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# A STUDY OF LIQUEFIED GAS SYSTEM EFFECTS ON INTERNAL COMBUSTION ENGINES

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MAY 2009

**DECLARATION**

"I admit that this report is my own composition except for the summary and extract which each of the source have been explain"

Name : ……..

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## ACKNOWLEDGEMENT

Author would like to express highest gratitude to Allah s.w.t for the blessing throughout execution of this Bachelor's Project. A sincere appreciation to supervisor, Dr. Mohd. Yusoff bin Sulaiman for the guidance and encouragement along accomplishing this project.

Credits also dedicates towards Faculty of Mechanical Engineering Laboratory Department especially to all technicians involved for being really helpful in order to accomplish experiments and tests conducted.

Lastly, acknowledgement dedicates to all party that contributes directly or indirectly for accomplishing this project. Hopefully, this research report will become a helpful reference to other students in the future.

**DEDICATION**

To my beloved Father and Mother

# ABSTRAK

Gas Petroliam Cecair (GPC) adalah gas petroleum cecair yang lazimnya digunakan untuk memasak di Malaysia. Selain itu, GPC juga digunakan sebagai bahan api alternatif untuk kenderaan di sesetengah negara, namun sistem ini belum lagi digunakan di Malaysia. Disebabkan perbezaan sifat kimia, enjin kenderaan mungkin menerima kesan berlainan akibat penggunaan GPC. Oleh itu, satu kajian dibuat untuk mengkaji kesan penggunaan GPC ke atas enjin pembakaran jenis petrol yang merangkumi bidang prestasi enjin, pelepasan, dan komponen enjin. Ujian prestasi enjin dijalankan menggunakan dinamometer ke atas kenderaan yang menggunakan sistem GPC dan ujian pelepasan dijalankan dengan menggunakan penganalisis gas dimana pengukuran dilakukan pada sebelum dan selepas penukar bermangkin. Pemeriksaan komponen dilakukan ke atas palam pencucuh dengan mengukur jarak antara elektrod dan memerhatikan pembentukan pemendapan pada seramik dan elektrod. Semua ujian dijalankan dengan mengambil data untuk petrol sebagai pembolehubah yang dikawal untuk tujuan perbandingan. Hasil ujian menunjukkan enjin yang menggunakan GPC mengalami kemerosotan pada kuasa dan daya kilas namun kemerosotan yang dialami adalah tidak terlalu besar. Bagi ujian pelepasan, GPC menghasilkan peratusan Karbon Monoksida yang jauh lebih rendah manakala peratusan Hidrokarbon yang dihasilkan adalah hampir sama dan lebih tinggi dari petrol bagi julat kelajuan enjin rendah manakala lebih rendah dari petrol pada julat kelajuan enjin tinggi. Pemeriksaan komponen pada palam pencucuh menunjukkan GPC menghasilkan pemendapan karbon yang lebih sedikit berbanding petrol manakala tiada perubahan dikesan pada jarak antara elektrod untuk kedua-dua jenis bahan api. Disebabkan pelbagai halangan dari segi kelengkapan dan kemudahan, ujian yang dijalankan tidak dapat merangkumi skop yang lebih luas untuk mendapatkan maklumat yang lebih banyak dan menyeluruh, oleh itu, kemudahan yang mencukupi diperlukan untuk mendapatkan keputusan kajian yang lebih ulung dan menyeluruh dari segi ketepatan dan keboleh harapan.

## ABSTRACT

Liquefied Petroleum Gas (LPG) is petroleum derived gas that mostly used for cooking in Malaysia. Other than that, LPG also used as alternative fuel for vehicles in certain country but not yet in Malaysia. Due to the difference in chemical nature, the engine might affected by its usage. Thus, a study on LPG effects on internal combustion petrol engine is carried out in order to find out the effects on engine system which generally covers area in performance, emission, and engine component. A performance measurement test was conducted by using dynamometer on cars with LPG system and the emission test was conducted using gas analyzer by measuring the exhaust gas before and after catalytic converter. Component check was conducted on spark plug by measuring the gap between electrode and by observing the discoloration on the ceramic and electrodes. All the tests were conducted by taking petrol measurement as the controlled variable for comparison purpose. The results shows that engine fuelled with LPG suffer power and torque loss but still comparable to existing performance. As for emission, LPG produced obviously lower Carbon Monoxide (CO) emission and a comparable hydrocarbon (HC) emission which are higher than petrol at low speed range and lower than petrol at higher speed range. The component check shows that LPG produces less carbon deposit to the spark plug as compare to petrol and there is no alteration on the distance between electrodes for both fuels after the test. Due to various limitations on equipments and facilities, the test could not be performed in wider range to get wider information, thus more comprehensive equipment and facilities should be prepared well in order to obtain excellent and wider results in more accurate and more reliable ways.

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# CHAPTER I

# INTRODUCTION & BACKGROUND

## 1.1 Introduction

Liquefied Petroleum Gas (LPG) as transportation fuel had been widely used in few countries, however, in Malaysia, this system still does not take places. LPG has been used as a transportation fuel especially in heavy trucks and forklift vehicles around the world for decades and currently there are 2,500,000 vehicles worldwide fuelled with LPG (Wilson, 2008).

Generally, LPG has higher research octane number (RON) compare to petrol, thus, LPG system might offer a comparable performance to petrol system. As for emission aspect, although vehicles are much cleaner than in the past, it still remains one of the most significant factors in air pollution. Referring to previous research, vehicles running with LPG produce relatively lower harmful emissions compare to petrol and diesel (Wilson, 2008). In addition, LPG has cleaner chemical composition compare to petrol such as the carbon percentage that might reduce the chemical deposit to engine component.

Thus, a research is carried out to study the effect of this LPG system on petrol engine as part of project to develop this system for Malaysian automobile user.

## 1.2 Objective of Study

To study the effects of liquefied gas on Internal Combustion (IC) petrol engines in power, torque, emission and component of engine.

## 1.3 Problem Statement

Liquefied gas has been used as an alternative fuel in petrol engines. Due to its different chemical nature to petrol, the engine might be affected by its usage.

## 1.4 Scopes

I. Use different engines fitted with liquefied gas system
II. Conduct power, torque, emission and component checks
III. Apply theories in the observations
IV. Compare data with other system and provide recommendation

## 1.5 Benefit of Study

The benefit of this study is to provide reliable information on the actual performance, emission, and component affects of automobile that using LPG system. The findings from this study could be used to determine the strengths and weakness of this system as well as proves and supports the previous findings. In addition, this information could be useful for evaluating and improving purpose for future researcher in order to develop an efficient LPG system in performance as well as environmental aspect.

# CHAPTER II

# LITERATURE REVIEW

This chapter will consist of previous study regarding LPG engine brought by previous researchers on their article and journal. This inlude details on various area of research such as LPG fuel data, LPG conversion method, tests involved, the effect on engine component, performance, and emission.

There is lots of existing study regarding LPG engine, and most of it leads to real application of LPG in automotive indusrty. This can tell from various type of existing company that run business on LPG conversion for petrol and diesel engine.

## 2.1 LPG Fuel

Liquefied Petroleum Gas (LPG) is a petroleum derived, colorless gas, typically comprises of mainly propane, butane, or a combination of these two constituents (Wallace, 2005). LPG fuel for vehicles is actually a mixture of various hydrocarbons which are gases at atmospheric pressure and temperature. LPG is manufactured during the refining of crude oil, or extracted from oil or gas streams as they emerge from the ground.

Varieties of LPG bought and sold include mixes that are primarily propane, mixes that are primarily butane, and the more common, mixes including both propane

(60%) and butane (40%) (Wallace, 2005). Propylene and butylenes are usually also present in small concentration. A powerful odorant, ethanethiol, is added so that leaks can be detected easily for safety reason. At normal temperatures and pressures, LPG will evaporate. Because of this, LPG is supplied in pressurized steel bottles. In order to allow for thermal expansion of the contained liquid, these bottles are not filled completely, usually, they are filled to between 80% and 85% of their capacity. The pressure at which LPG becomes liquid is called as vapor pressure.

Commercially three different grades of LPG are available; Table 2.1 shows the three different grades.

Table 2.1 Composition of LPG Types

(Source: Wallace, 2005)

| Component | HD-5 Propane | Commercial Propane | Commercial B/P Mixture |
|---|---|---|---|
| Propane | 90 % liquid volume (min) | Propane and / or propylene | Butanes and / or butylenes with |
| Propylene | 5 % liquid volume (max) | - | propane and / or propylene |
| Butane and heavier HC | 2.5 % liquid | 2.5 liquid | - |
| Moisture content | Dryness test of NGPA | Dryness test of NGPA | - |
| Residual Matter | 0.05 ml | 0.05 ml | - |
| Pentane and heavier HC | | | 2 % liquid volume (max) |
| Total sulfur | 123 PPMW | 185 PPMW | 140 PPMW |

*PPMW: Particles per million by weight fraction.

For LPG in terms of fuel application, the propane is needed in the LPG mixture due to the necessary of sufficient vapor pressure in order to deliver fuel to the engine, even at very low temperatures. Figure 2.0 and 2.01 shows the vapor pressure of propane and butane.

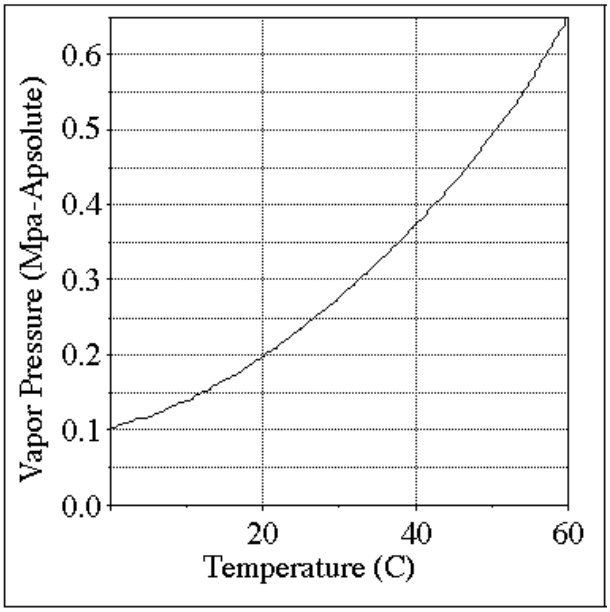


Fig 2.0 Vapor pressure of butane

(Source: Wallace, (2005))

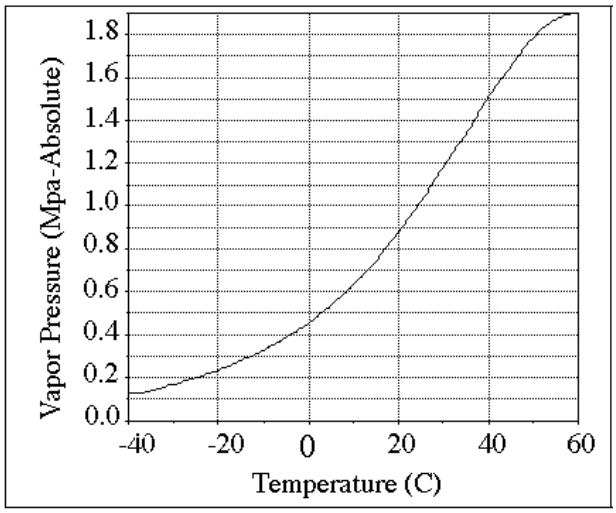


Fig 2.01 Vapor pressure of propane

(Source: Wallace, (2005))

Vapor pressure of butane is considerably less than that of propane at any given temperature and will not provide adequate pressure for proper equipment operation

below about 18-19 C, thus, problem will occur in delivering system when vehicle is under this temperature.

## 2.2 LPG Conversion

There is a lot of LPG conversion ways that already exist and currently being used in world wide. This study will review some of the technics and components used in order to run LPG on internal combustion petrol engine. Generally, the conversion will consists of modifying the engine system which involves addition of these components :

I. LPG storage tank
II. LPG Vaporiser/ Regulator
III. Solenoid Valve
IV. Fuel Changeover Switch
V. LPG Mixer
VI. Main LPG flow adjuster

### 2.2.1 LPG Storage Tank

LPG StorageTank is the tank that will store LPG in car. This tank apparently is isolated from existing petrol tank. The installation of this tank will connect it to the engine system through series of LPG conversion system. This tank usually will be placed at the boot space of car. Fig 2.2.1 below shows two types of common used LPG tank that is donut and cylindrical type.

Fig 2.2.1 LPG Tank; Cylindrical and Donut Shape
(Source: Prins Autogassystemen B.V (2008))

The torpedo shape placed at the boot compartment while the donut shape is design to placed at spare tyre space as to give more space in the boot. Fig 2.2.2 shows donut and torpedo shape at the boot compartment.

Fig 2.2.2 LPG Tank in boot (From left Donut and Cylindrical shape)
(Source: Prins Autogassystemen B.V (2008))

Besides that, there is also other design for LPG tank that is the duo-tank: flattened tank cylindrical to reduce height, twin-tank: 2 cylindrical tanks are welded together, and U.F.O.-tank: a round pill-shape tank which also can be installed in the spare wheel well of the boot (Osch, 2008).

The LPG tank incorporates various type of valve for safety reason, types of valve that included in the tank are:

I. Filling-hose connection with a 80% shut off
II. Overpressure relief valve which opens at ±30 bar
III. A shut off to close the tank by hand or electronically (solenoid)
IV. Fuel gauge which gives an indication of the amount of LPG in the tank
V. The valves covered by an air-tight box with an atmospheric vent to avoid LPG entering the car

Those safety devices can be gathered in one valve. This valve is called a multi-valve and can only be installed in a single-hole-tank (Osch, 2008). However, the most common technique is for multi-hole-tank where the valves are separately installed. The installation of the tank is much easier than a single hole-tank since there is more space between the components. Besides, filling up the tank can be done much faster because of the larger connection between the tank and the filler connection.

### 2.2.2 LPG Vaporiser / Regulator

LPG Vaporiser / Regulator, mostly known as vaporiser has twomajor functions. The first function is to heat up the liquid LPG so the vaporisers did not freeze when the LPG becomes a vapour. Most of the study doing this by making a connection to the water cooling circuit, where the hot water flow from engine section will pass over the vaporiser to heat up the liquid LPG in isolated chamber where both sections isolate by thin metal in the vaporiser to avoid contamination to the LPG. Fig 2.1.2 shows LPG vaporiser/regulator by one of LPG conversion company.

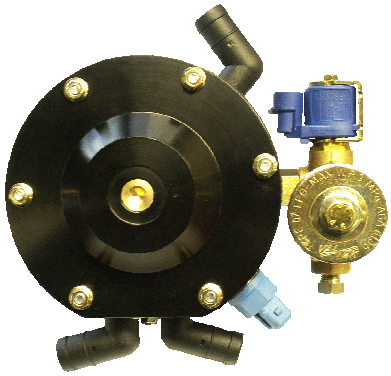

Fig 2.2.2 LPG Vaporiser/Regulator
(Source: Prins Autogassystemen B.V (2008))

The second function is to regulate the amount of LPG that goes to the engine. It has the same function as carburetor which to keep the mixture of LPG and air at the optimum proportion. Therefore, the vaporiser must deliver a stable LPG pressure to the engine. A problem is the changing of the pressure in the tank. The pressure depends on the outside temperature and the amount of LPG left in the tank (4bar up to 30bar). The previous study solved this problem by lowering the pressure in several stages. The vaporisers can be classified in the way they are built :

I. **Two stage vaporisers**. The two stage vaporisers are the most common used. They lower the pressure in two stages. The first stage lowers the tank pressure from ± 10 bar to ± 2 bar. The second lowers the operating pressure to ± 0,7 bar so the mixer can cope with it. The advantages are: they are small and can be cheap. Disadvantages are: they have a limited range (0,5L up to 1,5L or 1,0L up to 2,5L or 2,0L up to 4.0L engine size).

II. **Two stage tandem vaporisers**. The two-stage-tandem- vaporisers are functioning in almost the same way as the two stage vaporisers. The biggest difference is the second stage. The second stage is regulated in two. One accurate second stage regulates small amounts and a second big stage delivers high quantities of LPG. The small stage is operating when small quantities of LPG are required by the