IMPACT OF ETHANOL-GASOLINE BLENDS ON EXHAUST EMISSIONS, NOISE AND VIBRATION CHARACTERISTICS OF SINGLE CYLINDER SPARK IGNITION ENGINE

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Abstract

This paper aims to investigate the impact of ethanol-gasoline fuel blends on SI engine exhaust emission, noise and vibration. To achieve this experimental work a single cylinder, four stroke, air cooled, SI engine coupled with AC generator was used in this study. Ethanol fuel was blended with neat gasoline in volume rates of 5, 10, and 15%. The experimental investigation was conducted at an off-road engine under constant engine speed of 3000 rpm and different load conditions. The experimental results indicated that with increasing ethanol ratio in the blended fuel, engine pollutants such as CO and HC emission decreased dramatically, while CO_2 and NO_X pollutants increased .In addition, noise levels and vibration of engine showed a trend of increasing with increasing ethanol ratio in the blended fuel.

Keywords: Ethanol/gasoline blends, Engine emission, Noise and Vibration

I. Introduction

Recently, the world has been paying great attention to environmental pollution. As the steady increase in the use of vehicles leads to the emission of huge quantities of dangerous pollutants on human health and the environment. So researchers are looking for alternative solutions to reduce pollution from vehicles. Among these solutions is the mixing of fuel with alcohol to contribute to improving the performance of engines and thus reduce the pollution resulting from them. Alternative fuels are gotten from resources other than petroleum. When these fuels are utlized in internal combustion engines, they often produce less air pollution compared to gasoline and most of them are more economically beneficial compared to petroleum. Last but not least, they are renewable. The common fuel used as alternative fuel is natural gas, propane, ethanol, methanol and hydrogen [1]. At present, Ethanol is used as fuel for cars without mixing and can be mixed with gasoline to form a so-called "gashole" [2]. Because the ethanol molecule contains oxygen, it helps to increase the combustion efficiency of the engine, resulting in less emissions than. As ethanol is produced from plants , therefore ethanol can be considered a renewable fuel [3]. Numerous researchers investigated the utilization of ethanol-gasoline mixtures in a spark ignition engine. Valuable and useful papers have been summarized below.

Experimental results exposed that using ethanol-gasoline blended fuels devolved the engine performance. However, HC and CO emission levels lowered successfully due to the existence of oxygen in fuel mixture. In contrast, CO_2 emission level increased in consequence of the complete combustion process [4]. Investigation proved that mixing ethanol with gasoline resulted in an increase in engine power, volumetric and brake thermal efficiencies and noticeable decreasing in brake specific fuel consumption of engine. CO and HC pollutants emission were decreased, while the pollutant of CO_2 was increased. It also showed that E20 was the best blend fuel for engine [5]. The study uncovered that when E10 was employed, the output power and specific fuel consumption of the test engine increased a little. The study likewise uncovered that CO concentration lowered efficiently as a consequence of the leaning effect caused by the addition of ethanol but CO_2 concentration increased due to the perfecting of combustion inside the engine [6]. Experimental results indicated that with increasing the ratio of ethanol in fuel, CO and HC emission levels decreased due to oxygen enhancement generated from ethanol. It also indicated that using ethanol –gasoline blends gave better engine performance than pure gasoline

[7]. The test data demonstrated that the brake power, torque, volumetric efficiency, exhaust gas temperature and cylinder pressure increased, while brake specific fuel consumption decreased when ethanol blended to gasoline. Besides, HC and CO concentrations in the engine exhaust were decreased, while the CO_2 concentration was increased. Finally, he concluded that mixing 10% ethanol with 90% gasoline produced the best results for all tested parameters at all rotational engine speeds [8]. Experiment results exposed that when ethanol-gasoline mixture were utilized, vibration amplitudes and noise emission of the engine with the blended fuels showed a trend of increasing [9]. The results of this investigation confirmed the applicability of low ethanol - gasoline blended as clean fuel to reduce emitted exhaust gases like HC, CO, and NO_X emissions. Performance characteristics parameters such as brake power (BP) and thermal efficiency indicated a significant increasing and slight increasing of specific fuel consumption of engine [10].The test results exposed that HC and CO emission concentrations decreased with ethanol increasing in the blend due to leaning effect [11].

It can be understood form the present literature review that mixing of ethanol with gasoline in SI engine improves engine performance and reduces harmful emissions.

II. **Experimental apparatus and test procedure**

The engine under this study was a single cylinder, four stroke, air cooled, 171 cc, (Yamaha) spark ignition of rated output power of 2.7 kW at 3000 rpm and directly coupled to AC generator of rated output capacity of 2 kW, 220 V, 50 Hz.

The electric load board was used as variable electric loads. It consists of 8 light lamps and 4 light switches, every light switch shares two light lamps 500 W and 40 W. All components of the circuit were wired in parallel. The generated electrical power from generator was measured using a digital watt meter as an indication of the engine load.

The emission pollutants concentrations were measured such as CO, HC, CO_2 and NOx by an exhaust gas analyzer model - FGA4500**.** Readings of CO, CO_2, HC, and NO_X on the screen of the device were recorded for each operating condition of the engine.

Noise emission of the engine was measured using (Bruel & Kjaer 2239) sound level meter. Measurement distance was one meter from the engine**.** Before start of the experiment in the laboratory, the level of background noise was measured.

To measure the engine vibration, an accelerometer (356A11) was mounted on the engine cylinder head cover. The accelerometer generates signals to the amplifier then vibration signals were recorded by a laptop using data acquisition system for one minute. The schematic diagram of the tested engine and instrumentation systems are shown in Figure 1.

Four fuel blends ratios were experimentally tested during this study. Ethanol with the purity of 99.9% was obtained from local chemicals provider. Gasoline (92 octane) was obtained from local fuel station. The ethanol was blended with gasoline to get three test mixtures E5, E10 and E15. The blended fuels were prepared just before beginning the experiment to guarantee that the fuel mixture is homogeneous.

The engine was permitted to keep running for a time of 10-15 minutes for warm-up and achieving steady conditions. The experiment was conducted at a fixed speed of 3000 revolutions per minute (rpm) and at varying the load in the following sequences: No load, 0.52 kW, 1.03 kW, 1.50 kW, and 1.93 kW. Tests were carried out initially using gasoline fuel to provide the base line data. Then different ethanol-gasoline blends were examined under same test conditions. After the engine had reached the stabilized working condition, exhaust emission parameters, noise and vibration values were recorded. Before running the engine to another fuel mixure, it was permitted to keep running for a sufficient time to consume the rest of fuel from the past experiment.

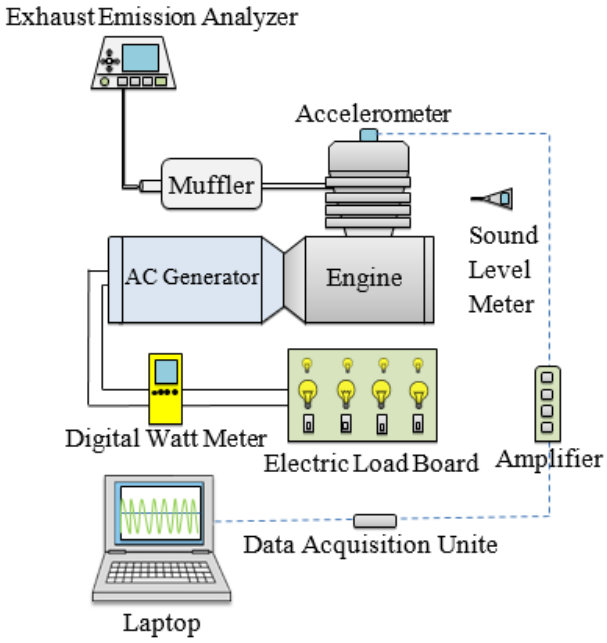

Figure 1 Schematic diagram of the test rig.

III. Results and discussion

3.1. Exhaust emission parameters

3.1.1 Carbon monoxide (CO) emission

CO is a colorless and odorless but high concentration from this pollutants may be cause harmfull for human. It is emitted from engine when it ran with a fuel-rich equivalence ratio. Oxygen content inside combustion chamber of engine plays a significant to provide an opportunity for the completion of chemical reactions and conversion of carbon of fuel into carbon dioxide. But in the case of a shortage of oxygen, this will increase the emission of carbon monoxide from the engine. . Poor mixing, local rich regions and incomplete combustion will also be the source for CO emissions [12]. The influence of ethanol–gasoline blends fuel on CO emission at different loads is illustrated in Fig. 2. It can be seen from this figure that when ethanol percentage increases, CO concentration decreases. CO concentration at maximum load condition (1.93 kW) using E5, E10, and E15 was decreased by 20%, 53.52% and 77.64% respectively in comparison to pure gasoline. This due to oxygen enrichment generated from ethanol. Besides, ethanol has fewer carbon atoms than gasoline.

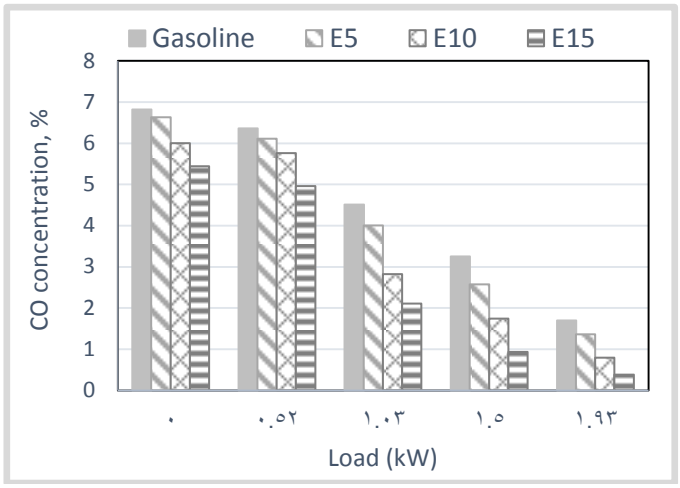

Figure 2 The effect of addition ethanol on CO emission

3.1.2 Carbon dioxide (CO_2) emission

Carbon dioxide (CO_2) is the inevitable consequence of hydrocarbon combustion. This inert gas is not harmful for plants or animals, but nevertheless it is a greenhouse gas [13]. The effect of the ethanol-gasoline blends on CO_2 emission at different loads is presented in Fig. 3. It can be seen that when ethanol percentage increases, CO_2 concentration increases. The increase of CO_2 emission signifies complete combustion process [14]. The concentration of CO_2 at maximum load condition using E5, E10, and E15 was increased by 1.92%, 4.78% and 8.82% respectively in comparison to pure gasoline.

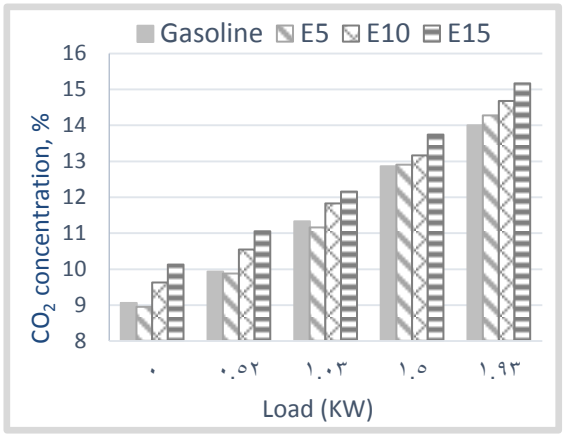

Figure 3 The effect of addition ethanol on CO_2 emission

3.1.3 Hydrocarbons (HC) emission

HC emission is the consequence of incomplete combustion of the hydrocarbon fuel. The concentration of hydrocarbons (HC) in exhaust gases is generally specified in terms of the total hydro carbon concentration expressed in parts per million carbon atoms [12]. The influence of the ethanol addition on HC emission at different loads is shown in Fig. 4. It can be seen that when ethanol percentage increases, HC concentration decreases. HC emission had similar tendency to CO emission. The reduction of HC by ethanol addition is a very welcome because it is one of harmful emissions. However, the hydrocarbons get reduced due to leaning effect. Compared to gasoline, HC concentration decreased by 22.7%, 56.96 % and 83.54 % using E5, E10 and E15, respectively, at maximum load condition.

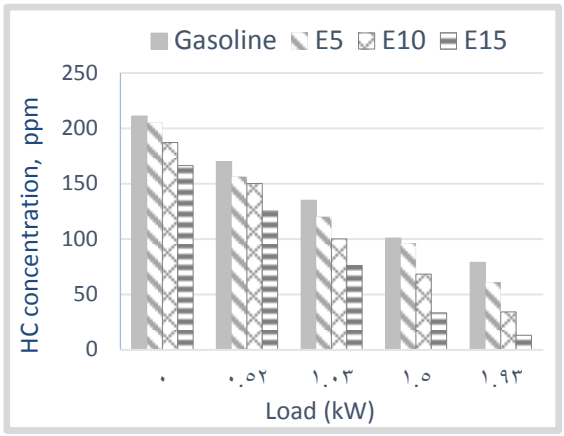

Figure 4 The effect of addition ethanol on HC emission

3.1.4 Nitrogen oxides (NO_X) emission

Nitrogen Oxides, NO and NO_2, also named as NO_X, are formed when atmospheric nitrogen or nitrogen from the fuel is mixed with oxygen helped with the high temperatures in the combustion chamber. NO_X emissions are dangerous to human because can cause respiratory diseases. Regarding the environment, NO_X contributes to the formation of ozone at ground level NO_X, but paradoxically, it also destroys the ozone at high altitudes damaging the ozone layer [13]. Figure 5 highlights the effect of the ethanol addition on NO_X emission at different loads. In this study, NO_X emission for all ethanol-gasoline blends was found to be consistently higher compared with baseline gasoline fuel across all engine loads. For instance, the increase of NO_X emission for E5, E10, and E15 are 7.6%, 11.29% and 22.11% respectively, as compared to gasoline fuel at maximum load condition. The increase of NO_X concentration using ethanol-gasoline blends is due to an increase in the combustion temperature.

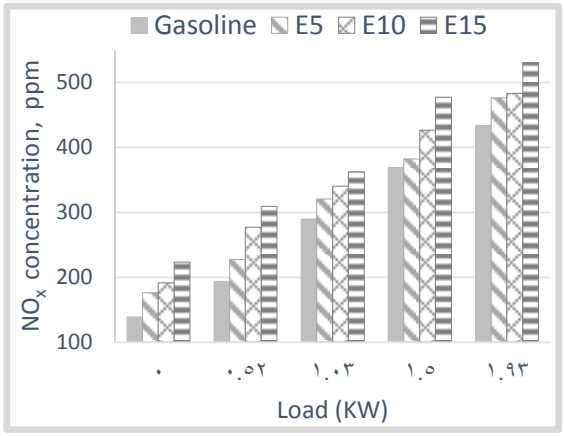

Figure 5 The effect of ethanol addition on NO_X emission

3.2. Noise and vibration

The noise produced by the internal combustion engines due to the main source of combustion within the engine as well as the movement of the mechanical parts. As the sound from explosions inside the engine combustion chamber moves outward as well as during the exhaust stroke [15]. The effect of the ethanol-gasoline blends on noise emission at different loads is shown in Fig. 6. It can be seen that when ethanol percentage increases, the noise level slightly increases. However, the higher noise values of the engine were measured with E15 at all test conditions.

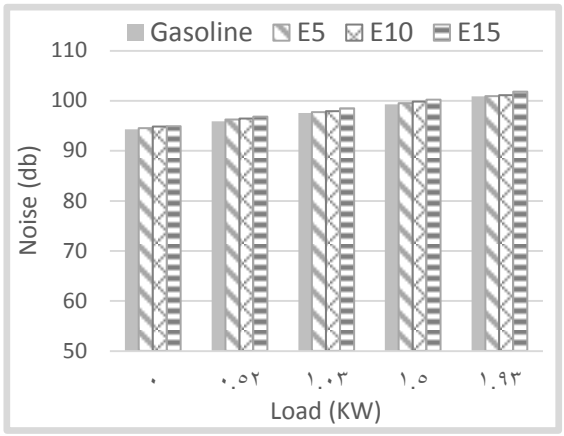

Figure 6 The effect of ethanol addition on noise emission

To measure the engine vibration at the top of cylinder head cover, root mean square (RMS) of acceleration is utilized as an indicator to represent the degree of vibration that caused by the combustion in the cylinder with time domain [16]. Figure 7 demonstrates the variations in RMS of acceleration for ethanol - gasoline blends in comparison with gasoline at different loads. It is observed that the E 15 fuel gave the higher RMS of acceleration than the gasoline for all load conditions.

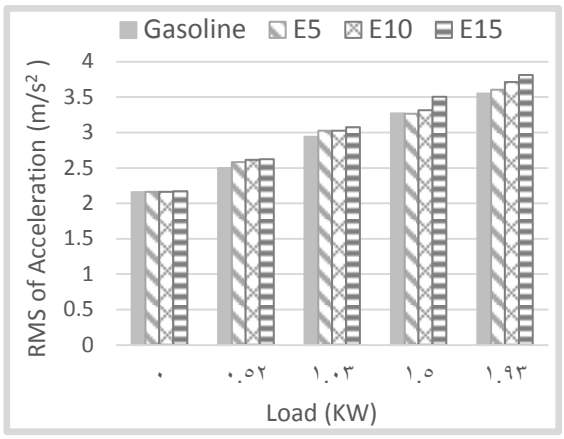

Figure 7 The effect of ethanol addition on RMS of acceleration

However, in comparison with gasoline, noise emission and vibration of the engine with the blend fuels showed a trend of increasing. These results are probably due to oxygen content and higher latent heat of evaporation of ethanol which increase the rate of pressure in the cylinder during the combustion processes. In general, there was a relation between vibration and noise emissions, because vibration values and noise emission showed a trend of increasing with blended fuels at the same test conditions [9].

VI. Conclusion

The main conclusions deduced from this study are as follows:

1. Ethanol-gasoline blends in lower proportion of ethanol by volume up to 15% can be utilized in spark ignition engine without any modifications. Higher than 15% of ethanol modification is required.
2. The results show that the use of ethanol as an addition to gasoline fuel is important to improve engine performance. Consequently, the use of gasoline ethanol blends reduces the pollutants emitted from engine during different operating conditions. For E15 blend,

the reductions are 77.64% for CO and 83.54% for HC at maximum load condition in comparison to neat gasoline.

3. Concentrations of NO_X and CO_2 emissions were increased with increasing ethanol percentage in blend. For E15 blend, NO_X and CO_2 emissions at maximum load condition were increased by 22.11% and 8.82% respectively as compared to neat gasoline.
4. Noise and vibration values showed a trend of increasing with use of ethanol-gasoline blends. For E15 blend, noise and vibration at maximum load condition were increased by 0.89% and 7.32% respectively in comparison to neat gasoline.

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تأثير استخدام خليط من الإيثانول ووقود البنزين على انبعثات وضوضاء واهتزازات محرك اشعال بالشرارة أحادي الأسطوانة

أحمد مصطفى، أسماعيل يوسف، محمد مراد

الملخص

الغرض من هذا البحث هو دراسة تأثير استخدام مخاليط من وقود الايثانول والبنزين على انبعاثات العادم وضوضاء واهتزازت محرك الاشعال بالشرارة مع مقارنة النتائج التى تمت باستخدام البنزين. لإجراء هذه التجارب تم استخدام محرك (احادى الاسطوانة- رباعي الاشواط -اشعال بالشرارة- تبريد هواء) متصل بمولد كهربائي لغرض التحميل. تم اضافة الايثانول الى البنزين بنسبة ٥ و١٠ و١٥% كنسبة حجمية. اجريت الاختبارات حيث تم تثبيت سرعة المحرك عند سرعة ٣٠٠٠ لفة في الدقيقة مع تغيير الاحمال المؤثرة على المحرك .أظهرت نتائج الاختبارات ان اضافة الايثانول الى البنزين يؤدي الى انخفاض ملحوظ في انبعاث اول اكسيد الكربون والهيدروكربونات بينما ادت الى زيادة في انبعاث ثاني اكسيد الكربون واكاسيد النيتروجين من المحرك . وقد تبين من قياس مستوى الضوضاء والاهتزازات للمحرك زيادة بسيطة مع زيادة نسبة الايثانول في خليط الوقود.