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STUDY ON PERFORMANCE AND EMISSIONS OF SI ENGINE FUELED BY DIFFERENT FUELS

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ABSTRACT

In recent years, reducing the exhaust gas emissions of internal combustion engines yet maintaining the same engine performance has become one of the most important challenges for automotive companies. Using clean energy, such as alternative fuels, could offer a promising solution for reducing air pollution. In the current work, a comparative study was carried out on the engine performance and exhaust gas emissions of a one cylinder, four stroke spark ignition engine using gasoline, ethanol and LPG fuels. For this reason, a model was proposed. The results were collected at various engine speeds (1500, 2000 and 2500 rpm). It was found that there was a slight variation in engine performance, while there was a marked difference in exhaust gas emissions between gasoline and the other selected fuels.

Keywords: emissions, performance, SI engine, alternative fuels.

1. INTRODUCTION

In the last two decades, the cost of fuels produced from crude oil has increased dramatically. Moreover, there are increasing concerns about the natural contamination of such fuels, which has encouraged many researchers to take an interest in alternative engine fuels. There are several possible alternative fuels, such as ethanol, propane, methane and biodiesel that could be used for spark ignition engines. These options have been known since the automobile was first produced [1-6]. According to previous studies, gaseous fuels could offer a promising alternative fuel for internal combustion engines because they have a higher octane number and higher calorific value than standard fuel, which will improve the combustion qualities and result in less toxic pollution [7-13]. With this in mind, some gaseous fuels, such as liquefied natural gas (LNG) and liquefied petroleum gas (LPG), have been widely used in commercial vehicles [14-18]. Researchers have carried out numerous examinations concerning the use of alcohol fuels (either pure or blended with gasoline fuel) in SI engines at different operating conditions. Cooney *et al.* [19] studied the influence of two different ethanol-gasoline mixtures, one E20 (20% ethanol + 80% gasoline, by volume) and one E84 on ignition qualities at a constant engine load and speed under various compression ratios of 8, 10, 12, 14 and 16:1, respectively. The results showed that the burning duration diminished only with E20 without any influence by any further ethanol added to the gasoline fuel.

Hsieh *et al.* [20] investigated the effect of E5 (5% ethanol mix with 95% gasoline, by volume), E10, E20 and E30 on spark ignition engine performance and exhaust gas emissions at different operating conditions. They concluded that the torque was almost similar to that of gasoline, whereas the brake specific fuel consumption (BSFC) increased when using mixed fuels. The carbon monoxide (CO) emissions of ethanol blends decreased at all selected conditions because it has a higher octane number, which improves the combustion process. In order to comprehend the execution and emanation qualities of an SI engine, Pourkhesalian *et al.* [21] numerically studied the effects of gasoline, hydrogen, propane, methane, ethanol and methanol on engine performance, combustion characteristics and emissions at selected operating conditions. As per the outcomes, the engine power and the emissions of CO and NOx diminished, while the BSFC increased when using these selected alternatives fuels rather than gasoline.

Celik [22] used an ethanol-gasoline E25 mix (25% ethanol+ 75% gasoline, by volume), E50, E75 and E10 in a spark ignition engine at different compression ratios (6:1, 8:1 and 10:1) under a constant engine speed and load. As indicated by the test results, with an expansion ethanol ratio in the fuel mix, the BSFC constantly expanded, while the CO, CO_2 and NOx emissions decreased. The optimal engine performance and exhaust gas emissions occurred when using ethanol blend E50 at the compression ratio of 10:1. The aim of this work is to investigate the engine performance, combustion characteristics and emissions of a one cylinder four stroke spark ignition engine fueled with gasoline, ethanol and LPG at different speeds under a constant engine load.

2. ENGINE MODEL

The specifications of the engine that was used in the numerical study are illustrated in Table-1. Recently, the AVL program has been considered one of the best programs for simulating an internal combustion engine at different operating conditions. The AVL program provides several types of standard fuels, as well as different sub model options, to simulate engine performance, combustion and emission formations. The starting point involved building a one-cylinder SI engine in the program and then providing all the requirements to make the program run. The model was firstly run at the engine speeds of 1000, 1500 and 2000 rpm, respectively by using gasoline fuel. The results of the model were collected and compared with the results that were provided by the manufacturer in order to test the usefulness of the model. Further running was carried out using ethanol and LPG fuels at the same engine speeds. A comparison was made

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after using the three selected fuels, the results of which will be presented later.

Table-1. Engine test specifications.

Particulars	Specifications
Type	**4 stoke, 1 cylinder, air cooler, indirect injection**
Number of cylinders	1
Bore *x* stroke (mm)	80 *x* 87
Displacement (liter)	0.437309
Compression ratio	9:1
Maximum power (Net @ RPM)	12 kW@3000
Maximum torque (Net @ RPM)	38 Nm@3600

3. RESULTS

3.1 Effective power (Pe)

The effective power of a spark ignition engine at different engine speeds when fuelled with gasoline, LPG and ethanol is illustrated in Figure-1. At all engine speeds, it could be observed that there was only a slight variation in the values of the effective power of gasoline, ethanol and LPG. The effective power of ethanol was slightly lower, while the LPG was almost higher than that of gasoline. This phenomenon is related to the difference in the selected fuel energy contents and properties. In general, all fuels produced almost the same effective power. Similar results were reported in [11, 17].

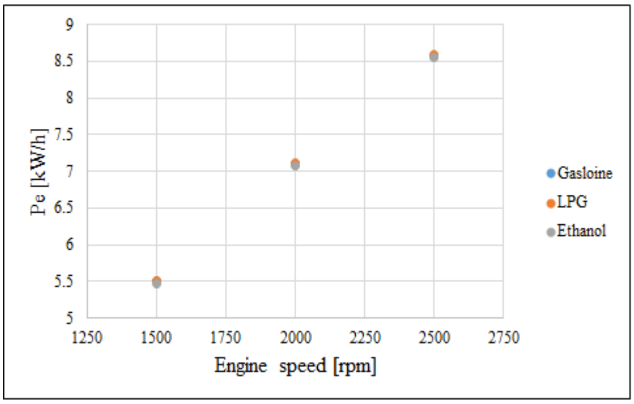

Figure-1. Variation of effective power for gasoline, LPG and ethanol with various engine speeds.

3.2 Effective torque (Pe)

Figure-2 shows the variation of effective torque for ethanol, LPG and gasoline fuel with various engine speeds. Effective torque is lowest for ethanol at all engine speeds due to its lower heating value and higher density compared to gasoline fuel. As shown in the figure, the LPG fuel produced the highest effective torque of the other selected fuels due to the fact that LPG has a higher calorific value. The research study by [6, 7] found similar results to those obtained in the current work.

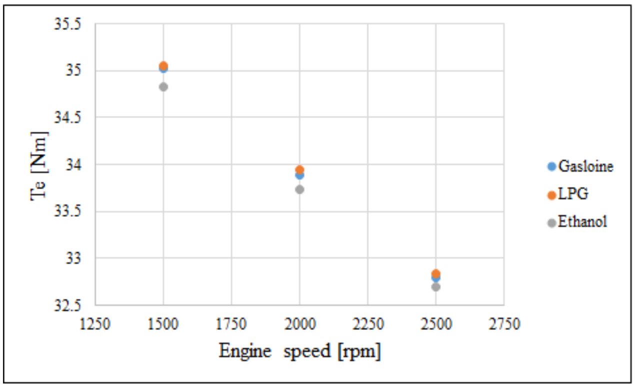

Figure-2. Variation of effective torque for gasoline, LPG and ethanol with various engine speeds.

3.3 Brake specific fuel consumption (BSEC)

The brake specific fuel consumption of various types of fuels at different engine speeds is presented in Figure-3. Brake specific fuel consumption is considered to be a very useful parameter that can be used to compare the efficiency of energy consumption of fuels. As shown in the figure, when using gasoline, LPG and ethanol, the BSFC decreased when the engine speed increased. In addition, the brake specific fuel consumption increased when using ethanol at all engine speeds when compared to LPG and gasoline. This reduction can be explained by the fact that ethanol has a lower heating value, which leads to more fuel being consumed in order to produce the same effective power as the other fuels. Arroyo *et al.* [9] performed a similar series of experiments to show the effect of LPG fuel on engine performance and they reached the same conclusions as the current study regarding BSFC.

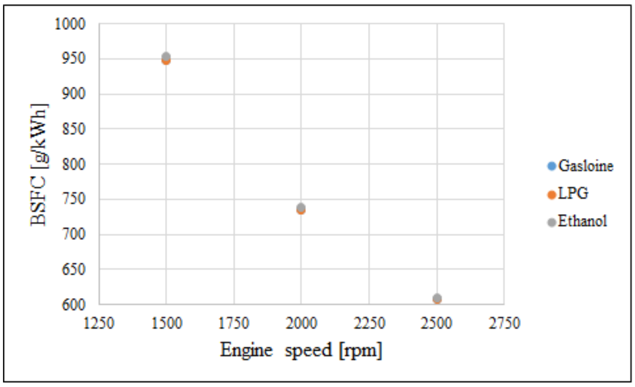

Figure-3. Variation of BSFC for gasoline, LPG and ethanol with various engine speeds.

3.4 Carbone monoxide (CO)

Figure-4 represents the carbon monoxide for the different fuels at engine speeds of 1500, 2000 and 2500 rpm, respectively. From the numerical results, it can be observed that ethanol fuel produces lower carbon monoxide at all engine speeds compared to baseline gasoline, while the LPG produced higher CO than that of gasoline. This variation in results may be associated with the difference in chemical and physical properties of these fuels. Similarly, Selim [6] found that carbon monoxide decreases when engines operate on ethanol fuel.

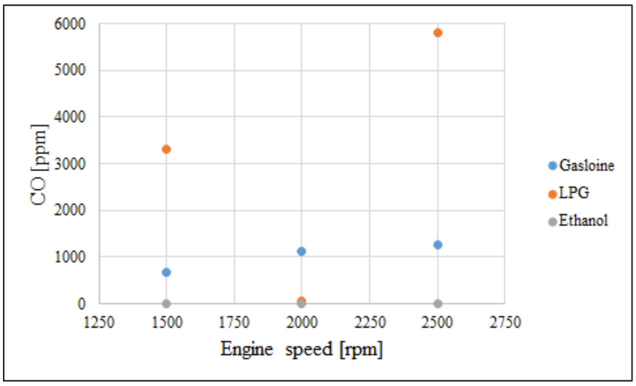

Figure-4. Variation of CO for gasoline, LPG and ethanol with various engine speeds.

3.5 Unburned hydrocarbon (HC)

Figure-5 represents the unburned hydrocarbon for different fuels at engine speeds of 1500, 2000 and 2500 rpm, respectively. From this figure, it can be observed that ethanol fuel produces lower unburned hydrocarbon at all engine speeds compared to baseline gasoline and LPG. This reduction is related to the fact that ethanol fuel has a higher octane number, which improves fuel evaporation and mixture with oxygen atoms, as well as combustion quality. In addition, it can be seen that LPG produces unburned hydrocarbon at a higher rate than ethanol fuel but at a lower rate than gasoline fuel at all engine speeds. There are similarities between the finding in this study and those described by [17].

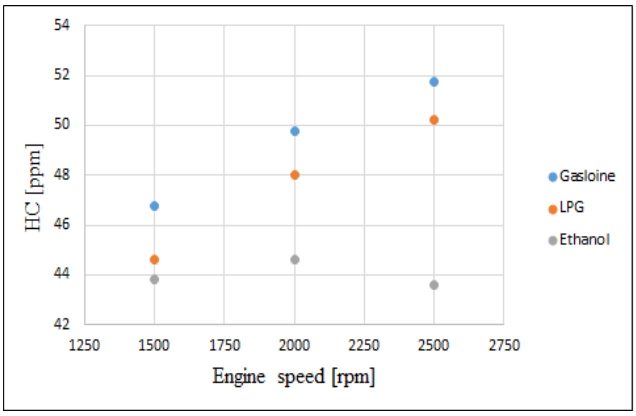

Figure-5. Variation of HC for gasoline, LPG and ethanol with various engine speeds.

3.6 Oxide nitrogen (NOX)

Nitrogen dioxide, nitrous oxide and nitrogen monoxide normally consist of the oxide nitrogen from internal combustion engines and either work on compression or spark ignition engines. Oxide nitrogen formation is affected by the high temperature of gases and oxygen inside the cylinder. Figure-6 presents the effects of different fuels and engine speeds on oxide nitrogen emissions. Compared to the gasoline fuel, oxide nitrogen emissions reduced when using ethanol and LPG. The NOx emissions increased when the engine speed increased due to the fact that a greater amount of fuel must be supplied, which results in an increase in the cylinder temperature. The figure clearly shows that ethanol and LPG produced a lower value of NOx than the baseline gasoline. However, they decreased in NOx when the engine speed increased.

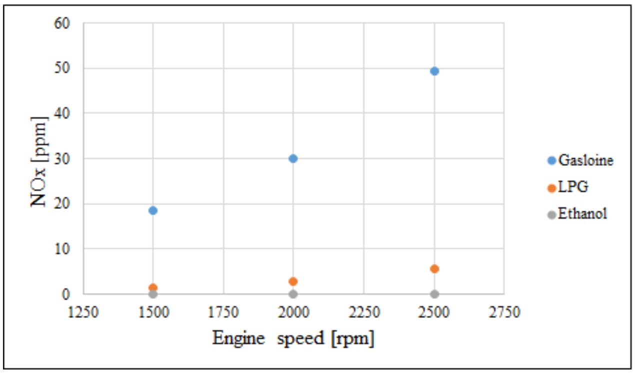

Figure-6. Variation of NOx for gasoline, LPG and ethanol with various engine speeds.

4. CONCLUSIONS

A numerical study was conducted on a one cylinder, four stroke, spark ignition indirect injection engine in order to predict the performance, combustion and emissions when using gasoline, ethanol and LPG fuels at a variety of engine speeds. The conclusions are summarized as follows:

- The finding of the present study suggests that LPG could be a promise alternative fuel for SI engines used in Iraq in order to reduce air pollution.
- The effective power of ethanol was slightly lower, while the LPG was almost higher than that of gasoline.
- Effective torque is lowest for ethanol at all engine speeds, but it is higher for LPG fuel.
- Brake specific fuel consumption increases for ethanol at all engine speeds when compared to LPG and gasoline.
- There was lower carbon monoxide for ethanol and higher CO for LPG at all engine speeds compared to gasoline.
- There was lower unburned hydrocarbon for ethanol at all engine speeds compared to baseline gasoline and LPG.

- There was lower oxide nitrogen emission produced when ethanol and LPG were used compared to gasoline.

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