Study the consumption and cost of using LPG in diesel engines

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Abstract

Diesel fuel used in diesel engines is more expensive than other fuels used in internal combustion engines and causes emissions that affect the environment and health. The researchers have established the possibility of providing fuel that operates in diesel engines and that is less expensive and pollution than diesel fuel. Iraq is one of the oil and natural gas producing countries, the choice of LPG makes the choice available because of the positives it possesses, which are low price, high thermal value and the possibility of mixing with air easily and low emissions, it is considered environmentally friendly and also maintains the engine as it does not contain high sulfur compared to diesel fuel.

The Electronic Control Unit (ECU) designed a new and used to adjust the injection of LPG timing and duration while opening the air intake valve into the combustion chamber and a magnetic sensor is installed on top of a single-cylinder diesel engine with air cooled. The test engine was operated with as D-100 and LPG-50. The diesel quantity was changed by is flow rates of injectors 100% and 50% and replaced by LPG. The test was for each condition load 0%, 25%, 50%, 75% and 100% at different speeds 1000, 1500 and 2000 RPM. The best case for BSFC is when the engine is running in dual fuel mode and at 1000 RPM, where the fuel improves by 9.81%. decreased that per hour running cost per liter of dual fuel compared to pure diesel fuel at speeds 1000, 1500 and 2000 RPM by 14.45%, 15% and 15.31% respectively.

Keywords: Diesel Fuel, Dual Fuel, Diesel Engine, LPG Fuel

1. Introduction

In recent years the consumption of petroleum products has increased tremendously due to increased engine use, rapid industrial and technological growth in all countries of the world. The diesel fuel is the commonly used fuel at automobile [2]. The diesel fuel is derived from crude oil, due to the limited reserves of crude oil, the cost of diesel is rising. Petroleum products are the primary energy source used in the shipping, commercial, domestic, manufacturing and other industries. Because of the material aspect that constitutes the most important foundations for the exchange of diesel fuel due to the high price of diesel compared to other oil derivatives, it led to the topic of searching for providing suitable alternatives to the combustion process in diesel engines at a
lower price than diesel fuel and one of the best alternatives available in the country of Iraq is LPG for several reasons including the appropriate price, less pollution and more abundance for its local production in Iraq, as well as its high calorific value, which makes it an alternative or complementary fuel compared to diesel fuel. LPG is a feasible substitute gaseous fuel also known as "Auto gas" and is a petroleum refining product mainly consisting of propane, propylene, butane and other light hydrocarbons [3][4]. LPG is considered to be one of the most promising alternative fuels. Compared to other gaseous fuels, LPG has a high calorific value, and also has a high octane but low cetane level. The high octane content of LPG makes it ideal for ignition engines[5]. Therefore it can only be used in dual fuel mode in the CI engine and has been extensively tested in this mode. This leads to improved results, low emissions of particulate matter and smoke [6]. The engine that uses traditional diesel and LPG fuel is called (LPG–dual fuel engine). In this engine, LPG fuel is combined with air in the engine cylinders either by direct injection into the cylinder or by direct mixing of air in the intake manifold [6][7]. The dual fuel operation has advantages compared to diesel equivalents and Spark ignition (SI) engines, potentially the thermal output is higher due to faster burning and lower emissions, high power density, strong sources of ignition providing more reliability [20].

In this study, dual fuel engine is used where diesel is used as an elementary fuel and LPG is used as a subsidiary fuel. The diesel-LPG engine is addressed which can either use single diesel fuel or use diesel-LPG fuel. LPG is operated by a new electronic system designed to suit the diesel engine with LPG after making an engine change and installing a magnetic sensor on the engine's head. The engine was initially run on the base diesel mode and then it was run on proportions of LPG-50 and at loads (0%, 25%, 50%, 75% and 100%) at speeds ranging from (1000, 1500 and 2000 RPM). LPG is injected into the intake manifold. At the beginning of the combustion chamber, by means of an air valve for the purpose of entering the LPG with the air into the combustion chamber and at 15 ◦C and pressure 1 bar.

2. Experimental Details

The experimental work was conducted in the laboratory of Technical College Najaf, AL-Furat Al-Awsat Technical University, Iraq. A brief description of the major components used is given below:

2.1 T85D-A test bed for internal combustion engine

Didacta's T85D Internal Combustion Engine Test Bed has been developed specifically for use in testing laboratories and to ensure optimum teaching productivity in the engines motoring. The device shown in Fig. (1) and Fig (2) manufactured by LOMBARDINI LGA 226 Company is used in the present work. A control panel equipped with a laboratory device (T85D) Italian Made controls these systems. The device is content for various operating parameters such as engine speed, operation and turns it off, load control and exhaust temperature measurement. Engine modification An experimental apparatus has been planned and developed to conduct the analysis. It consists of a CI engine test panel, LPG system. The CI Engine measures in two separate modes of operation are the diesel and LPG. The CI engine is tested in the first mode with no change. The LPG fuel is used in the second mode, but the diesel is replaced by LPG 50% at a reduced rate of 50% from pure diesel. The engine head is adjusted by a magnetic sensor, which signals the electronic control unit of the LPG system, which regulates the volume and the time of the intake manifold and mixes it with the air entering the engine's combustion
chamber. The operating pressure of the LPG used in this experiment is 1 bar and at 15 °C.

2.2 Experimentation Fuels

The fuels used in engine performance were LPG as an alternative fuel and diesel as a primary fuel. Iraqi liquefied petroleum gas is a three gas mixture of 0.05 C2H6 (Ethane), 0.5 C3H8 (Propane) and 0.45 C4H10 (Butane). Table 1 gives some essential fuel properties of these selected fuels.
Table 1: Shows characteristics of commonly used fuels.

| S. No. | Properties                  | Diesel          | LPG             |
|--------|-----------------------------|-----------------|-----------------|
| 1      | Normal state                | Liquid          | Gaseous         |
| 2      | Formula                     | C9.12H16.85     | C3.34H8.68      |
| 3      | Density (kg/m3) @ 15 °C     | 870             | 550             |
| 4      | Boiling Point, °C           | 160-320         | -34             |
| 5      | Flashpoint, °C              | >52             | -140            |
| 6      | Auto Ignition Temperature, °C | 242-257        | 525             |
| 7      | Calorific Value, KJ/kg      | 43500           | 49000           |

2.3 Test engine

Diesel engine with single cylinder direct 4-stroke, air-cooled injection was used for the experiment. Brief specification as follows in Table 2.

Table 2: Specification of the test engine

| Brand | LOMBARDINI, ITALY |
|-------|--------------------|
| Type  | 15LD315            |
| Injector type | Direct injection |
| Engine type     | Single cylinder direct injection 4-stroke |
| Cooling type    | Air-cooled         |
| Cylinders       | N                  |
| Displacement    | cm³                |
| Bore            | mm                 |
| Stroke          | mm                 |
| Compression ratio | 20:3:1             |
| Max. Power      | 5.0 kW/6.8 HP      |
| Dry weigh       | Kg                 |
| Max. Torque     | NM                 |
| Rated speed     | RPM                |
| Dimension (LxWxH) | mm                |
| Method of starting | Hand cranking     |

2.4 Diesel injection system

The amount of diesel fuel entering the combustion chamber is controlled by special nozzles that have been worked on according to the percentages (100% and 50%) as shown in Fig. (3) and in each experiment.
a specific type of these nozzles has been used with all variables and mathematical calculations. Where in the experiment the engine in two modes, the first mode using a diesel fuel nozzle (1) D-100%, and the second mode using a diesel fuel nozzle (2) D-50%. In the second mode, LPG is used at a rate of 50% (LPG-50).

### 2.5 Control unit for LPG

This electronic system controls the time and amount of LPG enters the engine via the injector and takes the signal through a magnetic sensor installed on the motor head and connected to a 12-volt DC source. This electronic system consists of several parts as shown in Fig. (4) and by the magnetic sensor shown in Fig. (5), LPG injector is instructed for the direct purpose in the injection when opening the inlet valve to be mixed with air and entering the combustion chamber in the engine.
3. Results and Discussion

The running of the engine is more economical in dual fuel mode, which is seen to be quieter and smoother due to better mixing of LPG and air. The running of the engine is more economical in dual fuel mode, which is seen to be quieter and smoother due to better mixing of LPG and air. The diesel substitution could be done even up to 50%. The tests were carried out in (1000, 1500 and 2000) RPM and at loads (0%, 25%, 50%, 75%, and 100%). The following parameters were studied:

3.1 Brake Specific Fuel Consumption (BSFC):

Figure (6) brake specific fuel consumption (BSFC) variability with loads (0%, 25%, 50%, 75% and 100%) under different engine speeds (1000, 1500 and 2000) RPM. In all test loads, engine operation is more economical in the dual diesel mode.

At 1000 RPM on (0 %, 25%, 50%, 75%, 100%) loads, BSFC average rate is 0.34124 kg/kWh on the pure diesel mode and it is 0.30776 kg/kWh on the dual fuel mode. Improved BSFC by 9.81% at LPG-50 a comparison of pure diesel, as shown in Fig. (6, A). At 1500 RPM, BSFC average rate is 0.32778 kg/kWh on the pure diesel mode and it is 0.29698 kg/kWh on the dual fuel mode. Improved BSFC by 9.4% at LPG-50 a comparison of pure diesel, as shown in Fig. (6, B). At 2000 RPM, BSFC average rate is 0.31555 kg/kWh and 0.285 kg/kWh respectively on the pure diesel mode and dual fuel mode with LPG-50. Improved BSFC by 9.68% at LPG-50 a comparison of pure diesel, as shown in Fig. (6, C).

From the above and through Fig. (6, A) that the best case for (BSFC) is when the engine is running in dual fuel mode and at 1000 rpm, where the fuel exchange improves by 9.81%. Similar results were reported in other studies [8][9][10].
3.2 Economic Analysis

LPG prices are much less extensive than that undertaken for petrol and diesel. The price of LPG in Iraq is 0.1667 (USD per Liter) and the price of pure diesel fuel 0.375 (USD per Liter) which explains the cost savings through the operation. Which reveals that LPG less priced around 55.55% than diesel fuel.

Figure (7) shows the cost of LPG-50 compared to pure diesel fuel. The units used in this graph are the USD per liter and within one hour of operation. As explained in Figure (7, A) shows at engine speed 1000 RPM the average cost for LPG-50 rate, decreased that per hour running cost per liter of dual fuel compared to pure diesel fuel by 14.45%. Figure (7, B) shows at engine speed 1500 RPM the average cost for LPG-50 rate, decreased that per hour running cost per liter of dual fuel compared to pure diesel fuel by 15%. Figure (7, C) shows at engine speed 2000 RPM the average cost for LPG-50 rate, decreased that per hour running cost per liter of dual fuel compared to pure diesel fuel by 15.31%.
4. Conclusion

Dual fuel operation is more efficient and cost effective in recovering useful conventional liquid fuels. The diesel baseline engine could run in dual fuel mode, with minor modifications. The following findings were drawn from the work set out above.

- The diesel engine can be powered on dual fuel (Diesel + LPG) effectively, and the dual fuel engine is suitable for all applications that the diesel engine can do.
- The engine operation is smooth and less consumption of dual fuel.
- Engine running on dual fuel mode is more economical.
- That’s the best case for BSFC is when the engine is running in dual fuel mode and at 1000 RPM, where the fuel exchange improves by by 9.81.
- Economic analysis showed that dual fuel (LPG+Diesel) saves cost savings compared to pure diesel fuel (D-100) and this is an economically important aspect.

**Nomenclature**

| Symbol | Description          |
|--------|----------------------|
| CNG    | Compressed natural gas|
| LPG    | Liquefied petroleum gas|
|       |                        |
|-------|------------------------|
| D-100 | Diesel 100%            |
| LPG-50| LPG 50% + Diesel 50%   |
| ECU   | Electronic control unit|
| GDI   | Gasoline direct injection|
| BSFC  | Brake specific fuel consumption |
| CI    | Compression ignition engine |
| SI    | Spark ignition engine |

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