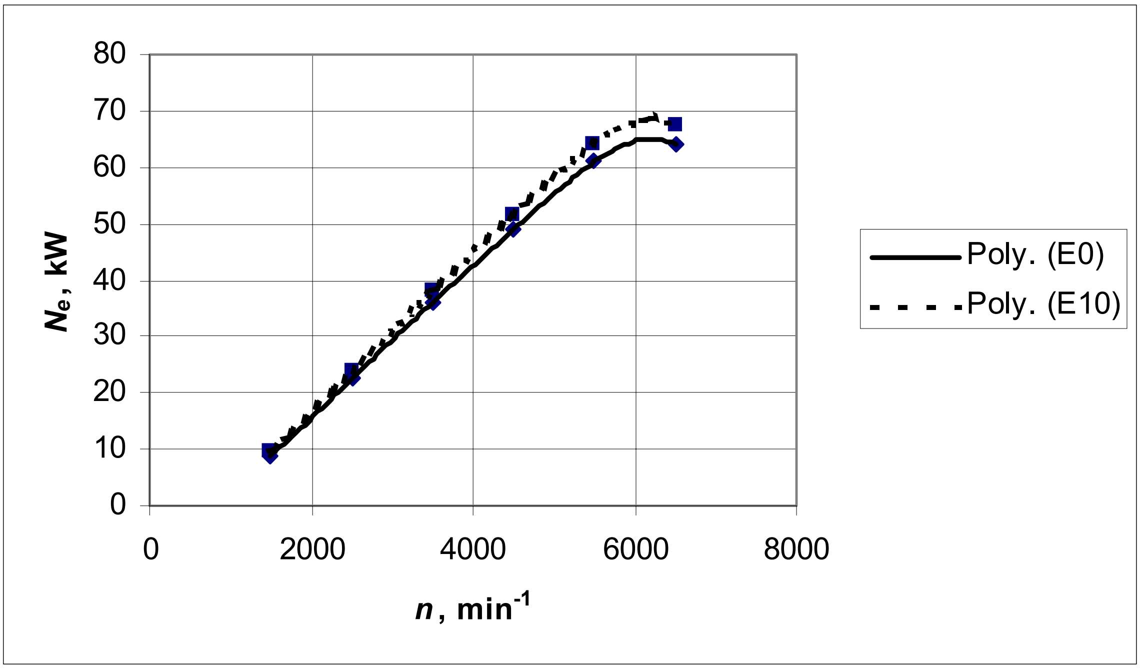

Fig. 1. The effect of ethanol addition on the engine power

Due to oxygen in ethanol composition the combustion process improves in the engine cylinders. However, specific fuel consumption (Fig. 2) slightly increases, approximately by 1-2 %. It is obvious because the heating value of ethanol is 1,6 times less than that of gasoline.

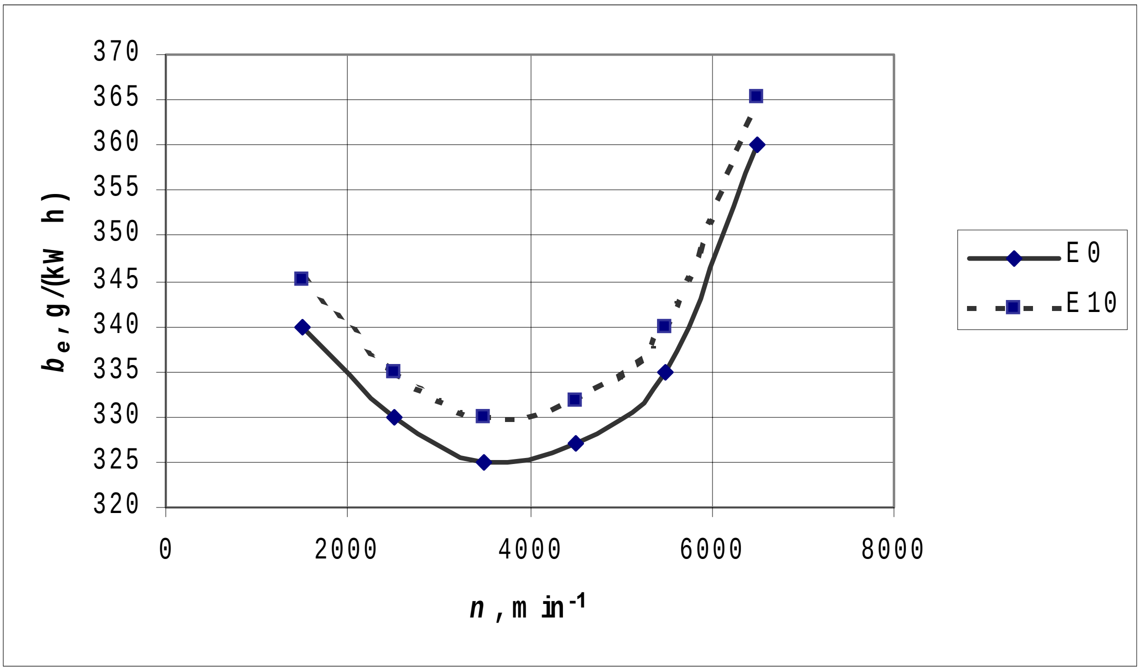

Fig. 2. The effect of ethanol addition on the specific fuel consumption

The results of the emission worked out in the experiments are displayed in fig. 3 –5.

When E 10 blend is used, the amount of carbon monoxide in exhausts greatly decreases (Fig. 3). In the beginning, when the engine power and revolutions are little, the amount of CO decreases by 15%, when we use E 10 blend in comparison with conventional fuel. When the power and revolutions increase, the difference of CO emission increases by 30%.

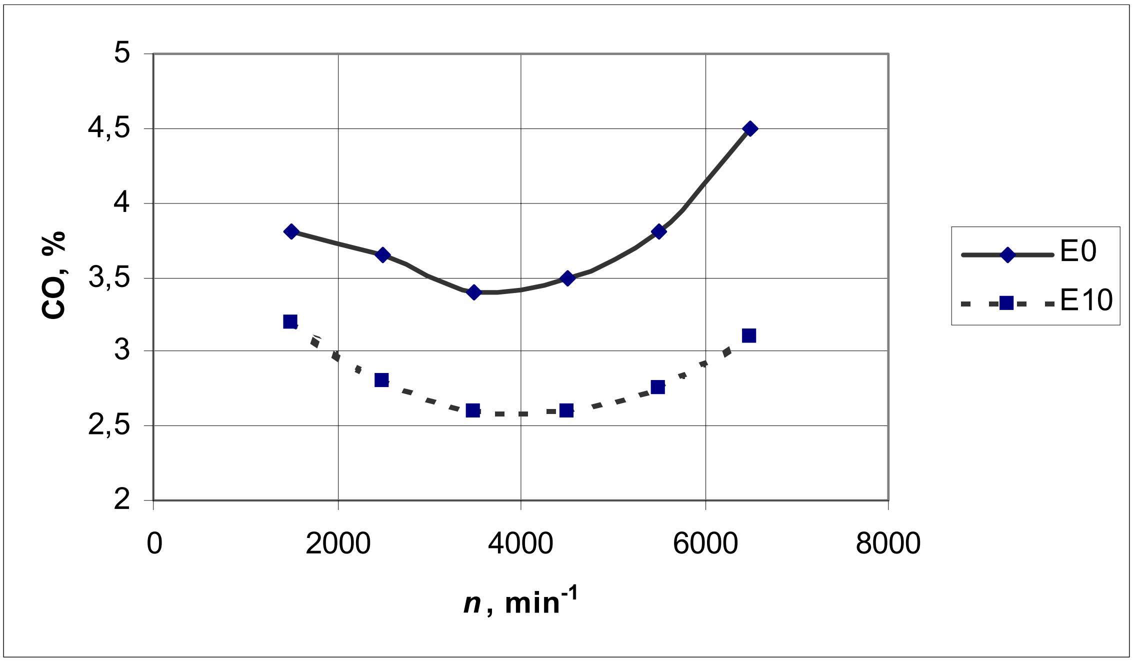

Fig. 3. The effect of ethanol addition on the CO emission

Ethanol increases the amount of carbon monoxide emission in the engine exhausts (Fig. 4), because the fuel mixture combusts better and the amount of incomplete combustion products decrease.

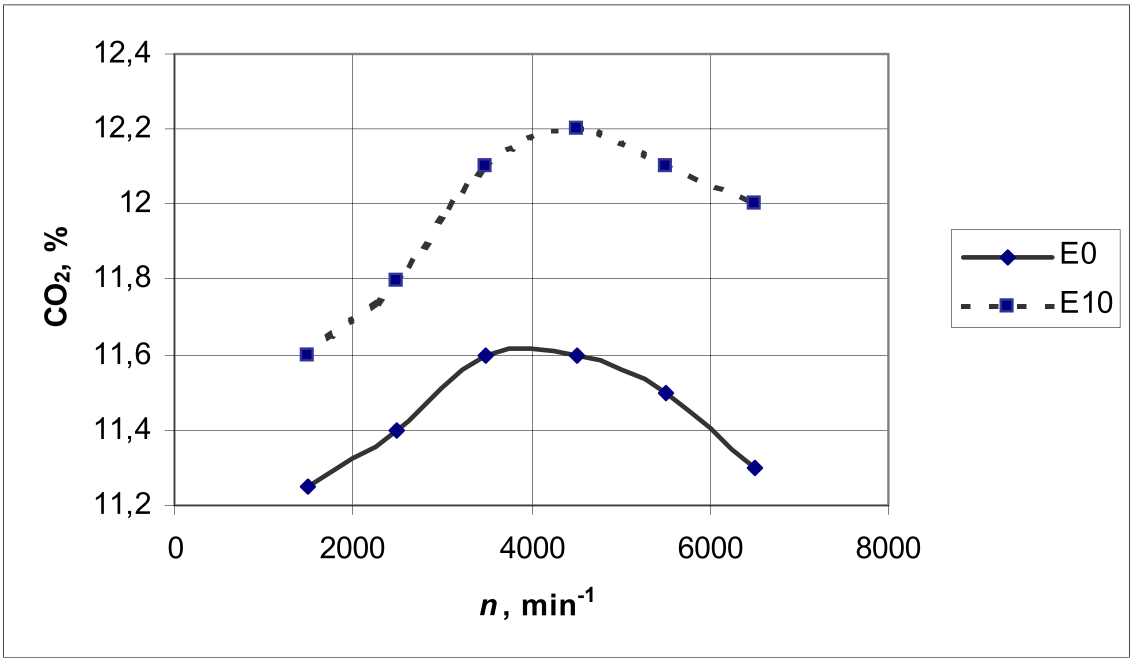

Fig. 4. The effect of ethanol addition on the CO_2 emission

The hydrocarbons emission decreases when the engine load is little and medium (Fig. 5). When the load reaches the maximum value, the amount of HC slightly increases, if E10 blend is used.

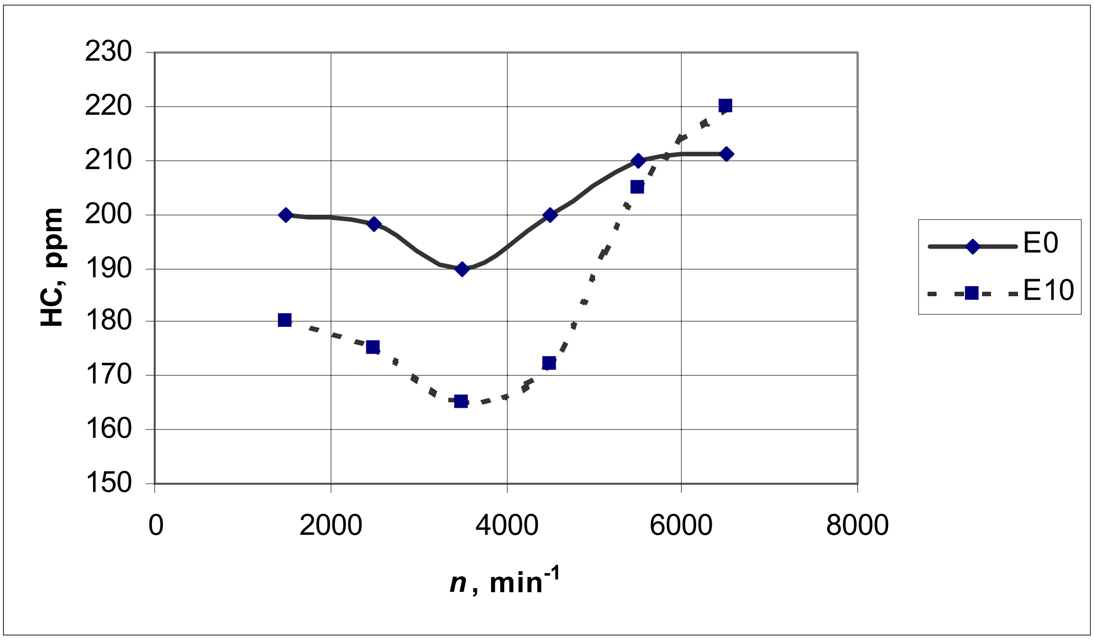

Fig. 5. The effect of ethanol addition on the HC emission

There are no exactly obvious reasons why the amount of HC increases at the maximal loads. It will be the material of further experiments.

5. Conclusions

The engine performance and pollutant emission of a SI engine have been investigated by using ethanol–gasoline blended fuel E10 and pure gasoline. Experimental results indicated that when ethanol–gasoline blend is used, the engine power and fuel consumption of the engine slightly increase; CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases only in some engine working conditions; and CO_2 emission increases because of the improved combustion.

In this study, we found that using ethanol–gasoline blend, CO emission may be reduced by 10–30%, while CO_2 emission increases by 5–10% depending on engine conditions. The engine power and specific fuel consumption increase approximately by 5% and 2–3%, respectively, in all working conditions.

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