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Experimental Investigation of Using Ethanol-Gasoline in Spark Ignition Engine

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Abstract:

The consequence of mixing pure ethanol with gasoline on the pollution and performance of SI engine are investigated experimentally in the existent study. The SI engine that employed in the experiment is a single cylinder four stroke. Analysis is carried out for engine operation parameter, CO_2, CO and unburned HC productions. The measurements are recorded for several engine speeds from 1500 – 3000 rpm with load and ethanol addition of (0E, 10E, 20E, 30E, 40E, 50E,). The results displayed increasing in brake power, and brake thermal efficiency while the brake specific fuel consumption decreases when the ethanol- gasoline blends fuel increases. Also it was found that CO, HC, and CO_2 concentrations decrease when the ethanol-gasoline increases. The best results obtained in the study is for the blend of E-50

Keywords: Ethanol, Gasoline, Brake Power, Fuel Consumption, Engine Efficiency, Emission.

1. Introduction

For many recent years the employed of alternative fuels has an important and special place in the area of internal combustion development. The family of alternative fuels proceeding usual petroleum ones is defined by many types and the alcohols represent a significant percent due to adequate properties for internal combustion engines use; good conditions of producing process from agriculture products or green mass [1]. The using of biofuels is great dependent on the obtainable of developing feedstock sources and biomass. Ethanol will be very important increasingly when crude oil prices growth and when governments approve new rules promoting biofuels [2]. The countries using biofuels for reducing oil dependence and for reduce carbon emissions that objectives of the Kyoto protocol [3]. Ethanol is made from all biological feedstock which holds considerable quantities of the sugar [4]. The process of addition alcohols like methanol and ethanol to gasoline leads the fuel for combustion extra completely because of the existence in oxygen, which is growing the engine efficiency and decreasing pollution [5]. The organic emissions (ozone originators) from alcohol combustion have lower amount, which promotes ozone formation significantly [6]. Corrosion to metallic fuel system components appeared due to the presence of alcohols in fuel [7]. Corrosion must reduce and create the greatest using of alcohols in engine by redesigned the engine. [8].

Numerous academics displayed the influence of ethanol–gasoline blends and methanol–gasoline mixtures, on the measured exhaust emissions of SI engine. It recognized from the literatures texts that methanol or ethanol–gasoline mixtures successfully decrease the pollutant discharges, comparing with only gasoline [9]. Biofuel markets have been grown rapidly in current years. In USA and Brazil there is increasing use for bioethanol as a substituted of fossil fuels, also in the EU increasing for the purposes set by the Paris Climate Agreement [10]. Biofuels production international is shown in Figure (1). Ioannis et al. [11] experimentally found that the engine brake power somewhat increased with engine speeds as ethanol content in mixture fuel is increased, also with low engine speeds there is increasing in engine volumetric efficiency and the blend density with ethanol percentage, that leads to develop in power developed. Yüksel and Yüksel [12] Measured experimentally concentrations of (O_2), (HC), (CO_2), and (CO) in the exhaust gas by analyzer for different speed for fuels up to 60% ethanol by volume. The results indicated CO and HC reduced nearly 80% and 50%, respectively, but CO_2 emissions increased 20%. Ceviz and Yüksel [13] absorbed the influence of ethanol–gasoline mixtures on cyclical changeability and emissions in the SI engine. The results shown that a important decrease in exhaust for CO and HC emissions as 30,01% and 20.21%, respectively, at E-10% compared with pure gasoline, while increased CO_2. Koç et al. [14] studied using of ethanol–gasoline mixtures on both exhaust emissions and performance for the spark-ignition engine with speed of 1500 to 5000 rpm for WOT (wide open throttle). Three different fuels namely (E-0, E-50 and E-85) were tested with each speed value. Improvement of the performance for SI engine is investigated by Siddegowda and Venkatesh [15] and proved increasing in the engine performance and reduction in pollution emissions. Salve and Patel [16] study the using of ethanol as an alternative fuel in SI engine in India. The results showed increasing in engine efficiency and reduction in harmful exhaust gases; also, it found that the cost of ethanol is much less as compared with gasoline.

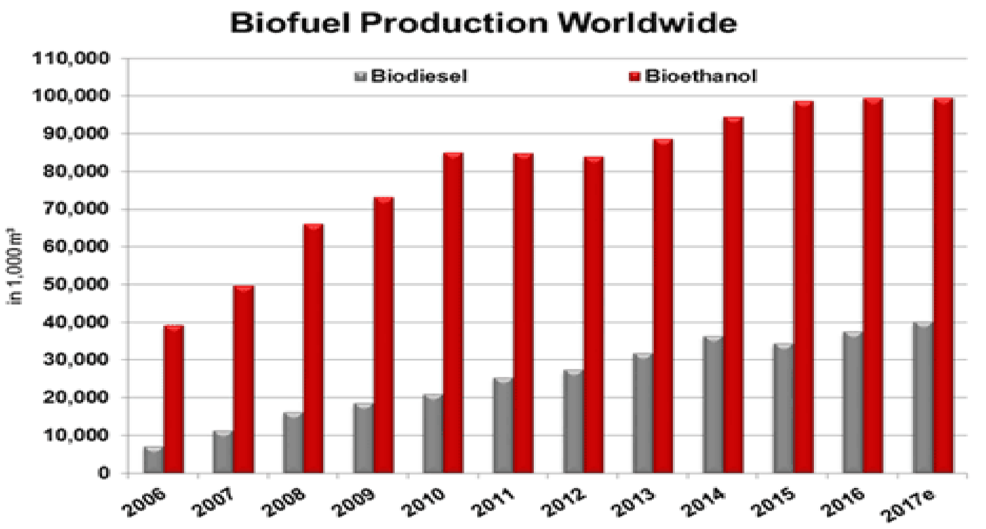

Figure 1: Biofuel production worldwide [10].

The chemical and physical properties of the bioethanol directly affecting combustion process, performances and efficiencies of the IC engine. Bio-ethanol is a neutral liquid, with specific properties. In storage and manipulation conditions, bioethanol is a stable produce when it's storage in sealed tanks at the room temperature, else appears the risk of water vapors absorption from the air. Also, from physically and chemically stability point of view [17]. Bio-ethanol has a low volatility expressed by a low value of the superficial tension at ambient temperature, because the vapors pressure of the bio-ethanol (at 0ºC) is almost 4 times lower comparative to gasoline, the vaporization of bioethanol at temperatures below 10ºC becomes difficult. As any other alcohol, the bioethanol has a lower caloric energy relative to gasoline (26800 kJ/kg and 43850 kJ/kg for gasoline). This deficiency leads to the requirement of increasing the ethanol consumption and also of the storage capability on panel of the vehicle, this last subject need larger fuel tanks in case of bio-ethanol use as single fuel [18].

The object of this work is studying the effects of various mixtures of ethanol which represented an environmental friendly alternative fuel and gasoline on the performance of internal combustion engine and emission.

2. Experimental Setup and Procedure

Experimental test rig is displayed in Fig.(2) Contains TBMC 12 engine produced, which has a single- cylinder 4-stroke engine, spark ignition, and air cooling system. The schematic of the complete experimental system is exposed in the Fig.(3).

Figure 2: Experimental Setup.

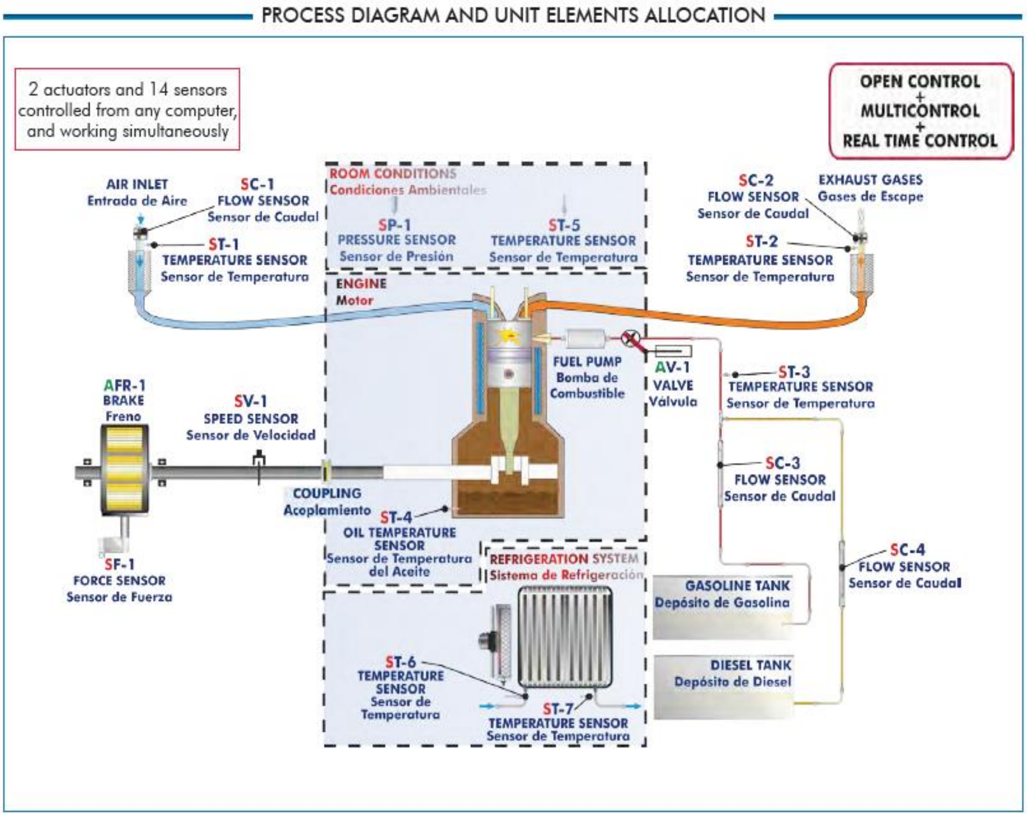

Figure 3: The schematic of the complete experimental setup [19].

Engine used in tests is equipped with carburetor and the engine specifications utilized in the present experiment is displayed in Table (1).

Table 1: Specification engine that used in the experiment**.**

Engine Kind	Spark ignition, four stroke
Number of cylinder	Single cylinder
Bore Stroke	81 mm *64 mm
Compression Ratio	8.3:1
cooling	Air cooling
Maximum Output Power	11 kw
Swept Volume	0.000329 m^3

Multigas 488 – Italy, exhaust gas analyzer is employed to analyze the exhaust gases. This instrument used to measure the concentrations of (CO), (CO_2) and (HC). Also, it is used to observe fuel relative to air ratio (λ), which characterizes as the inverse of equivalence ratio. Ethanol has a chemical composition of (C_2H_6OH) and purity 99.9% added to gasoline which has a chemical composition (C_8H_{18}) then six blends of gasoline-ethanol namely (E-0, E-10, E-20, E-30, E-40, and E-50) are used to analyze the performance and emissions pollutants of SI engine. Table (2) shows the characteristics of ethanol and gasoline, while Table(3) shows the characteristics of ethanol –gasoline mixture include blends densities and octane number which measured by using (IROX2000) device in the oil products company in Iraq-Babylone. The engine was started operation firstly then warm up for 10-15 minute for all different mixtures. The fuel consumption is measured by the use of flow meter. The same process is repeated for blends of E-10, E-20, E-30, E-40 and E-50 and for only pure gasoline. The experimental tests are carried out with load and conducted for engine speeds rang of (1500-3000) rpm with step of 250 rpm. The data gained from the directed tests have been recorded then the results and diagrams were associated. In all tests the parameters that measured directly by the setup sensors and read in monitor include torque, brake power, air mass flow rate, fuel mass flow rate, while the emissions measured by gas analyzer which recorded all the emissions values.

Table 2: Characteristics of gasoline and ethanol.

Property	Gasoline	Ethanol
Formula (liquid)	C_8H_{18}	C_2H_6OH
Density (kg/m^3)	765	785
Heat of vaporization(kJ/kg)	305	840
Specific heat (kJ/kg.k)	2.4	1.7
Heat Value(kJ/kg)	44000	26900
Stoichiometric air –fuel ratio	15.13	9.00
Octane Number	91	107

Table 3: Characteristics of gasoline and ethanol blends by used (IROX2000) device.

Ethanol Fraction	Density (kg/m^3)	Octane Number
E0	765	91
E10	767	94.1
E20	769	95.7
E30	772	97.3
E40	774	98.9
E50	777	101.5

3. Engine Performance features:

The brake power is gotten direct from experimental device monitor. Brake thermal efficiency (η_{thb}) is represented the ratio of the engine brake power to the fuel heat power as [20]:

$$\eta_{thb} = \frac{Bp}{(LHV) \times \dot{m}f} ----------- (1)$$

4. Results

The effects of varies blends of ethanol and gasoline on the SI engine performance and emission characteristics are analyzed. Figure (4) displays the brake specific fuel consumption with variable speeds of engine with load at varies mixtures. It is found the brake specific fuel consumption which measured by flow meter decreases when ethanol concentration increases due to lesser heat values for ethanol when compared with gasoline. Also, the brake specific fuel consumption decreases as the engine speed increases.

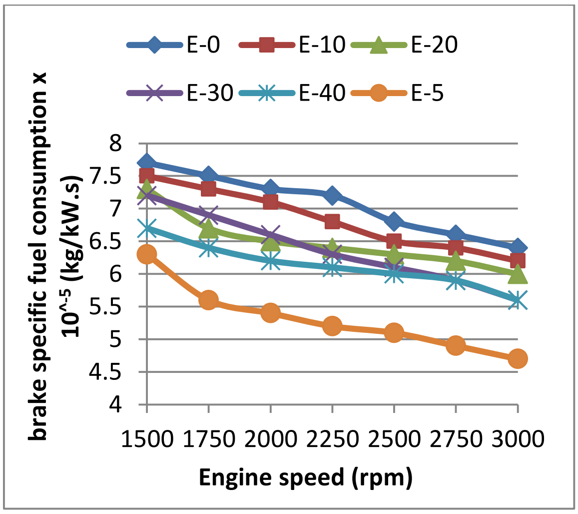

Figure 4: Brake specific fuel consumption verse engine speed.

Figure (5) presented brake power which directly measured with several speeds of engine at different mixtures. It observed brake power rises as the volume percentage of ethanol increases. The brake power increases as speed of engine increases for the same mixture because of the high heat of evaporation of ethanol when compared with gasoline. This increasing in the brake power for ethanol-gasoline blends is associated with the improved properties of combustion for the ethanol fuel and combustion duration decreases.

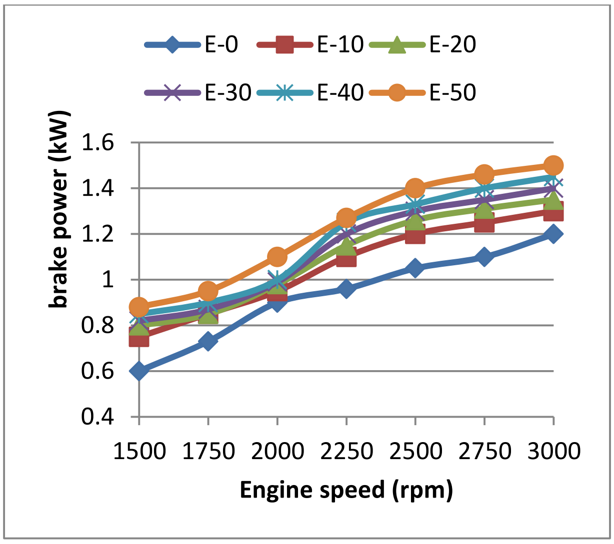

Figure 5: Brake power verse engine speed**.**

Brake thermal efficiency which calculated from equation (1) with several speeds of engine at different mixtures is presents in Figure (6). It observed brake thermal efficiency improved as the volume fraction of ethanol increases and the brake thermal efficiency improved as speed of engine increases for the same blend because of brake power increases.

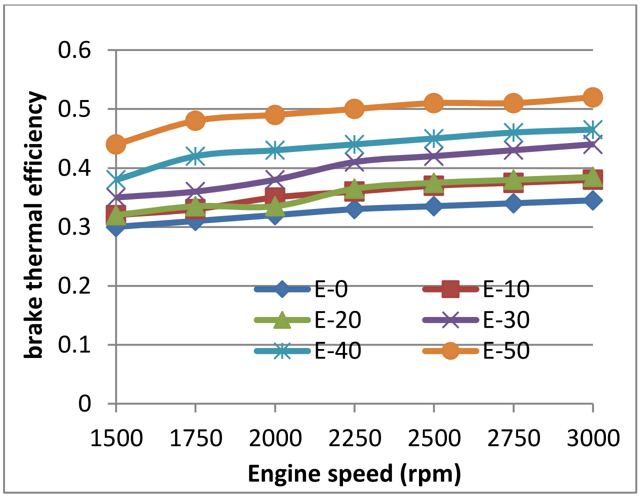

Figure 6: Brake thermal efficiency verse engine speed.

Carbon monoxide, which directly measured by gas analyzer for different, speeds of engine and different mixtures are exposed in Figure (7). It displayed the increasing of ethanol in mixture the concentrations of carbon monoxide (CO) reductions. It is also noticed for mixtures 20E-

50E the concentrations of CO is lesser compared with only pure gasoline.

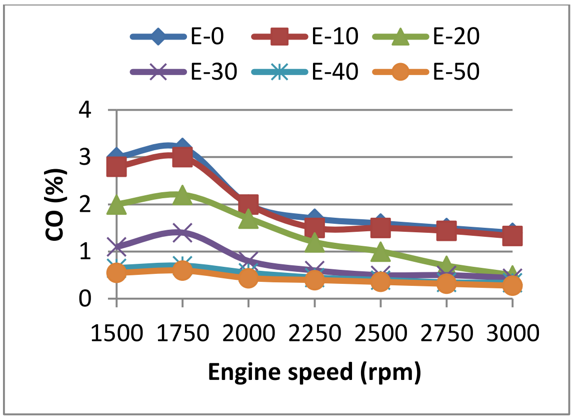

Figure 7: CO percentage verse speed engine.

Figure (8) shows Carbon dioxide which directly measured by gas analyzer for different speeds of engine at different mixtures. It clear that is significant reduction for concentrations of CO_2 when ethanol increasing in mixtures compared to only pure gasoline.

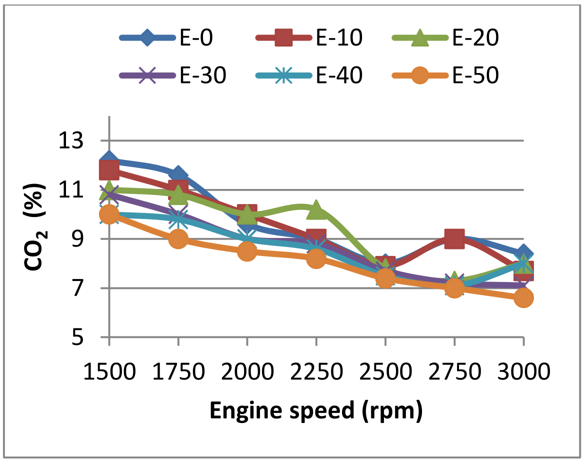

Figure 8: CO_2 percentage verse speed engine.

Hydrocarbon (HC) which directly measured by gas analyzer for different speeds of engine and various mixtures are shown in Figure (9). It was found increasing of ethanol fraction in mixtures leas to decrease the amount of HC when the speed of engine increases. The amounts of HC all mixtures are fewer when compared with only pure. The present work is compared with the results of Talal et al. 2015 [21] which represented experimental investigation of effects for ethanol-gasoline mixtures up to E-10 on SI single cylinder engine performance and emission. Comparison gave increasing of 7.3 % and 4.3%, at E-10 at 3000 rpm for brake power and brake fuel consumption respectively for the present study, Also reduction of 23.8 % and 24.7 % for CO and CO_2 respectively for the present study.

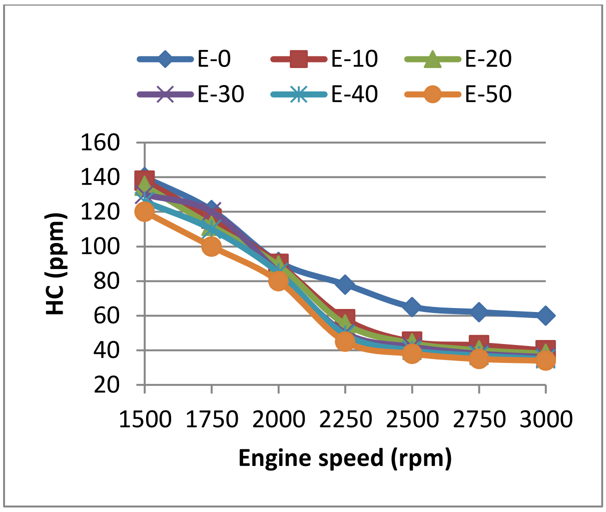

Figure 9: HC percentage verse engine speed.

6. Conclusions

This paper represented the analysis of performance and exhaust emissions of a single cylinder SI (spark ignition) engine which operates with ethanol-gasoline blends of 0%, 10%, 20%, 30% and 40% and 50% called (E-0, E-10, E-20, E-30, E-40, and E-50). In the experiments, the engine runs at various engine speeds for each test fuel. In comparison with gasoline fuel, the brake power, engine torque, and thermal efficiency increase when using ethanol blends, while the brake specific fuel consumption reduces. Increasing of the ethanol in the blends fuel leads to decrease CO, HC, and CO_2 concentration in the emissions. The best blend used in the study is E-50.

Nomenclature

Symbol	Definition	Units
Bp	Brake power	W
Bsfc	Brake specific fuel consumption	Kg/kW s
FAa	Fuel-air actual ratio	-
FAs	Fuel –air stoichiometric ratio	-
LHV	Fuel low heating value	J/kg
ma	Air mass	kg
$\dot{m}f$	Fuel mass flow rate	Kg/s
P	pressure	
R	Air constant	J/kg °C
T	Temperature	°C
Vd	Displacement volume	m^3
Greek symbols		
ρ	density	Kg/m^3
η	Efficiency of collector	-
ϕ	Equivalence ratio	-
Subscripts		
thb	Brake thermal	

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دراسة عملية عن استخدام الايثانول والبنزين في محركات الاحتراق الداخلي ذات الاشتعال بالقدح

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الخلاصة:
تم اجراء دراسة عملية حول تأثير أضافه الايثانول ذات نقاوة 99.9% إلى البنزين على أداء محرك احتراق داخلي ذات الاشتعال بالقدح وانبعاث غازات العادم. المحرك المستخدم في هذا العمل هو محرك أحادي الاسطوانة ، رباعي الأشواط. تم تحليل عوامل التشغيل للمحرك وانبعاثات غازات العادم وهي أول اوكسيد الكاربون CO ، ثاني اوكسيد الكاربون CO_2، وكميه الهايدروكاربونات المنبعثة. تم تسجيل القياسات لسرع مختلفة للمحرك تراوحت من 1500 الى3000 دورة بالدقيقة بوجود الحمل لنسب خلط تتراوح من (E0-E50). اظهرت محصله النتائج وجود زيادة في القدرة المكبحية والكفاءة الحرارية المكبحية، بينما اظهرت النتائج نقصان في استهلاك الوقود النوعي المكبحي عند زيادة كمية الايثانول في الخليط . ايضا وجد إن زيادة أضافه الايثانول إلى البنزين أدى إلى انخفاض في تراكيز CO ، HC و CO_2. افضل النتائج في هذه الدراسة هي عند استخدام نسبة خلط E50.