Experimental Investigation of Using Ethanol-Gasoline 750 on the Performance and Exhaust Emmision of Spark İgnition Engine in Iraq

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Abstract:

The influences of adding pure ethanol 99.9% (0E, 10E, 20E, 30E, 40E, 50E,) to gasoline 750 blends on the performance of the engine and characteristic emission of spark ignition (SI) engine are conducted in the present study. The Internal combustion engine that employed in the experiment has specifications of a (singl – cylinder) and 4- stroke (SI). Performance tests are carried out for brake power (Bp), brake specific fuel consumption (Bsfc), brake thermal efficiency (η_{Bth}), for carbon dioxide (CO_2), carbon-monoxide (CO) and hydrocarbon born (HC) emissions. The measurements are recorded under several engine speeds from (1500-2500rpm) for two cases, the first with load and the second case without load. The experimental result showed that ethanol- gasoline750 blends fuel increases the (Bp), and (η_{Bth}) about 2.61% and 30.9%, respectively for all engine speeds. Also, the (Bsfc) a bit decreases about 4.97%. By increasing the ethanol- gasoline750 blend fuel decreases the CO, HC emissions about 4.67% and 6.4%, respectively, where the CO_2 concentration increases about 6.1%. It was detected that the temperature of exhaust gas increases about 33.60%, as engine speed increases

Keywords: Ethanol, Gasoline 750, Engine performance, Emission characteristics.

Nomenclature

Subscripts	
Symbols	**Meaning**
BSFC	Brake specific fuel consumption kg/kw.sec
SI	Spark ignition
CO	Carbon monoxide %
CO_2	Carbon dioxide %
NO_x	Oxides of nitrogen %
HU	Hydrocarbon burn ppm
G	Gasoline
E	Ethanol
ICE	Internal combustion engine
BP	Brake power kw
E10	10 percentages by volume ethanol
E20	20 percentages by volume ethanol
E30	30 percentages by volume ethanol
E40	40 percentages by volume ethanol
E50	50 percentages by volume ethanol
AFR-1	Mass ratio of air to fuel present in engine
W-L	With load gasoline 750
Symbols	**Latin Symbols**
η_{Bth}	Brake thermal efficiency %
$\dot{m}f$	Mass flow rate kg/sec

1. Introduction

Alternative fuels can be utilized to actively improve the emissions pollution and performances of (SI) engine [1]. It becomes increasingly significant to really know which kind of fuel is employed in the engine. If the right kind is not used of fuel, there will certainly be trouble with the engine running. For instance, gasoline is the fuel designed for spark-ignition engines [2],[3]. Ethanol can highly be compressed as a result of its lower steam pressure thus it can easily be transported and stored. It contains the oxygen atom in its chemical structure which has a positive influence on the environment by reducing the proportion of the carbon-monoxide (CO) and hydrocarbons (HC) emissions when burning fuel that contains a percentage ratio of ethanol [4],[5]. The first attempts of mixing fuel with ethanol to run vehicles were between 1880s-1890s. Henry Ford introduced ethanol as the fuel choice for many cars during the early steps of development [6]. The use of bioethanol is also recommended as a substitute fuel for (SI) engines as a consequence of the severe pollution standards at the present time, which requires minimizing (NO_x) and CO_2 emissions [7]. According to many reports, ethanol–gasoline blends can be utilized as fuel in order to replace some part of gasoline in engine applications. Using gasoline–ethanol blends including ethanol at low concentrations could get better engine performance and characteristic emissions [8].

F. Yüksel and B. Yüksel. [9] Reviewed the use of (E–G) mingle as a fuel in SI engines. They conducted test performance on a (4-cylinder SI) engine with compression ratio 8:1. In the experiments, the concentrations of (CO), (HC), (CO_2), and (O_2) in the exhaust gas were measured by the VLT-3600 analyzer with pre-calibration. It was found that in using (E–G) blended fuel, the (CO) and (HC) emissions would be reduced approximately by80% and 50%, respectively, while the (CO_2) emission increases 20% depending on the engine conditions.

M.A.R. Sadiq et al. [10] reviewed the influences of the (E –G) mingle on exhaust and noise emissions from (4- stroke SI) engine. In their experiment ethanol purity 99.9% was added to gasoline blends to engine type T85D carbureted single-cylinder (4-stroke SI) with bore and stroke (70mm, 66mm). Results of the engine tests showed that using of ethanol- gasoline blended fuels increased the value of power output of the engine dramatically (up to 50%). While (CO) and (HC) emissions decrease, as a consequence of the leaning effects that caused by ethanol additions and the CO_2 emissions increase due to the improvements of combustion.

A. Pal. [11] has studied the impact on SI engine performance and emissions. The performance and emission features of a (4-stroke, 4-cylinder SI) MPFI engine was investigated with different ethanol -gasoline blends. The performance considerations like the (BP), (η_{Bth}), and the exhaust emission considerations as (CO), (HC), (NO_x) and (CO_2) were recorded. The results demonstrated the applicability of low ethanol mixed gasoline as clean fuel to decrease (CO), (HC) and (NO_x) emissions.

A.S. Raja et al. (2015) [12] presented the influence of (E-G) mingle on performance characteristics and emission of (single- cylinder), air-cooled motor SI engine. Experiments were conducted at partial load and several engine speeds ranging from (3000 - 5000 rpm) of a (single-cylinder 150cc), 4- strokes, air cooled (SI) engine. Results of the engine test indicated that using (E–G) blended fuels volumetric efficiency and excess air factor increased. Finally, the (CO), (UHC) and (NO_x) emissions concentrations in the engine exhaust decrease, while the (CO_2) concentration increases.

2. Experimental Setup

Experimental test rig is displayed in **Figure (1)** consists of TBMC 12 created by EDIBON of German (2011) which has numerous features include advanced real-time SCADA, open control, multicontrol, genuine-time control, specialized EDIBON control software, Instruments data acquisition board (250 KS/s), calibration exercises and projector or electronic whiteboard compatibility. The calibration educates the user of how to calibrate a sensor and the importance of checking the precision of the sensors before taking measurements. In this experiment, using the (ICE) with a (single- cylinder 4-stroke, spark ignition), and air-cooled the engine. The engine is equipped with a mixture of air - fuel through carburetor process. The specifications of the engine used in the experiment displayed in the table (1).

3. Fuel Used:

In this experimental study, the influence of adding ethanol with purity 99.9% to gasoline 750 with rates volumetric different form the six kinds of fuel (E0, E10, E20, E30, E40, E50) on performance engine and emissions pollutants of SI engine. So, it was appropriate to conduct some experimental tests on ethanol-gasoline (750) available. Also, the fuel produced by mixing ethanol - gasoline (750) in the proportions mentioned previously, density, as well as octane number for each type of fuel used. Use device (IROX2000), machine examination octane number found in the company's central oil products Sadat al- hindiah in Babylon. Tables (2) show the test results of fuel used and also, table (3) shows the characteristics of ethanol and gasoline.

4. Experimental Procedures:

Step-1: Before starting, there should be guarantee that there is no oil in the tank engine.

Step-2: Supply the first kind of fuel to be tested by a gasoline type 750 (0E) about 1000 ml at the engine tank. For example to obtain the (10E – 90G) mixture the ethanol is added to the beaker to the level of 100 and gasoline is added to the level 1000. Then the blend is well mixed and the obtained mixture is supplied to the engine tank. The mixing process is by volume (Vol./Vol.).

Step -3: Start the software SCADA TBMC -12 program before starting the engine to be positive that there is no flaw in the program.

Step -4: Start the engine by switching on the key in the gray box, and then keep the engine running for (3-5) minutes to steady the combustion process in the engine. When observing that the different sensors maintain their values stable, record them by the software. Also, measure the consumption value of the fuel ($\dot{m}_f$), and the values resulting from the combustion, when speed changes between (1500 to 2500) in case of without load.

Step -5: With load, to do it, activate the actuator AFR-1 during an approximate period of one minute. When observing that the different sensors maintain their values stable, record them by the software. Compute the torque for each position, the Bp and also the fuel consumption ($\dot{m}_f$).Then take a sample of the exhaust gases, show the results on the display device, and is printed by especial printer within the exhaust gas analyzer.

5. Performance characteristics:

Brake specific fuel consumption (Bsfc) is defined as the ratio of mass flow rate of fuel to break power, which calculated as (i) [13]:

$$Bsfc = \frac{\dot{m}f}{Bp} \dots\dots\dots\dots \left(\frac{kg}{kws}\right) \dots\dots\dots\dots \text{(i)}$$

Brake thermal efficiency (η_{Bth}) is defined the ratio of the brake power to the fuel power which calculated as (ii) [14]:

$$\eta Bth = \frac{Bp}{(LHV) \times \dot{m}f} \dots\dots\dots\dots\dots\dots \text{(ii)}$$

The brake power can be obtained direct from software.

6. Results and Discussion

In this study, the engine performance is tested. The engine performance indicates the degree of success in converting the stored chemical energy in the fuel into mechanical energy. The impact of two several concentrations of the ethanol – gasoline 750 is studied. Also, the effects of different blends of ethanol-gasoline on the performance and emission characteristics for each of the above concentrations are analyzed. The blends used are as follow:

1- 0% ethanol – 100% gasoline (Pure gasoline case)
2- 10% ethanol – 90% gasoline
3- 20% ethanol – 80% gasoline
4- 30% ethanol – 70% gasoline
5- 40% ethanol – 60% gasoline
6- 50% ethanol – 50% gasoline

All the analysis is carried out in two cases. The first case with load and the second case are without load. Both cases are conducted at engine speeds rang (1500-2500) rpm.

6.1 Engine performance for ethanol-gasoline 750 blend with load:

The results of the brake specific fuel consumption, brake Power, brake thermal efficiency, and exhaust gas temperature for various engine speeds were obtained.

The variation of brake specific fuel consumption versus the engine speeds with load at different blends is shown in Figure (2). It is noted that as the ethanol concentration increases, the brake specific fuel consumption decreases about 4.97% for all engine speeds. This result is expected because of the lower heat value (LHV) of ethanol compared with gasoline 750, as displayed in table (3). Another notice is that the brake specific fuel consumption decreases as the engine speed increases with load. The minimum brake specific fuel consumption of 5.18×10^{-5} (kg/kw.sec), was obtained at an engine speed 2500 for (E50-G50).

The influence of the ethanol – gasoline750 blend on the brake power for different engine speeds is shown in Figure (3). It viewed that the (BP) increases with the increase in the volume proportion of ethanol- gasoline750. It increased by 0.31kw for 10% blend, 0.43 kw for 20% blend, 0.47 kw for 30% blend, 0.51 kw for 40% blend, and 0.51 kw for 50% blend at several engine speeds (1500-2500) rpm. This result is reasonable because of the high evaporation heat (HOV) of ethanol measure up to gasoline (750), as presented in table (3-3). Ethanol's high heat of evaporation could provide the cooling sensation for a fuel-air charge; hence the density of the blend escalated, and more BP might be obtained. Maximum (BP) output of 1.30 kW was obtained at engine speed 2500 rpm for E50. The (BP) begins to increase more as the ethanol content becomes more than 30 % at speed value of 2000 rpm and more.

The influence of the ethanol – gasoline750 blend on the brake thermal efficiency for different engine speeds is shown in Figure (4). It viewed that the brake thermal efficiency increases as the engine speed increases for the same blend. Also, the brake thermal efficiency increases as the volume percentage of ethanol-gasoline750 increases. It increased by 4% for 10% blend, 5.4% for 20% blend, 6.9% for 30% blend, 5.4% for 40% blend and 9.2% for 50% blend at different engine speeds (1500-2500) RPM. This result is also expected because of the high heat of evaporation of ethanol compared to gasoline. Maximum brake thermal efficiency is found at engine speed 2500 rpm for E50. The brake thermal efficiency begins to increase when ethanol content is more than 40%.

The impact of ethanol- gasoline750 blends on exhaust gas temperature at variable engine speeds is shown in Figure (5). It can be observed that the exhaust gas temperature increases as engine speed increases for the same blend. It is noticed that the exhaust gas temperature increases slowly at the engine speeds of 2000-2500 rpm, when compared to pure gasoline 750 (E0). However, at the engine speeds of 1750-2500 rpm results show an opposite effect where E30 shows the largest increase in (EGT). It may indicate that the EGT changes proportionally with the maximum cylinder temperature; due to the ethanol has higher latent of vaporization than that of gasoline 750. This interpretation is correct for the speed range 2000-2500 rpm. However, for speed range 1750-2500 rpm, E30 shows great increase in the exhaust gas temperature.

6.2 Emission characteristics for ethanol-gasoline750 with load:

The result of carbon monoxide (%CO), carbon-dioxide (%CO_2), and amount of hydrocarbon burns (HC ppm) for ethanol- gasoline750 blends versus variable engine speed with load are presented as following.

Carbon monoxide versus different engine speeds with load at different blends is shown in Figure (6). It can be viewed, that when ethanol–gasoline750 volume percentage increases the concentrations of carbon monoxide (CO) decreases. It is also noticed that with blends between 20E-50E the emission of CO is lower compared with pure gasoline750 (0E) fuel. It can be explained by enrichment of oxygen in ethanol. Ethanol has a high oxygen content that will enhance oxidation through the engine exhaust process. The CO emission begins to decrease when ethanol- gasoline750 at 20% blend and when the engine speed is more than 1750 rpm.

Carbon dioxide versus different engine speeds with load at different blends is shown in Figure (7). The lowest CO_2 emission value is 9.5% which was obtained at a concentration of 50E at 2000rpm. It can be viewed that there is significant reduction in concentrations of CO_2 emission when using volume percentage of ethanol- gasoline750 blends compared to pure gazoline750. The most noticeable reduction is noticed at E50-G50 blend. Due to the existence of maximum blends of additive in ethanol-gasoline750 blends.

Hydrocarbon burns (HC) versus different engine speed with load at different blends is shown in Figure (8). It can be seen that when ethanol volume proportion increases the amount of HC decreases as the engine speed increases. The amount of HC emission at all blends percentage is less when compared with pure gasoline750 at all engine speeds. Because of the fact that, ethanol has less flame speed compared to pure gasoline750 fuel operation. At E30-70G, the amount of the HC emission is 10ppm at 2500rpm which is lowest obtained value for HC in this experiment.

6.3 Engine performance and emission characteristics for ethanol-gasoline750 blend without load:

The results of specific fuel consumption, carbon monoxide (%CO) and carbon-dioxide (%CO_2) for ethanol–gasoline 750 blend at different engine speeds without load are shown and investigated.

The variation of specific fuel consumption versus the engine speeds without load at different blends is shown in Figure (9). It can be viewed that the specific fuel consumption increases as the engine speed increases. The specific fuel consumption decreases when compared with pure gasoline750 (E0) by adding ethanol. Because of the lower heat value of ethanol compared with gasoline750, as shown in the table (3). Minimum (SFC) of 2.55×10^{-5} (kg/sec) was obtained at the concentration of E10-G90 at speed of 1500 rpm**.**

The variation of carbon monoxide (CO) emissions in relation to the engine speeds without load at different blends is displayed in Figure (10). It can be seen that as ethanol –gasoline750 volume ratio increases the concentrations of carbon monoxide (CO) decreases when compared with pure gasoline 750(E0). It can be viewed that the fuel E30-G70 at 1500 rpm has the lowest CO emission (0.14%) and the emission is lower when compared with pure gasoline750 (0E) fuel. It can be explained by enrichment of oxygen in ethanol. Ethanol has a high oxygen content that will enhance oxidation through the engine exhaust process.

The variation of carbon dioxide CO_2 emissions versus engine speeds without load at different blends is shown in Figure (11). The concentration of CO_2 value of 9.1% is minimum at 1500rpm for E50 and it is lower than pure gasoline750 (0E) fuel. It can be seen that there is a significant decrease in concentrations of CO_2 emission when using volume ratio of ethanol- gasoline750 blends at speeds lower than 200 rpm. As the engine speed increases above 200 rpm, the CO2 concentrations start to increase as the ethanol concentration increases in the blend.

7. Conclusion:

In this work, the effect of using ethanol–gasoline 750 (E0, E10, E20, E30, E40, E50) blend of SI engine on the performance characteristics and emission with two cases load and without load are analyzed. The following can be concluded:

1-Ethanol- gasoline750 blend fuel increases the (Bp), and (η_{Bth}) about 2.61% and 30.9%, respectively for all engine speeds, Also, the (Bsfc) slightly decreases 4.97%.

2- Increasing the ethanol- gasoline750 blend fuel lead to decrease the (CO), (HC) emissions about 4.67% and 6.4%, respectively. And also, the (CO_2) concentration increase about 6.1%.

3- Exhaust gas temperature increases about 33.60% as engine speed increase for all fuel types.

4- The addition of up to %50 ethanol - gasoline (750) is investigated in our experiments without any trouble.

5- Ethanol can be utilized as an alternative fuel and it can be added to gasoline to improve the performance engine and emission in the engine operation.

6-The maximum (η_{Bth}), of 54%, was obtained at engine speed 2500 rpm, for ethanol-gasoline750 blends (E50-G50) with a load.

7-At ethanol- gasoline 750 blends (E30-G70), it is found that the minimum amount of the (HC) emission is (10ppm), at 2500 RPM with a load.

CONFLICT OF INTERESTS.

There are no conflicts of interest.

8. References

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Table (1): Specification engine used in the experiment

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

Table (2): Results Tests of fuel

Fuel kind (750)						
	E0	**E10**	**E20**	**E30**	**E40**	**E50**
Density (kg/m^3)	765	767.5	769.8	772.2	774.6	777
Octane Number	91	94.1	95.7	97.3	98.9	101.5

Table (3) Characteristics of gasoline and ethanol

Property	**Gasoline (750)**	**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

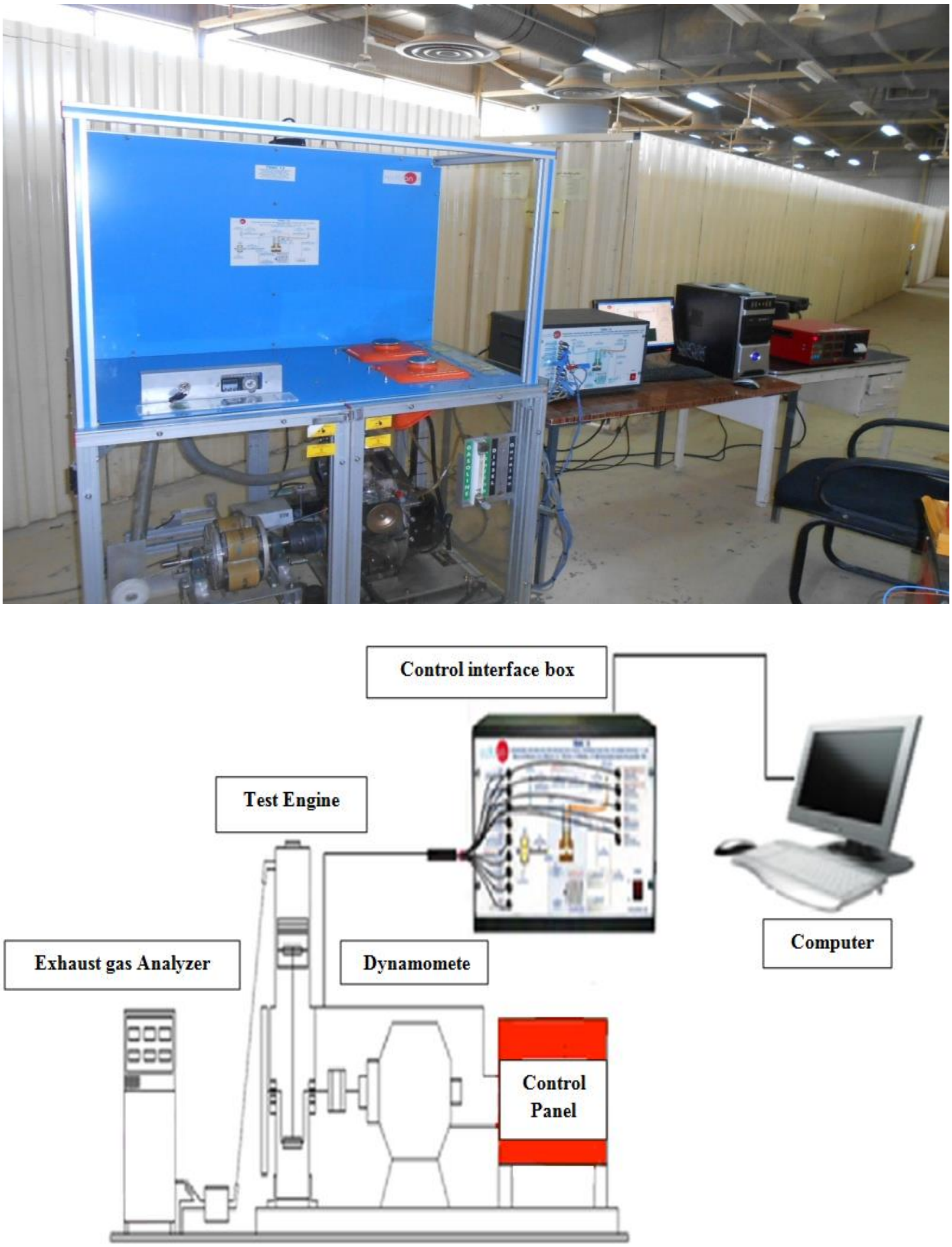

Figure (1): Experimental setup used in lab.

Figure (2): Brake specific fuel consumption versus engine speed at different blends

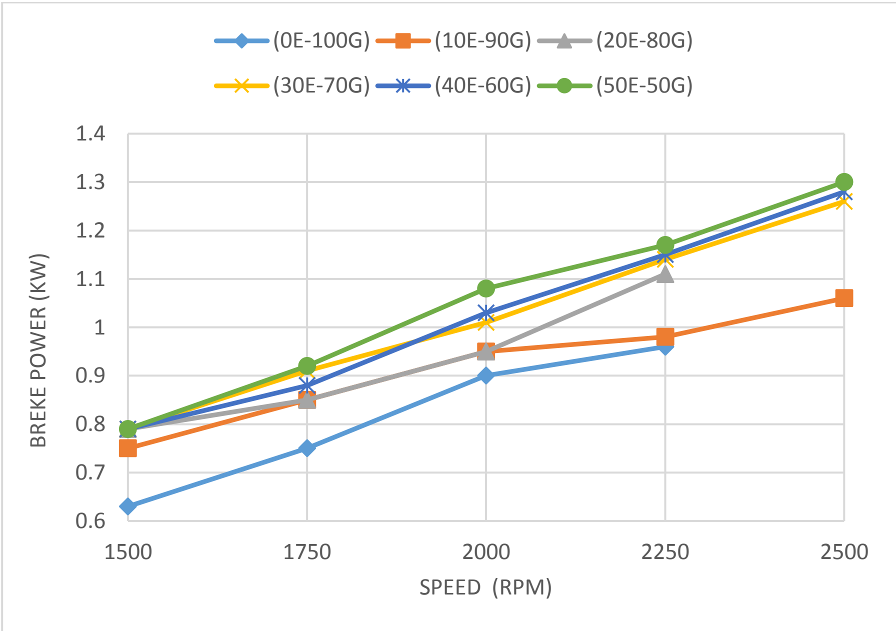

Figure (3): Brake power against engine speed at different blends with load

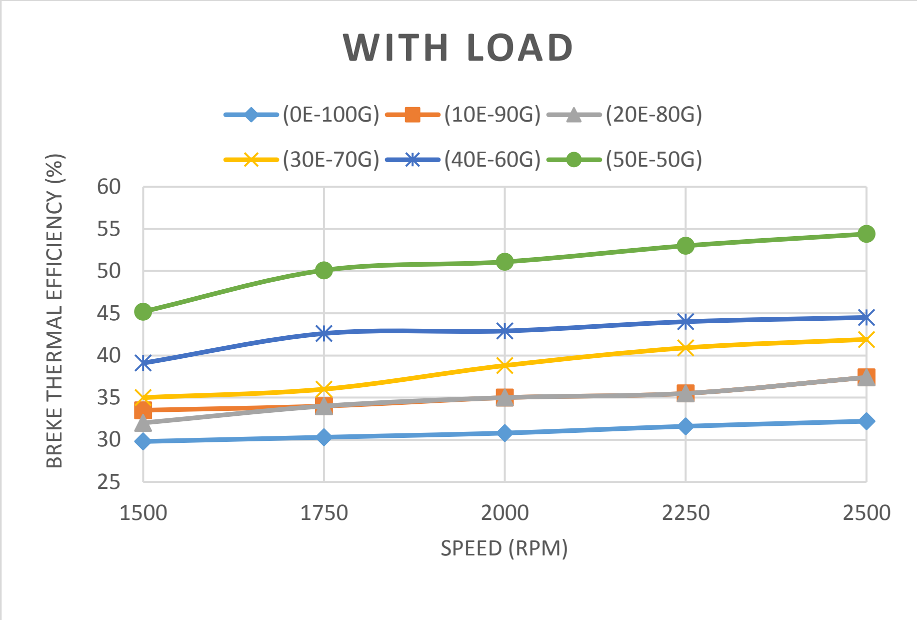

Figure (4): Brake thermal efficiency versus engine speed at different blends

Figure (5): Exhaust gas temperature versus engine speed at different blends

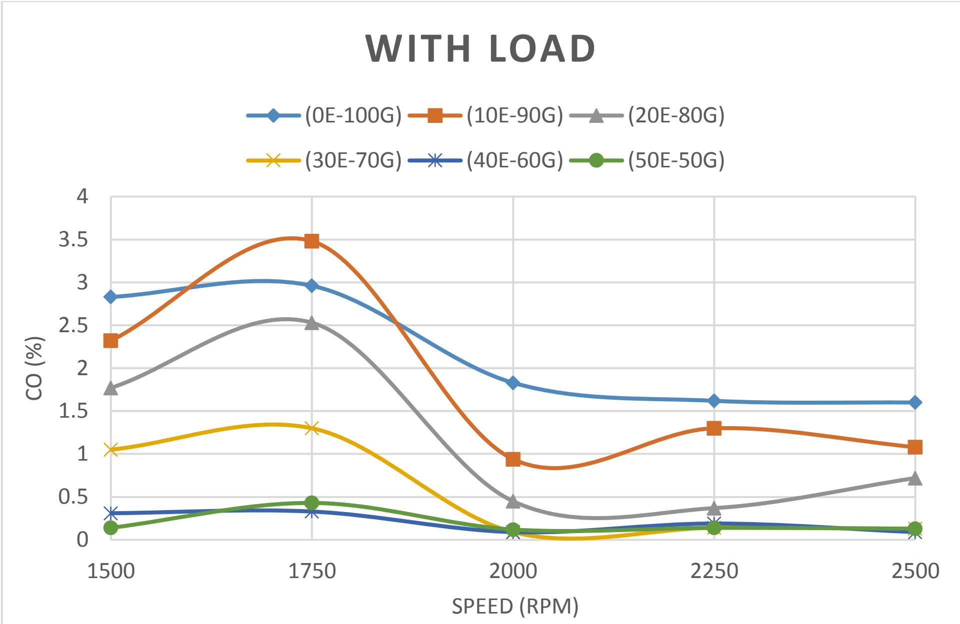

Figure (6): Carbon monoxide versus engine speed at different blends

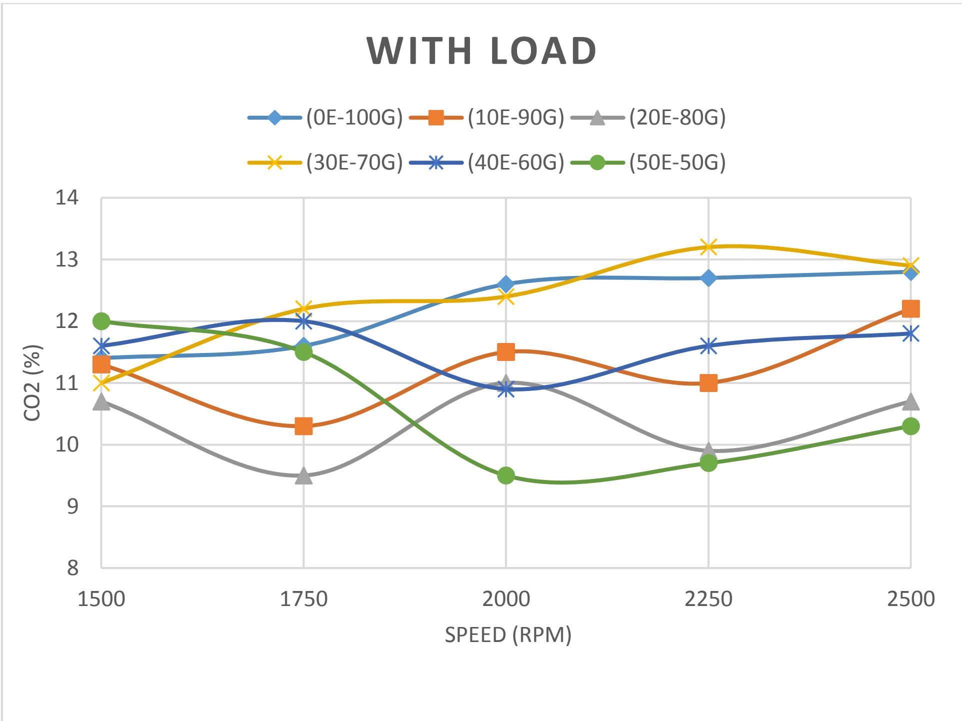

Figure (7): Carbon dioxide versus engine speed at different blends

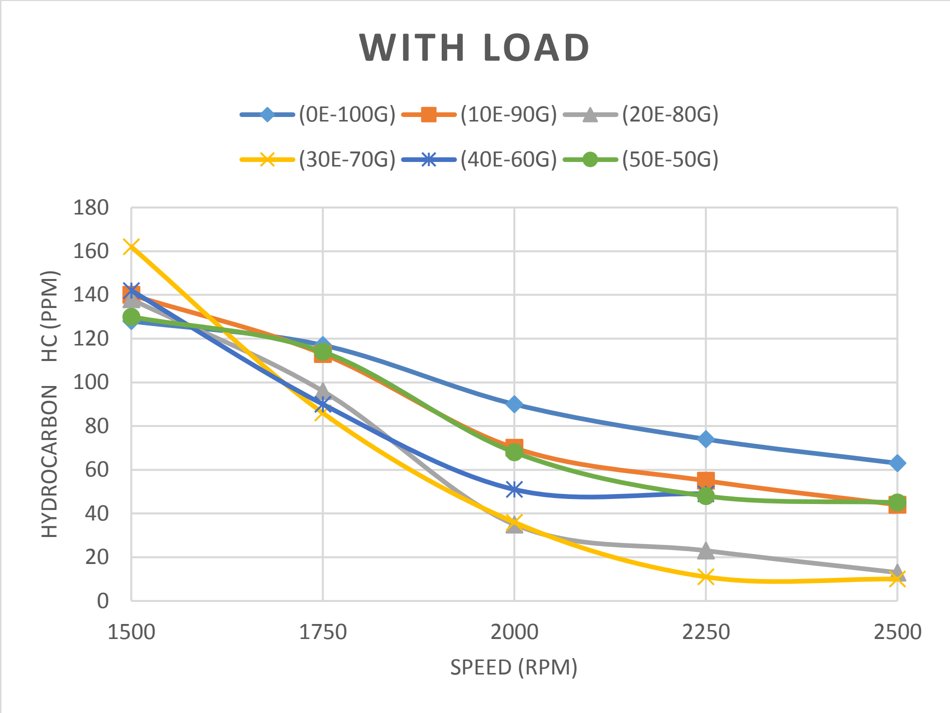

Figure (8): Hydrocarbon burn versus engine speed at different blends

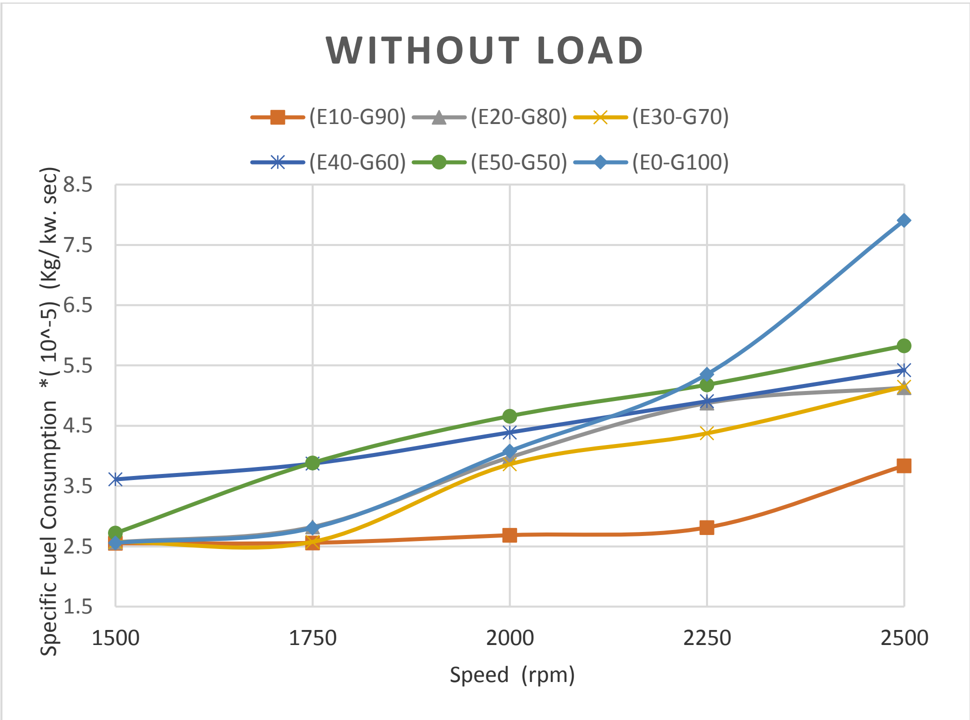

Figure (9): The variation of specific fuel consumption in relation to the engine speed at different blends

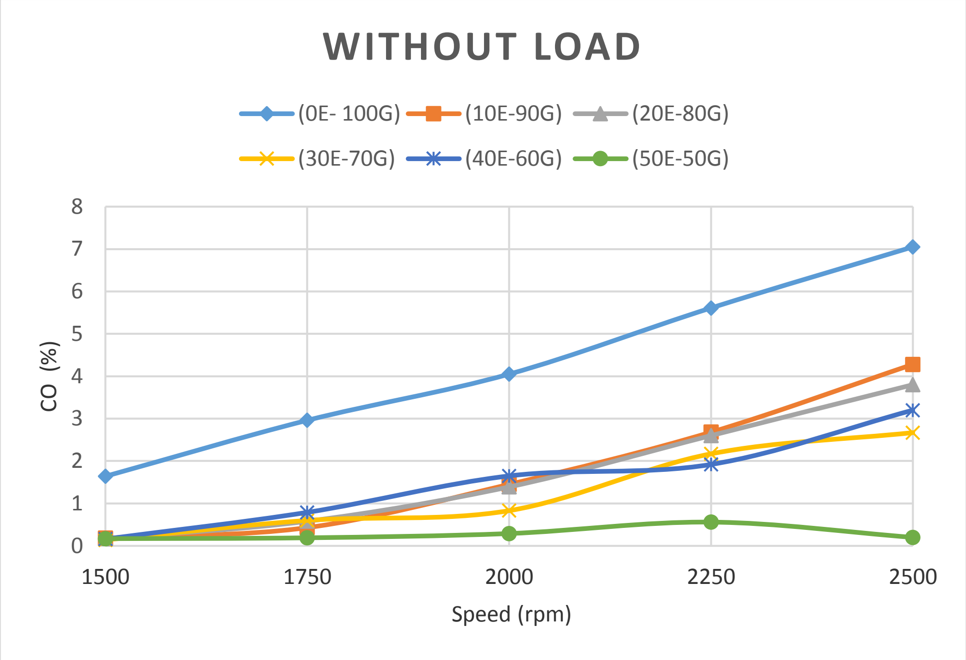

Figure (10): The variation of carbon monoxide (CO) emissions in relation to the engine speed at different blends

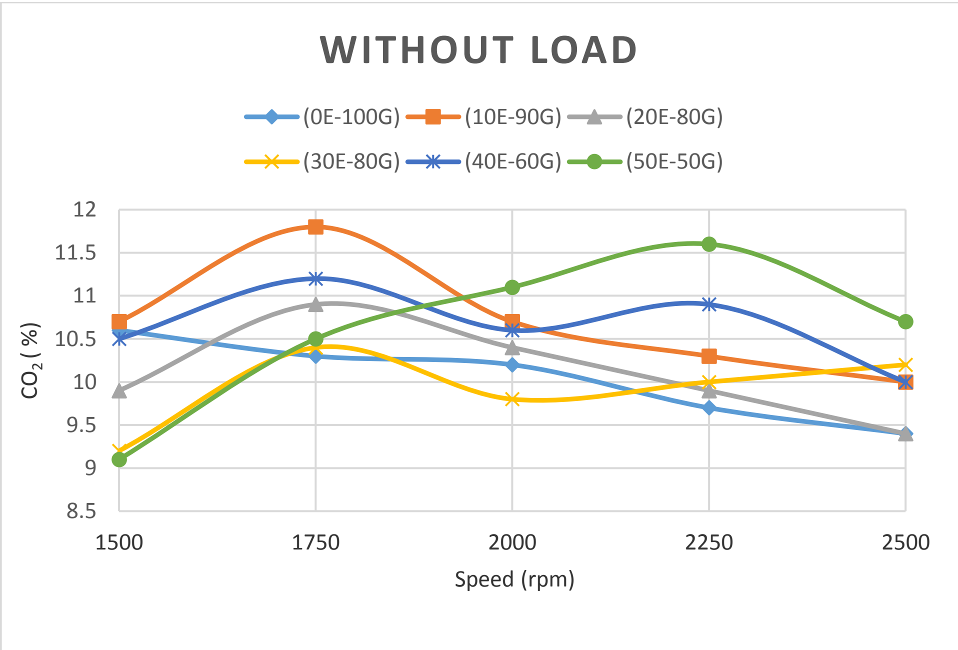

Figure (11): The variation of carbon dioxide CO_2 emissions in relation to the engine speed at different blends

تجريبياً تحقيق أضافة أللأيثانول الى الكازونين على اداء تأثيرات الخارجية للعادم في محرك بعمل بشررة في العراق

الخلاصة:

في هذه الدراسة، تأثير أضافه الايثانول ذات نقاوة 99.9% إلى الكازولين (750)في نسب خلط تتراوح من E0%-(E50%) أي زيادة E10% عنده كل نسبه خلط على أداء محرك يعمل بالشرارة وانبعاث غازات العادم. في هذه التجربة يتضمن محرك أحادي الاسطوانة، رباعي الأشواط. اختبارات الأداء كانت تحمل على القدرة المكبحيه، الاستهلاك النوعي للوقود المكبحي، والكفاءة الحرارية المكبحيه. من حيث الانبعاثات غازات العادم كانت على تركيز أول اوكسيد الكاربون CO، ثاني اوكسيد الكاربون 2CO، وكميه الهايدروكاربونات المنبعثة. هذا العمل أجريت تحت مختلف السرعة تتراوح من 1500-2500rpm أي زيادة السرعة 250rpm في حالتين حمل وبدون حمل. محصله النتائج وجود زيادة في القدرة المكبحية، الكفاءة الحرارية المكبحية، وأيضا نقصان في استهلاك الوقود النوعي المكبحي. إن أضافه الايثانول إلى الكازولين 750 أدى إلى نقصان في تراكيز HC ،CO المبعثات من غازات العادم وأيضا زيادة في تركيز CO_2. وجد ايضا عنده زيادة سرعة المحرك مع أزديادة في نسب الخلط أدئ إلى زيادة درجه حرارة غازات العادم.

الكلمات الداله: – الأيثانول، البانزين 750، اداء المحرك، خصائص الانتشارية.