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Study the performance and emissions of a spark ignition engine works with ethanol and petrol mixture

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Abstract— **Bioethanol is an attractive alternative to gasoline in spark ignition engines. In most of the published researches, the ethanol was blended with gasoline in low percentages from 3% to 20%. In the recent study, the impact of using high volume percentages of bioethanol added to conventional Iraqi gasoline on the performance and emitted emissions of a four cylinder Mercedes engine.**

The results showed that E60 gave the lowest fuel consumption and the highest exhaust gas temperature compared to gasoline and E40. CO and HC levels were reduced by using E40 and E60 blends compared to gasoline while CO_2 levels were increased. NOx levels increased with using E40 compared to gasoline while reduced highly with using E60.

***Index Terms*— ignition generator; emission; ethanol; petrol**

I. Introduction

THE Ethanol has become very desirable in recent years as an additive to gasoline works to increase the octane number. Ethanol is characterized by a high octane number compared to commercial gasoline which makes its knock resistance high [1]. Researchers expect a significant increased demand for bio-ethanol in the future because of its environmental benefits [2]. For example, the US Energy Independence and Security Act (EISA) has given (in 2007) a target to increase the share of bio-ethanol for use in transport modes so that rise from 9 billion gallons in 2008 to 36 billion gallons in 2022 [3]. Bioethanol is produced from various crops like Corn, switch grass, sugar cane, and wood and the production of bio-ethanol process includes the fermentation of sugars and distilled it [4-6].

The main interest in adding ethanol to gasoline at different rates is to improve the octane number of the mixture and reduce pollutants emitted from motor exhaust [7]. The presence of the OH molecule in ethanol combination causes an increase in the amount of oxygen in the mixture and reduces the pollutants of CO, HC, PM, and caused a limited increase in NOx [8]. Bioethanol has a high latent heat of vaporization, which caused a decrease of the temperature of the air-fuel charge, leading to delay the self-ignition [9]. The high octane number of the mixture means burning without a knock, and then the compression ratio of the engine that works with this mixture can be raised, which means a higher thermal efficiency [10].

The disadvantages of ethanol that has a low calorific value less than gasoline, resulting in a decrease in the value of stored energy per unit volume and an increase in the specific fuel consumption compared with gasoline [11]. The ethanol-gasoline mixture is influenced by the added ethanol rate and the type of gasoline used; as gasoline includes hundreds of hydrocarbons compounds [12].

Huang conducted a numerical study to investigate the impact of added ethanol ratio to gasoline on the cooling effect on the fuel-air charge. The model studied the fuel vaporization and mixture formation inside the engine. The study results indicated high effect of the charge cooling on in-cylinder temperature depending on the ethanol's low evaporation rate compared to gasoline [13].

Iodice et al. [14] conducted an experimental study investigate the ethanol/gasoline blends variable ratios on CO and HC at cold start of four-stroke SI engines. The study results revealed that CO and HC emissions at engine's cold start decreases compared to the commercial gasoline engine operation about 20% when the added ethanol blend was 20% by volume to gasoline.

Saurret et al. [15] studied the effect of adding ethanol to gasoline in four variable rates (from 7.8% to 20% volumetric fractions) on the performance and exhaust emissions of a spark-ignition (SI) engine. The results manifested that increasing the ethanol rates in the blend increased the engine performance and reduced exhaust emissions.

Elfasakhany [16] investigated the effects of adding ethanol to unleaded gasoline in three variable rates (3, 7 and 10%). The engine used in the rests was a four-stroke spark-ignition single cylinder engine, and the tests were conducted at variable engine speeds (2600–3500 rpm). The study results showed that adding ethanol to the unleaded gasoline improved the engine performance. The author demonstrated that the fuel consumption depends on the engine speed rather than the ethanol content for ethanol less than 10% blended ratio. The emitted exhaust CO and unburned hydrocarbons emissions decrease significantly due to impact of engine operation at lean mixture resulted from adding ethanol.

Yucesu et al. [17] and Topgul et al. [18] studied the impact of adding ethanol to gasoline in variable rates (0, 10, 20, 30, 40, and 60%) on a single cylinder, four-stroke, spark ignition engine performance and emission at variable compression ratio. The two studies agreed that adding ethanol to unleaded

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gasoline increased the brake power and decreased the emitted CO and UHC emissions, slightly. The studies revealed that adding ethanol managed to increase the compression ratio without engine knock.

This paper aims to investigate the impact of adding bioethanol to Iraqi conventional unleaded gasoline in high rates (40 and 60%) on the performance and exhaust emissions of a four cylinders, spark ignition engine. This work is a fruit on continuous efforts between Mechanical Eng. Dept. and The Energy and Renewable Energies Technology Center to produce an efficient and effective renewable fuel for fossil fuels to be used in Iraq [19-72].

II. Experimental Setup

A. Materials

An Iraqi conventional gasoline (leaded gasoline) was used in this study. The Iraqi gasoline is a low octane number (not exceed 82), with high sulfur content (not less than 500 ppm). Bioethanol was bought from local markets with purity of 99.9% which was made from Iraqi dates. Table 2 illustrates the used gasoline and ethanol specifications.

B. Engine

A four cylinder in-line, four strokes and natural aspirated spark ignition engine type Mercedes was used in the current tests. Table 1 represents the major engine specifications. The torque was measured by means of hydraulic dynamometer represented in Fig. 1.

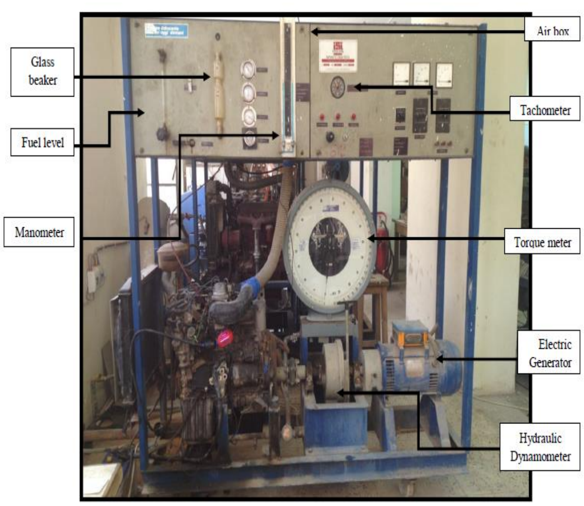

Fig. 1, the engine and dynamometer

C. Engine speed measurement

The engine speed was measured by means of tachometer fitted with the engine and was calibrated by a digital tachometer fixated on the crankshaft Figs. 2 and 3.

Fig. 2, the engine tachometer

Fig. 3, digital tachometer

D. Fuel consumption

The fuel consumption measuring was done by means of glass bulbs as Fig. 4 represents.

Fig. 4, the glass bulb

E. Measurement of brake torque

The hydraulic dynamometer attached to the engine was used to measure the brake torque in this study. Dissipating power in fluid friction is the dynamometer measuring principle.

F. Air consumption

The consumed air mass flow rate was measured using an orifice which is fixed on air box and a manometer that measures the difference pressure between the atmosphere and the intake pressure. The manometer's measured value was used to evaluate the air mass flow rate.

G. Exhaust temperature

The exhaust gas temperature measurement was done using thermocouples and a digital temperature reader. The measuring instrument was attached to the exit exhaust manifold pipe by a mean of prop, Fig. 5 shows the digital reader.

Fig. 5, thermocouples digital reader

H. Exhaust emission

The Flux 2000-4 (Fig. 6) was used to measure the CO_2, CO, NOx and HC emission from exhaust gases. The gases were picked up by means of probe from the exhaust manifold. After he gases entered the device the exhaust gases were separated from moisture using condensation filter, and then they went to the measuring cell.

Fig. 6, exhaust gas analyzer

III. Experimental engine procedures

After preparing the fuel blends which were consisted of three ratios of added ethanol rates to gasoline (E0, E40, E60). The engine was also prepared by warming it up to start the tests which were conducted after the engine was reached the steady state. All the measurement as were taken using the previous explained instruments as the fuel and air consumption and the exhaust temperature and exhaust gases emission. The tests were conducted for a variable engine speed ranging (1000 to 2600 rpm) at a maximum load on the engine.

IV. Results and Discussions

Adding ethanol to Iraqi conventional gasoline has two benefits: the first one, it increases the blend octane number, and the second one, it reduces the sulfur content in the blend. Fig. 7 shows the impact of adding bioethanol with two high volume fractions to gasoline on the fuel consumption rate. E40 consumption rate was higher than that of gasoline representing the effect of lower calorific value of ethanol. E60 has two specifications which are the high oxygen content of ethanol and the high calorific value of gasoline; as a result its fuel consumption was lower than gasoline.

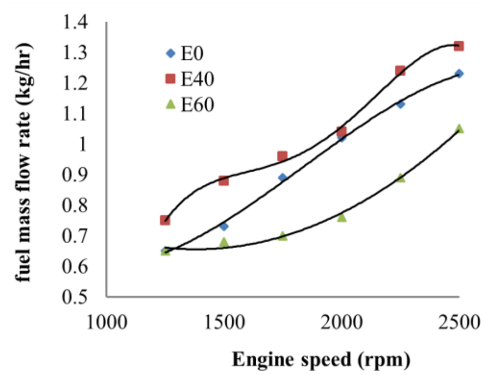

Fig. 7, the impact of using E40 and E60 on the engine fuel consumption

Fig. 8 represents the improvement in combustion when the bioethanol is added to gasoline as the exhaust gas temperatures were higher than gasoline for both ethanol-gasoline blends. Bioethanol has high oxygen content which enhances the fuel combustion generating higher exhaust gas temperatures.

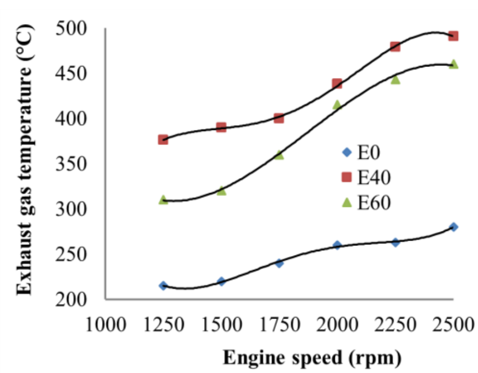

Fig. 8, the impact of using E40 and E60 on the exhaust gas temperatures

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Adding bioethanol to gasoline with 40% (E40) caused increments in NOx levels compared with gasoline, as fig. 9 reveals. Nitrogen needs excess of oxygen and high temperature to oxidize and both parameters were available in E40 case. When E60 was used as a fuel, the low heating value of ethanol affected the resulted combustion temperatures which reduced the emitted NOx levels.

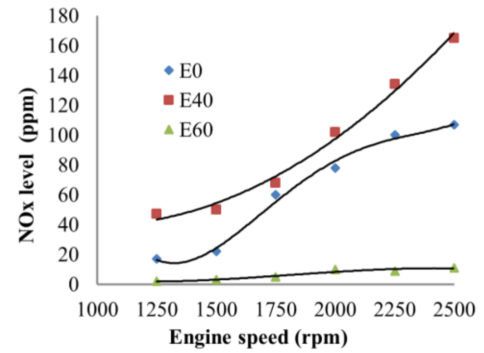

Fig. 9, the impact of using E40 and E60 on the emitted NOx emissions

Fig. 10 manifests that adding bioethanol reduced the emitted CO emissions highly and when the ethanol percentage increased the emitted CO was decreased. In all cases, increasing the engine speed increased CO levels.

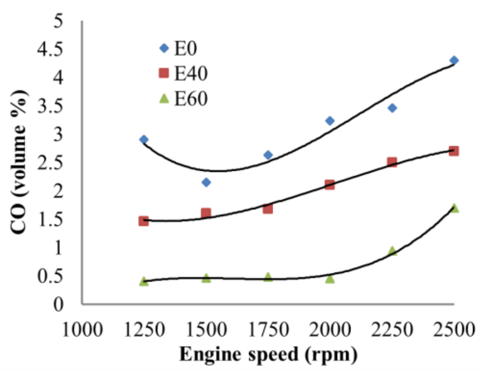

Fig. 10, the impact of using E40 and E60 on the emitted CO emissions

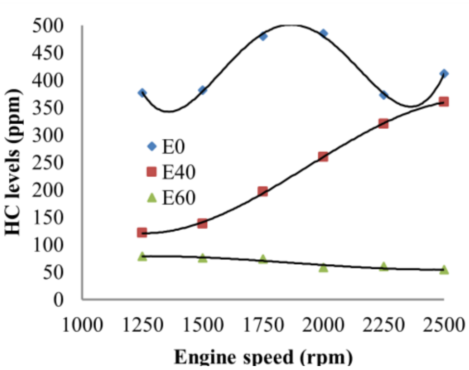

Fig. 11, the impact of using E40 and E60 on the emitted HC emissions

The same results can be seen with HC emissions levels (Fig. 11), where gasoline has the higher emitted levels and E60 has the lower levels. This result can be returned to the higher oxygen content in E60 that enhanced the combustion process and reduced both CO and HC levels.
Whenever CO and HC levels decreased that means better combustion and higher CO2 levels can be achieved, as Fig 12 indicates. E60 and E40 have higher CO_2 levels compared with neat gasoline. The available oxygen in the ethanol combination improved the combustion as well as the higher octane number of ethanol reduced the knock existence.

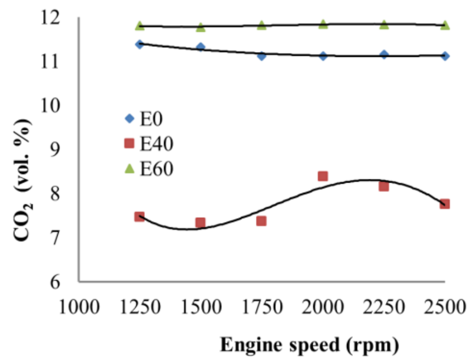

Fig. 12, the impact of using E40 and E60 on the emitted CO_2 emissions

The improvement in combustion process means higher pressure rates generated in the combustion chamber which is measured as higher noise, as Fig. 13 illustrates. E40 produced the higher noise values taking advantages from high heating value of gasoline and high oxygen content of ethanol. In all cases, the engine noise increased with engine speed increase.

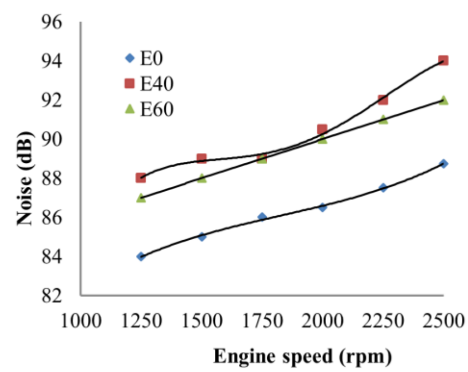

Fig. 13, the impact of using E40 and E60 on the engine noise

V. CONCLUSIONS

In the recent investigation, we tried to study of using higher percentages of bioethanol with conventional Iraqi gasoline to evaluate its effect on the engine performance and emissions.

The results revealed that using E60 gave lower fuel consumption and higher exhaust gas temperature compared to gasoline. Both bioethanol blend affected CO and HC levels as these missions were reduced highly. The reduction in CO and HC levels reflected in higher CO_2 which means better combustion process. E40 usage caused high NOx levels in contrary of E60 which generated lower NOx levels compared to gasoline. Using bioethanol becomes a necessity to reduce the Iraqi gasoline sulfur content as well as to increase its octane number and reduces the emitted emissions.

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