ANALYSIS OF ENGINE POWER USING 3 TYPES OF PRE-COMBUSTION CHAMBER'S DESIGN

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Report

Projek Sarjana Muda II

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APPROVAL

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Automotive)."

Signature: .....

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Date: .....

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This report is submitted in partial
fulfillment of the requirements for the award of a
Bachelor in Mechanical Engineering (Automotive) with honours

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May 2017

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DECLARATION

"I hereby declare that the work in this thesis is my own except for the summaries and quotations which have been duly acknowledge."

Signature :……..

Author : AMARUL AFIQ ADLI BIN ROSLI

Date :..…….

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DEDICATION

I dedicated this report to my parents, family, to my supervisor Assoc. Prof. Dr. Musthafah bin Mohd Tahir, to my friends and all those who knew me. Not to forget to Universiti Teknikal Malaysia Melaka (UTeM) and all staff that had helped me a lot in completing this project.

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ABSTRACT

In this report, the characteristics of the engine performance consuming the gasoline fuel and Compressed Natural Gas (CNG) fuel is measures. Using CNG as fuel to the engine, the power of the engine drops compared to gasoline fuel. The engine was modified to a dual-fuel system which can be operated either by gasoline fuel or CNG fuel. Besides that, the head of the engine is also had been modified for suitability to attach the PCC on to the head. For this case study, there are three types of PCC used to test the engine power output of each PCC. The PCC will be run using CNG fuel and each PCC output are compared to choose the best PCC among the three types of PCC tested. The engine was tested at engine speed between 1500 rpm to 4000 rpm. Therefore, the power of the engine can be studied so the performance result of PCC are compared. However, the experiment of CNG without PCC was also been tested and the result is compared with the three types of PCC. Besides using PCC for the experiment, we are also using the high pressure sensor to determine the power output and other parameters needed for the experiment. The result from the experiment done shown that with the application of the PCC, the power increased to 3.4 kW at the top performance of the engine while without PCC the power value is only 3.1 kW. The research is important as applying the CNG reduces the pollution to the environment but reducing the engine performance. The effect of those PCC are expected to increase the performance of the engine while using the CNG as it fuel.

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ABSTRAK

Di dalam laporan ini, ciri-ciri prestasi enjin tersebut yang menggunakan minyak gasolin dan juga "Compressed Natural Gas (CNG)". Dengan penggunaan CNG pada enjin tersebut, "power" yang dikeluarkan oleh enjin tersebut menurun berbanding dengan penggunaan gasolin sebagai bahan bakarnya. Enjin tersebut telah diubahsuai supaya menjadi "dual-system" yang mana membenarkannya untuk menggunakan minyak gasolin dan CNG. Selain dari itu, "head" enjin juga telah diubahsuai bersesuaian dengan penggunaan PCC pada enjin. Dalam uji kaji ini terdapat tiga jenis PCC yang bakal digunakan untuk menguji "power" pada enjin yang di hasilkan untuk setiap satu PCC. PCC akan diuji menggunakan CNG dan setiap PCC akan dibandingkan bagi menentukan PCC yang terbaik antara ketiga-tiga PCC yang diuji. Enjin telah diuji pada kelajuan 1500 rpm hingga 4000 rpm. Oleh yang demikian, "power" pada enjin dapat dikaji dan keputusan prestasi bagi PCC dapat dibandingkan. Walau bagaimanapun, uji kaji bagi CNG tanpa menggunakan PCC juga telah dijalankan dan hasilnya dibandingkan dengan hasil dari tiga PCC yang telah diuji. Selain menggunakan PCC pada enjin, "high pressure sensor" juga digunakan bagi mengetahui "power" dan lain-lain parameter yang perlu untuk uji kaji ini. Keputusan yang dikeluarkan dari uji kaji ini telah menunjukkan bahawa dengan penggunaan PCC, nilai bagi "power" untuk enjin tersebut telah meningkat kepada 3.4 kW pada kemuncak prestasi enjin berbanding hanya 3.1 kW tanpa menggunakan PCC. Uji kaji ini sangat penting di mana CNG telah pun digunakan bagi mengurangkan pencemaran yang berlaku pada persekitaran tetapi, ia juga telah mengurangkan prestasi enjin. Kesan dari PCC yang diuji diharap dapat meningkatkan prestasi enjin tersebut walaupun dengan penggunaan CNG sebagai bahan bakarnya.

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LIST OF SYMBOLS AND UNITS

kJ/kg	kilo Joule per kilogram
MJ/kg	Mega Joule per kilogram
Pa	Pascal
m/s	meter per second
Q	Flow rate
^{o}C	Degree Celsius
S	Stroke length
N	engine speed per one revolution
rpm	revolution per minute
kg/mol	kilogram per mol
CO_2	Carbon Dioxide
NO_x	Nitrogen Oxide
CO	Carbon Oxide
HC	Hydrogen Carbon
%	Percent
vol	Volume
kg/m^3	kilogram per meter cube

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cc	centimeter cubic
mm	milimeter
N.m/rpm	Newton meter per revolution per minute
g/kW.h	gram per kilo watt hour
kW/rpm	kilo watt per revolution per minute
kpsi/bar	kilo per square inch per bar
pC/psi	pico coulomb per per square inch
mm^3	milimeter cube

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LIST OF ABBREVIATIONS

PSM	Projek Sarjana Muda
CFD	Computational Fluid Dynamic
PCC	Pre-Combustion Chamber
CNG	Compressed Natural Gas
LNG	Liquid Natural Gas
SI	Spark Ignition
ICE	Internal Combustion Engine
ECU	Electronic Control Unit
NG	Natural Gas
CI	Compression Ignition
BDC	Bottom Dead Centre
TDC	Top Dead Centre
2D	2-Dimension
3D	3-Dimension
MPV	Multi-Purpose Vehicle
etc.	Etcetera

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Most vehicle's engines around the world are Internal Combustion Engine (ICE). Normally Spark Ignition (SI) engine and Compression Ignition (CI) engine. For standard SI and CI engine, its normally use gasoline fuel and diesel fuel. In this modern world, people now are more concern on environmental health.

SI and CI engine that use gasoline and also diesel fuel create more pollution. The combustion of gasoline fuel will produce CO_2, HC, and NO_x (Engerer and Horn, 2010, Jääskeläinen and Wallace, 1993) that are hazardous to the environment.

One of the solution to overcome this problem, is the modification mostly on SI engine had been done by replacing the combustion fuel from gasoline fuel changed to Natural Gas (NG) fuel. NG are well known as Compressed Natural Gas (CNG) or Natural Gas Vehicle (NGV). By using this CNG, the emission of those dangerous gases by gasoline fuel can be reduce. Moreover, the price of the NG fuel in the market is way cheaper compared to both gasoline and diesel fuel.

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However, there are several disadvantages using the Natural Gas(NG). NG are known to have lower performance output compared to the normal gasoline fueled engine. Besides that, NG fuel lead towards a decreased of power for the engine at low speed.

1.2 PROBLEM STATEMENTS

The present SI engine in the market are using gasoline fuel as their combustion fuel. It give enough power as the output to any vehicle that use this kind of engine usually from Sedan model to Multi-Purpose Vehicle (MPV).The main problem of SI engine that use gasoline fuel is that it produce more pollution and it is not an environmental friendly fuel. Nowadays, engineers had done research to overcome this problem and had started to use NG as to replace the gasoline fuel in the SI engine. NG is a better emission fuel compared to gasoline in terms of pollution(Amorim et al., 2005). In fact, one of the advantages offered by this Natural Gas (NG) is emission in CO_2, HC and NOx (Engerer and Horn, 2010; Jahirul et al., 2010; Jääskeläinen and Wallace, 1993; Ma et al., 2009). But it is not as good as gasoline fuel when it come to the output power. Natural Gas (NG) produce low power output by 18% less than gasoline (Yamamoto et al., 1994). Moreover, based on previous research, the pressure inside the cylinder for gasoline fuel, in comparison to CNG is higher during ignition stage (Sera et al., 2003; Sasaki et al., 2002; Zheng et al., 2009; Zareei et al., 2012). From the research done, the application of Pre-Combustion Chamber(PCC) to improve the performance of the engine had only been

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done on the L-type of engine and there are some limitations using this type of engine. Besides that, the PCC used is limited to only one type of PCC.

Research on this problem had come to an invention of Gas Engine With Pre-Combustion Chamber (Matsuoka et al., 2000). The main purpose of the PCC in an SI engine is to shorten the combustion duration and thereby enhance performance. (Matsuoka et al., 2000). Different design or types of PCC will result to different outcomes. The study on the Pre-Combustion Chamber is still on going to invent the best PCC design with the best result.

1.3 OBJECTIVES

There are three objectives that are used as the guideline of the study. The objectives are :

- To investigate the effect using PCC in single cylinder overhead cam that use CNG as it fuel.
- To determine the output performance produce using different types of bolted PCC.
- To validate the best bolted PCC geometry when using CNG.

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1.4 SCOPE

In the case study, a single cylinder SI engine powered by CNG was used. An experiment is conduct by using a SI engine single cylinder with overhead cam. Different designs of Bolted PCC been used to experiment the best output result. The range for the experiments is in between 1500 rpm until 4000 rpm.

- Apply the Bolted Pre-Combustion Chamber(PCC) to a single cylinder Spark Ignition(SI) engine.
- Use Compressed Natural Gas (CNG) as fuel into the single cylinder SI engine.
- Record the output performance of the CNG fueled for SI engine.
- Analyze and study the performance result of the CNG fueled SI engine.
- Compare the effect of different design of PCC on the performance of the CNG fueled SI engine.

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CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

In this chapter, it will cover on the information gained from variety resources of information such as jurnal, engineering books, internets and etc. The main topic to be discuss in this chapter will be on the SI engine which will cover on the type of combustion. Besides that, we also will discuss on the working fuel used by the SI engine to be tested which is Compressed Natural Gas (CNG). Other than that we also will cover the Pre-Combustion Chamber (PCC) used in this project. The project will use the Bolted types of PCC with 3 different designs to be tested. The output of the experiments are expected to be different among those three designs. The optimum output will be taken as the best result for the project.

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2.2 NATURAL GAS

Most of the present SI engine vehicle uses gasoline as their working fuel. The amount of vehicle that uses SI engine type grows by year. The statistic is shown in Figure 2.1 (Ong, H.C. *et* al.2012). The demand of the gasoline fuel in the market is getting higher. As the demand increasing, there are some problems occurs. The gasoline use as the fuel to most of the vehicles in this world is not a renewable and yet is harming the environment. This kind of power source has reduced gradually . Many researcher try to find the solution for the problem and come with solution by changing the working fuel use. One of the alternative found is by using NG as the working fuel to the SI engine.

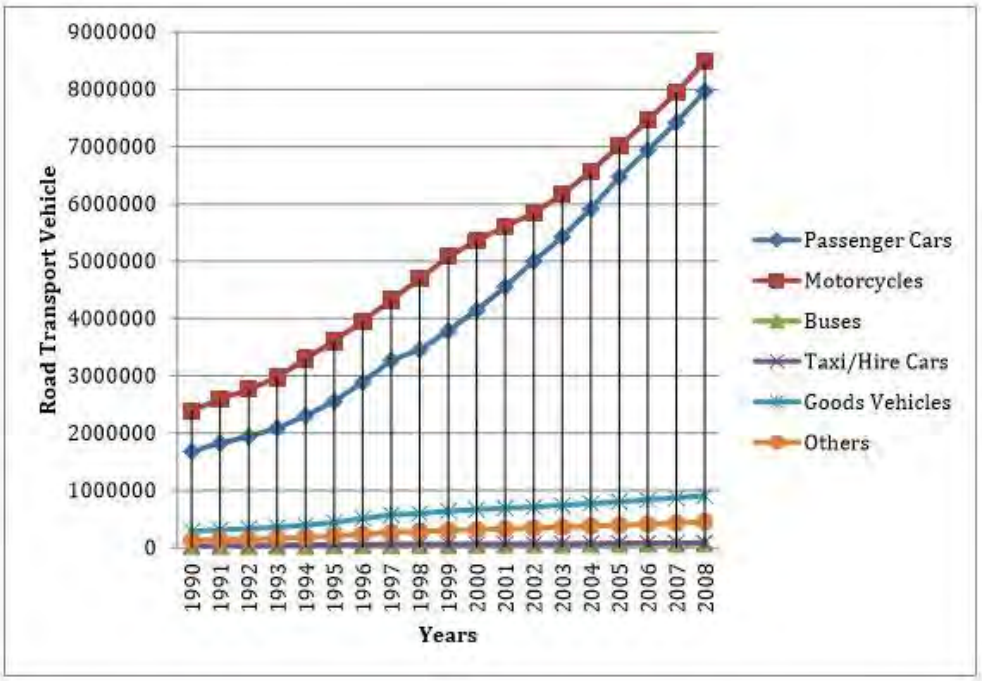

Figure 2.1 : Road transportation statistic (Ong. 2012)

Natural Gas is a natural fuel produced in a million years of time process from the fossil of animal and plants stored the underground reservoir. The component is mainly contain of methane but there are also some other mixture. NG is colorless and also odorless that make it more environmental and user friendly. Besides that, the emission produces is lower compared to liquid fuel and diesel (Cho and He, 2007). It

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also have a lower specific gravity than air which is between the range of 0.6 to 0.8 and that make it dissipated into air quickly.

Besides that, NG is a safety gas fuel as it only burns with more than 15% of volume. It's self-ignition temperature is at 537 – 540^{o}C. For overall, NG is a much better fuel compared to any other fuel in term of environmental friendly. And because of that, it has been used for over than 150 years in many kind of industry. Besides been used as a working fuel in the transportation field, it also had been used as a cooling system and used to produce glass, steel, papers, cloth and many more. Figure 2.2 shows the Natural Gas used in United States of America in2007.

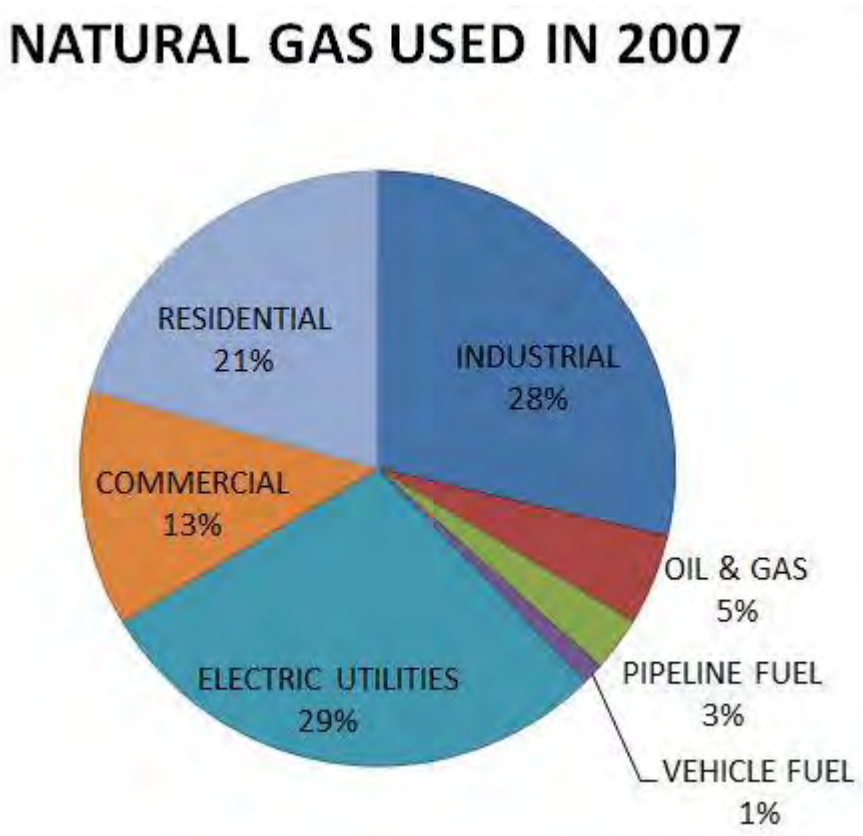

Figure 2.2 : Natural Gas used in United State of America(www.eia.gov>kids)

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2.3 SPARK IGNITION ENGINE

SI Engine stands for Spark Ignition engine. The word "spark ignition" tells the principle of the engine. This type of engine needed an additional force to ignite the working fuel used to start the combustion. The first engine was developed by Abu al-'IZ Ibn al-Razaz al Jazari (1136-1206) then during 1860, Lenoir (1822-1900) developed the first spark plug engine. In 1876, Otto proposed four cycles engine called four strokes engine. Figure 2.3 shows the simplification of the engine types.

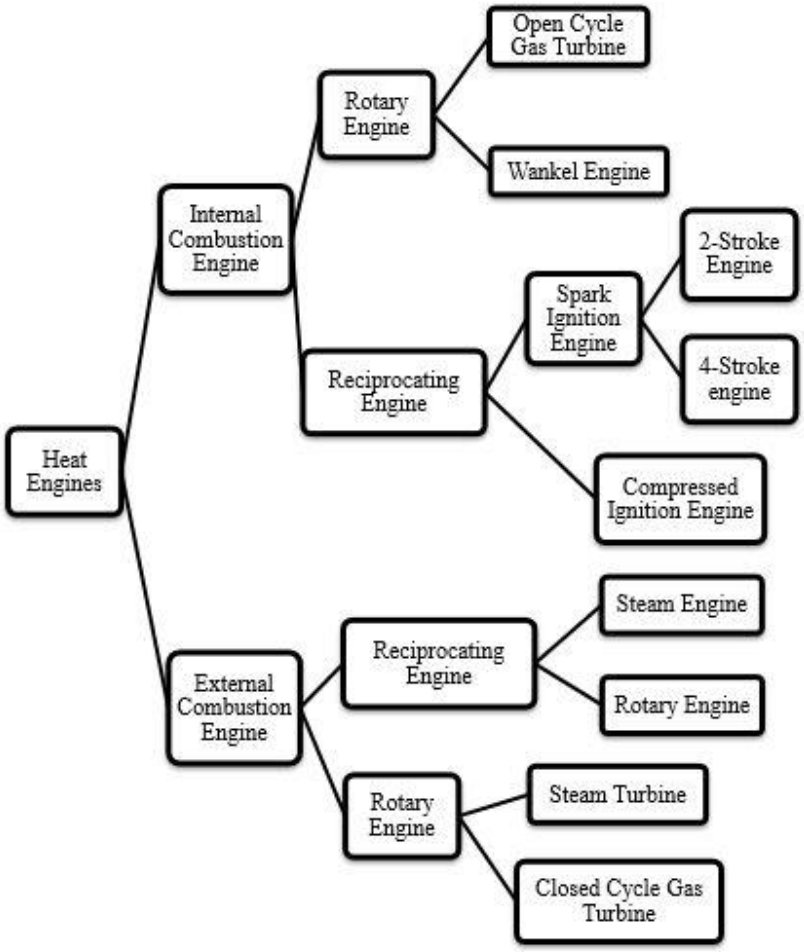

Figure 2.3 : The simplification of the engine based on type and operation (Ganesan. 2010)

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