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Research Article

DESIGN AND FABRICATION OF A TWO STROKE ENGINE USING LPG FUEL WITH VACUUM SUCTION MODE OF LUBRICATION

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ABSTRACT

An attempt has been made in this project to use alternative fuel in two stroke engine to increase the efficiency. The fore most aim in selecting this work is to use non-conventional fuel against conventional fuel which is becoming scarce and costly now days. With this air is less polluted than conventional fuels. It is also good with regard to economical considerations and engine efficiency. In the present work, an LPG fuel system has been installed in two stroke vehicle wherein both gasoline and LPG could be used. The alternations made to install LPG in the vehicle have been discussed. The commonly used carburetted two-stroke engines in developing countries have high exhaust emission and poor fuel efficiency. To meet more rigid emissions requirements, two-stroke vehicles are typically phase out in favour of four-stroke engines. The problems of ubiquitous legacy two-stroke vehicles remain unsolved by these measures and they are likely to be a major source of transport for many years to come. A number of technologies are available for solving the problems associated with two-stroke engines such as catalytic after-treatment and direct fuel injection (DI). However, these solutions are relatively high cost and have shown only slow market acceptance for applications in developing countries. Research in recent years has demonstrated that direct fuel injection is a well developed and readily deployable solution to existing two-stroke engines. Gaseous fuels such as Liquefied Petroleum Gas (LPG) are considered a promising energy source and in many countries provide fuel cost savings. LPG coupled with DI two-stroke technologies, is expected to be clean and cost effective retrofit solution for two-stroke engines. In this research project, direct injection (DI) of Liquefied Petroleum Gas (LPG) is introduced and tested on a typical two-stroke engine. Results of in cylinder combustion pressure translated to fuel mass fraction burned, engine performance and exhaust emissions are taken and compared for various injection timings from premixed (early injection) to fully direct injection mode (late injection). Results show that DI of LPG effectively reduces exhaust hydrocarbon and can substantially improve the fuel economy of two-stroke engines.

INTRODUCTION

In recent years the use of alternative fuels for internal combustion engines has had a strong push coming from both technical and economic-environmental aspects. Among these, gaseous fuels such as liquefied petroleum gas and natural gas have occupied a segment no longer negligible in the automotive industry, thanks to their adaptability, anti-knock capacity, lower toxicity of pollutants, reduced CO2 emissions and cost effectiveness[1].

A work has been done to present a preliminary study to estimate, using on-road and laboratory tests, the mileage range of liquefied petroleum gas (LPG) as an alternative fuel for diesel-fed public utility jeepneys in the Philippines. Measured on-road diesel jeepney mileage was about 6.7 km/liter at 63.5% load factor while that for LPG jeepney was 3.8-4.2 km/liter at 59.8% load factor. Drive cycle tests yielded 5.2 km/liter for diesel and 2.6-3.1 km/liter for LPG [2]. LPG kit was reconfigured for DME and LPG blend to bring down the emissions within the specified emission limits. The Emission values observed for DME20 were 0.635 g/km (CO), 0.044 g/km (THC), and 0.014 g/km (NOx) against the Euro IV limits of 1.0 g/km, 0.1 g/km and 0.08 g/km, respectively [3]. Liquefied petroleum gas (LPG) is commonly known as auto gas when used as a fuel for internal combustion engines. In North America, auto gas primarily consists of propane, but can contain small amounts of butane, methane and propylene. Engine dynamometer testing demonstrated that auto gas

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produced similar performance characteristics to gasoline at part load, but could be used to improve brake thermal efficiency at loads above 9 bar Brake Mean Effective Pressure (BMEP)[4]. The power hybridization characteristics of LPG-HEV city buses in real world and the relation between degree of hybridization (DOH) and vehicle operating conditions are studied.

A study has been done to show that the LPG-HEV city buses are mainly operated at the DOH range from 15% to 40%, it means that the hybridization is moderate [5]. Alternative fuels and power trains are expected to play an important role in reducing emissions of greenhouse gases (GHGs) and other pollutants. In this study, five light-duty vans, operating on alternative fuels and propulsion systems, were tested on a chassis dynamometer for emissions and efficiency. The vehicles were powered with Tier 2 gasoline, low blend ethanol (E10), compressed natural gas (CNG), liquefied petroleum gas (LPG), and an electric battery. Four test cycles were used representing city driving and cold-start (FTP-75), aggressive high speed driving (US06), free flow highway driving (HWFCT), and a combination of urban, rural, and motorway driving (WHVC). Tests were performed at a temperature of 22°C, with select tests at -7°C and -18°C. Exhaust emissions were measured and characterized including CO, NOX, THC, PM and CO2. On the FTP-75, WHVC, and US06 cycles additional exhaust emission characterization included N2O, and CH4[6].

Liquefied Petroleum Gas direct injection (LPG DI) is believed to be the key enabler for the adaption of modern downsized gasoline engines to the usage of LPG, since LPG DI avoids the significant low end torque drop, which goes along with the application of conventional LPG port fuel injection systems to downsized gasoline DI engines, and provides higher combustion efficiencies[7].

In a work, the performances of a propane-diesel mixture in a research diesel engine have been investigated. The injection strategies of Euro 5 calibration have been used as reference for the development of optimized strategies. The aim of the optimization process was to ensure the same engine power output and reduce the pollutant emissions[8]. A work has been done to communicate some preliminary results of the research in progress related to the introduction of LPG as a supplementing fuel for the Colombian power grid supply. Most of the power units operating in Colombian oil wells are running on Diesel fuel and natural gas[9]. The focus of internal combustion (IC) engine research is the improvement of fuel economy and the reduction of the tailpipe emissions of CO2 and other regulated pollutants. Promising solutions to this challenge include the use of both direct-injection (DI) and alternative fuels such as liquefied petroleum gas (LPG)[10]. Engine manufacturers have explored many routes to reduce the emissions of harmful pollutants and conserving energy resources, including development of after treatment systems to reduce the concentration of pollutants in the engine exhaust, using alternative fuels, and using alternative fuels with after treatment systems. Liquefied petroleum gas (LPG) is one alternative fuel in use and the paper has discussed emission measurements for several LPG vehicles[11].

In the automobile field now the fuel used is known as petrol and fuel oil (Diesel). Petrol is a volatile fuel which is used in spark ignition engines and fuel oil which is used in compression ignition engine. Basically both the fuels petrol and diesel is obtained from the crude oil (i.e. petroleum). Now the problem is, its availability is decreasing day by day in bulk and insufficient for future decades. Hence an alternative fuel is essential to fight against scarcity. In term of long sight some alternative fuels are suggested and experimented by various manufacturing units with technicians, such alternative fuels are Methyl alcohol, Compressed Natural gas (CNG) and Liquefied Petroleum gas (LPG). In the present work LPG has been employed as the alternative fuel in two stroke Gasoline engine. In this research project, direct injection (DI) of Liquefied Petroleum Gas (LPG) is introduced and tested on a typical two-stroke engine. Results of in cylinder COMBUSTION ANCE and exhaust emissions are taken and compared for various injection timings from premixed (early injection) to fully direct injection mode (late injection). Results show that DI of LPG effectively reduces exhaust hydrocarbon and can substantially improve the fuel economy of two-stroke engines.

Fuels and Equipments

This section comprises the fuel selection and other mountings required for the modification of engine. This section also throws light upon the basis on which the usability of different equipments is justified.

The Properties & Composition of LPG

LPG-Liquefied Petroleum Gas-describes flammable hydrocarbon gases including propane, butane and mixtures of these gases. LPG, liquefied through pressurisation, comes from natural gas processing and oil refining. LPG has many properties including density (specific gravity), flame temperature, boiling point, flash point, vapour pressure, odour, appearance, energy content, gaseous expansion, combustion formula, limits of flammability, nomenclature and molecular formula.

Main Characteristic of LPG

One of the main characteristics of butane and propane, and the one which determines its use, is their vapour pressure i.e. the pressure of the vapour in equilibrium with the liquid in a closed environment. Another important characteristics that differentiate two gases, butane and propane, is their boiling point i.e. the temperature at which they pass from a liquid state to a gaseous state are;

Propane will liquefy at -43°C.
Butane will liquefy at 0°C.

In cold climates, the mixtures of the both gases at relatively high proportions of propane will facilitate its gasification properties. In and around the world, however, the climate can differ appreciably from country to country therefore, LPG for use in internal combustion engines must be mixed in order to give good combustion results in all possible conditions.

LPG Boiling Point

Water boils at 100°C or 212°F, becoming a gas (steam).
In contrast, LPG boils at -42°C or -44°F, becoming gas vapour. LPG stays liquid because it is under pressure in a gas cylinder.As a liquid, it looks a lot like water. It is colourless and odourless in its natural state.

LPG Melting Point - Freezing Point

Water freezes at 0°C or 32°F, becoming ice.LPG freezes at a much lower temperature. LPG (propane) melting point/freezing point is at -188°C or -306.4°F

LPG Density and Specific Gravity

LPG – propane – gas density is 1.55 times heavier than air at 1.898 kg/m^3 v-s 1.225 kg/m^3 for air (both 15°C at sea level).LPG – propane – liquid density is about half that of water at 495 kg/m^3 (25°C) v-s 1,000 kg/m^3(4°C) for water.Specific gravity of propane and water is 0.495 (25°C) and 1.000 (4°C), respectively.

Energy Content of LPG

LPG (propane) contains approximately 25MJ per litre.This also converts to 6.9kWh.

Combustion Formula Equation for LPG – Propane

In the presence of sufficient oxygen, LPG burns to form water vapour and carbon dioxide, as well as heat.
Formula Equation for Complete Combustion of LPG - Propane:
Propane + Oxygen → Carbon Dioxide + Water + Heat
$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$ + Heat

If not enough oxygen is present for complete combustion, incomplete combustion occurs with water, carbon monoxide, and carbon dioxide is being produced.

Formula Equation for Incomplete Combustion of LPG - Propane:
Propane + Oxygen → Carbon Dioxide + Carbon Monoxide + Water + Heat
$2\ C_3H_8 + 9\ O_2 \rightarrow 4\ CO_2 + 2\ CO + 8\ H_2O$ + heat

Limits of Flammability

The lower and upper limits of flammability are the percentages of LPG that must be present in an LPG/air mixture.
This means that between 2.15% and 9.6% of the total LPG/air mixture must be LPG in order for it to be combustible.

LPG Flash Point Temperature

The flash point of LPG (propane) is -104°C or -156°F. This is the minimum temperature at which propane will burn on its own after having been ignited. Below this temperature, it will stop burning on its own. However, if a source of continuous ignition is present, it will burn below -104°C.

Auto-ignition Temperature

The auto-ignition temperature is the lowest temperature at which it will spontaneously ignite in air without an external source of ignition, like a spark or flame. The auto-ignition temperature decreases as the pressure or oxygen concentration increases. The auto-ignition temperature of LPG – Propane – is 470 °C or 878°F.The auto-ignition temperature of Butane is 405°C or 761°F.

Composition of LOVATO Gas Kit

1. Reducer
2. Mixer
3. Gas adjuster
4. Multivalve
5. Gas Tight Box
6. Filler Valve

In general, liquid LPG flows into the vehicle thru the filler valve, into the tank, thru the Multivalve. The Multivalve is protected by a Gas Tight Housing In case of leakage. The LPG is stored with the use of a Reservoir (tank). LPG is feeding to the engine from the Reservoir thru the Multivalve. With the use of a cooper pipes LPG is transferred to the LPG solenoid valve, where the LPG is filtered. The LPG solenoid valve has also the function of stopping the flow of LPG when the engine stops or during engine operation with petrol.

From here the liquid LPG is conveyed to the Vaporiser/Reducer. In the Vaporiser the LPG is vaporised and reduced in pressure. At this point, the LPG, now in its gas state, is convoyed to the engine thru the step motor (not required with carburettor engines) thru the mixer. The mixer is used to input and mix LPG into the engine intake. The mix LPG-Air, once in the engine, will flow into the combustion chamber for final combustion.

All the above, simplified process, is controlled by the use of specially designed electronics.

Some Important Parts of Kit

Filler Valve

The filler valve is a very simple item and is shaped to couple with the LPG gun and it houses a non return valve (check valve).The filler valve has the function of maintaining a gas tight condition during refilling procedure. In addition it houses a non returned valve (check valve). The non return valve has the function of retaining the liquid LPG in order to avoid any leakage in case of the Multivalve malfunction.

The Multi-Valve

The Multivalve is the component of the L.P.G. system which is installed on the Reservoir’s flange. Multivalve is available in many sizes. Normally it is available in accordance to the dimensions of the Reservoirs available in the market. The Multivalve has its name from the fact that its body houses a number of valves with different functions. The main valves are:-

1. Service manual valve.
2. 80% limit filler valve.
3. No Return Valve (Check Valve)
4. Excess Flow Valve
5. Cut-off valve (available in the new generation multi-valves)
6. Thermal Fuse Valve (available in the new generation Multivalve).
7. Safety Valve (Pressure Valve)

The Multivalve is also equipped with a rod system that actuates a magnet, which depending in its position will indicate the level of fuel contained in the reservoir.
Main functions of above mentioned valves:
The Service valve is normally used only during maintenance requirements and in case of accidents. In the case of accidents the Service valve must be closed in order to prevent hazardous conditions.

The 80% limit filler valve has the function to limit the filling of the reservoir to 80% of the reservoir maximum filling capacity.

The No Return Valve is positioned in the inlet of the Multivalve and it is connected thru a pipe to the filler valve. Its function is to limit the flow into the Reservoir avoiding the LPG flow to return towards the Filler Valve.

The Excess Flow Valve has the function to interrupt the flow of LPG out of the reservoir in the event of accidental breaking of the Copper pipe that feeds the engine.

The cut off valves, this valve is nothing more than an LPG solenoid valve incorporated into the Multivalve and it has the function to stop the flow of LPG when turning the engine's power off. This valve is also useful when performing maintenance to the LPG system.

The Thermal Fuse valve, is a valve used only in the case of fire and it has the function to discharge the reservoir of its LPG content in the case of extreme high temperatures. The discharge of the reservoir, in case of fire, will avoid the explosion of the Reservoir.

The Safety Valve, the function of the safety valve is to release the excess pressure in the reservoir. This valve will come into action only at high temperatures (in case of fire) or in case of over pressure created in extreme conditions. Such as filling the tank to 100% its fuel capacity and with an high external ambient temperature.

Gas Tight Box

The Gas Tight Box is installed on the Multivalve. Its main function is to convey any LPG leaks outside of the vehicle and to keep the Multivalve ventilated at all times. The secondary function of the Gas Tight Box is to protect the Multivalve from dirt and accidental hits. The gas tight box is connected to the external of the vehicle thru ventilation hoses. The ventilation hoses the copper tube that connects the Multivalve to the filling valve on one side and the copper pipe that connects the LPG solenoid valve on the other.

LPG Reservoirs

LPG reservoirs for motor vehicles are manufactured in many forms and shapes. The most commonly used shapes are the cylindrical and the toroidal.

The reservoir are most commonly manufactured with special steel alloys.

Diffuser

The main function of the diffuser is to create a vacuum in a pipe so that the lubricant gets sucked through the pipe into carburettor.

Modifications and Working

The modification which have been done for the successful completion of the work are

1. A mixer plate is fixed below the carburettor so as to produce the vacuum for functioning of vaporizer and sucks lubricant oil from oil container.
2. A hole has been made so as to give the supply of LPG with the help of rubber pipe.
3. Since we are using LPG as a fuel so additional supply of oil has been provided for smoothly running of engine.
4. Specially designed vaporizer for two stroke engine has been installed.

Working

A rough sketch has been prepared which is shown below. The components of the entire assembly have been clearly highlighted in the figure. The main components used are-

- Vaporizer
- LPG cylinder
- Diffuser plate
- oil controller
- small diameter plastic pipe
- gas regulator
- rubber pipe used for gas supply
- lubricant oil container
- carburettor

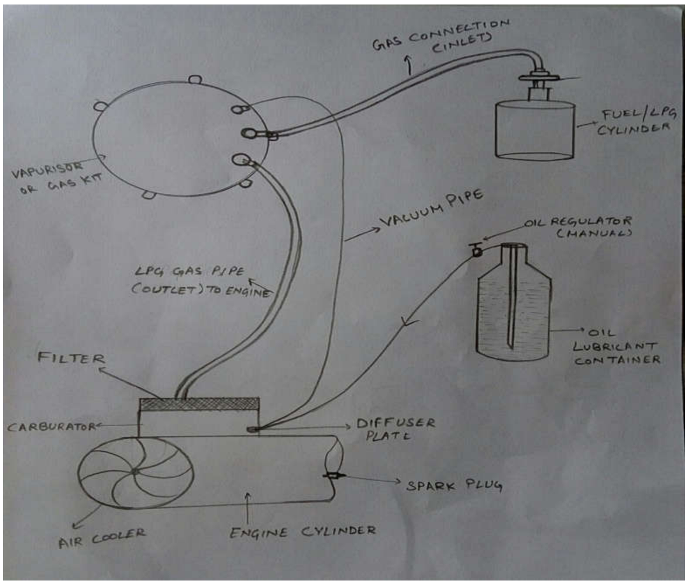

Fig 1 The structural diagram of constructional feature of the engine

There are three ports which are connected at the common base of Laveto gas kit also known as vaporiser. One of the pipe connects LPG cylinder to the vaporiser. Second pipe connects vaporiser to diffuser plate. Third pipe connects LPG pipe line to the engine carburettor. The diffuser plate is connected with the extra container provided for the storage of lubricant oil.

The diaphragm inside the vaporiser creates vacuum that sucks the gas from the engine cylinder which later gets transferred to the carburettor. Unlikely as in the normal engines in which lubricating oil is directly fed along with the fuel, the oil is not fed directly but sucked by diffuser plate creating vacuum through a pipe whose amount is regulated by a regulator to avoid excess suction of the same. The two fluids thus drawn gets mixed up homogeneously in carburettor and the mixture thus obtained is later transferred to the engine for combustion as usual. The combustion process takes place in the engine cylinder with the help of spark plug.

RESULTS AND CONCLUSION

Necessity of Using Alternative Fuel

In the automobile field now the fuel used is known as petrol and Diesel. Basically both the fuels petrol and diesel is obtained from the crude oil (i.e.) petroleum. Now the problem is its availability is decreasing day by day in bulk and insufficient for future decades. Hence an alternative fuel is essential to fight against scarcity. In term of long sight some alternative fuels are suggested and experimented by various manufacturing units with technicians, such alternative fuels are as follows: • Methyl alcohol • Compressed Natural gas (CNG) • Liquefied Petroleum gas (LPG) In this project we have installed LPG as alternative fuel in four stroke Gasoline engine.

Emission from LPG and Gasoline

On an energy basis LPG has lower carbon content than gasoline or diesel fuel. When used in spark-ignition engines, LPG produces near-zero particulate emissions, very little CO and moderate HC emissions. Variations in the concentration of different hydrocarbons in LPG can affect the species composition and reactivity of HC exhaust emissions. CO2 emissions typically are also somewhat lower than those for gasoline due to the lower carbon-energy ratio and the higher octane quality of LPG. NOX emissions are similar to those from gasoline vehicles, and can be effectively controlled using three-way catalysts. The higher CR of an engine, the more efficient is the engine and more is the power generated with given amount of the fuel. LPG has high octane rating of 110+ that allows CR to be high up to 15:1, which is in the range of 8:1 to 9.5:1 for gasoline engines. The performance of the vehicle is marked satisfactorily at a considerable level giving a good average of about 60-70km/kg of LPG. It has been proven that use of LPG as fuel results in significantly better efficiency than petrol and much lower emission levels. There are nearly 5 million vehicles running on LPG the world over. The technology primarily consists of manufacturing of kit containing vacuum operated gas air mixing system and pump-less lubrication system.

Fuel cost is 35% cheaper than petrol Bio-fuel mode of operation ie. both on petrol & LPG. There has been no internal modification of engine required. Operating costs and emission levels of carbon monoxide and carbon dioxide is quite less as compared to petrol engines.

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