SUPERVISOR DECLARATION

"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: ....

AIR AND FUEL FLOW ANALYSIS OF A SINGLE CYLINDER ENGINE

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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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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 :…………………..

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This thesis is dedicated to Rosli bin Mohd. Noor, Noriah binti Ahmad, family and friends.

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ABSTRAK

Kepentingan corak aliran di dalam enjin pembakaran dalam adalah untuk meningkatkan prestasi sesebuah enjin dengan kehadiran aliran berpusar dan aliran jatuh. Oleh itu, kajian tentang corak aliran pada injap masukan adalah sangat penting. Kajian ini memfokuskan tentang kesan bukaan injap yang berbeza-beza terhadap corak aliran di dalam enjin. Dinamik Bendalir Berkomputer digunakan untuk meramal ciri-ciri aliran pada injap masukan di dalam enjin satu silinder. Aliran berpusar dan aliran jatuh dipercayai akan meningkat semasa lejang mampatan apabila halaju meningkat semasa melalui injap masukan. Selain daripada penganalisaan terhadap ciri-ciri aliran, hasil penemuan projek ini juga akan membantu dalam meningkatkan prestasi enjin di dalam penggunaan gas semulajadi termampat. Hal ini kerana gas semulajadi termampat mempunyai indeks pencemaran udara yang lebih rendah yang mana sangat diperlukan oleh alam sekitar. Keputusan kajian simulasi dipersembahkan dalam bentuk grafik di mana aliran berpusar dan aliran jatuh di tunjukkan. Selain itu kontur pergolakan tenaga kinetik turut dipaparkan untuk menyokong lagi hasil dapatan simulasi yang telah dijalankan. Nilai maksimum digunakan bagi membandingkan kesemua parameter. Parameter didalam kajian ini melibatkan bukaan injap yang berbeza-beza bermula dari bukaan injap paling kecil sehingga bukaan injap terbesar. Hasil kajian mendapati, bukaan injap yang rendah menghasilkan nilai aliran berpusar, aliran jatuh dan pergolakan tenaga kinetik adalah lebih tinggi. Hal ini membantu meningkatkan prestasi enjin.

ABSTRACT

The importance of flow patterns in internal combustion engine is to intensify the performance of the engine in presence of swirl and tumble. Therefore, it is crucial to investigate the flow behavior at the intake valve. In this research, the effects of valve lift to the flow pattern inside the engine are to be investigated. Computational Fluid Dynamic is used to predict the flow behavior in the single cylinder engine. The higher velocity during intake stroke is believed to increased swirl and tumble throughout compression stroke. Besides analyzing the flow behavior, the findings of this project will helps in increasing the performance of engine using compressed natural gas as it has lower air pollution emission which is badly needed for the environment. Results of the simulation are presented in graphical data in terms of swirl pattern and tumble pattern. Besides, contours of Turbulence Kinetic Energy are presented to support the results. A maximum value is compared for all five parameters. The parameters are taken from different valve lift from the lowest to the highest valve lift. From the result, it is found that the lower valve lift results in better swirl, tumble and turbulence kinetic energy value. This gives off better performance to the engine.

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LIST OF SYMBOL

kJ/kg	kilo Joule per kilogram
MJ/kg	Mega Joule per kilogram
Pa	Pascal
m/s	meter per second
Q	Flow rate
A	Area
u	Fluid velocity
S	Stroke length
N	engine speed per one revolution
Ūp	average piston speed
rpm	revolution per minute
kg/mol	kilogram per mol
ω	angular speed
u_t	swirl tangential speed
$\bar{U}_p$	average piston speed
°C	degree celcius
NO_x	Nitrogen Oxide
C-H ratio	Carbon-hydrogen ration
CO	Carbon Oxide
HC	Hydrogen Carbon

LIST OF ABBREVIATION

CFD	Computational Fluid Dynamic
CNG	Compressed Natural Gas
LNG	Liquid Natural Gas
SI	Spark Ignition
ICE	Internal Combustion Engine
NG	Natural Gas
NGV	Natural Gas Vehicle
TKE	Turbulence Kinetic Energy
PSM	Projek Sarjana Muda
FYP	Final Year Project
bTDC	before Top Dead Centre
BDC	Bottom Dead Centre
TDC	Top Dead Centre
2D	2-Dimension
3D	3-Dimension
SR	Swirl Ratio
CAD	Computer Aided Drawing
vol	volume
AF Ratio	Air Fuel Ratio
etc.	etcetera

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CHAPTER I

INTRODUCTION

1.1 OVERVIEW

This chapter explains briefly on the overview of the project. The air and fuel flow analysis is important in the development of engines using compressed natural gas (CNG). Analysis was done on a single cylinder engine for its less complexity and compact yet can provide possible maximum power. Besides, cooling process is simpler than multi cylinder engine in a way the weight used is lesser. Using a single cylinder engine in engine development research also requires lower cost. This research intended to improvise the inadequacy of previous research. Thus, the problem statement explains the reasons of having this research. The objectives state the aim to be fulfilled at the end of this project. All the scopes covered in completing this project will be described in the scope of study section.

1.2 PROBLEM STATEMENT

Research on using Compressed Natural Gas (CNG) as a transport engine fuel has found many advantages over petrol. The advantages of CNG compared to petrol are unique combustion and suitable mixture formation due to high octane number of CNG, engine operates smoothly with high compression ratios without knocking, CNG with lean burning quality will leads to lowering exhaust emissions and fuel operating cost, CNG has a lower flame speed, engine durability is very high, the flame speed of Natural gas is lower compared to petrol (Aslam et al., 2006). Besides that, CNG is attractive for five reasons. It is the only fuel cheaper than gasoline or diesel. It has inherently lower air pollution emissions. It has lower greenhouse gas emissions. Its use extends petroleum supplies, and there are large quantities of the fuel available in the world.(Abu Bakar, 2008).

However, it does have disadvantages that could affect the performance of the engine. Therefore, research on increasing its performance is actively developed. There are various factors that affect engine performance. One of them is the fluid motion in the combustion chamber. According to Pulkrabek (2008), efficient operation of an engine depends on high turbulence in the air-fuel flows as it enhances mixing, evaporation, heat transfer and combustion. Method of conducting experiment may give the results of the motion in the chamber but it will not give the exact overview of what is happening inside. Software that helps in giving more knowledge of the motion in the chamber is Computational Fluid Dynamic (CFD). CFD is needed to demonstrate swirl and tumble behaviors during intake and compression stroke so that improvement can be made to increase the performance.

1.2 OBJECTIVES

There are four objectives to be fulfilled by the end of this project. The objectives are as follows;

1. To simulate flows in the engine using ANSYS Fluent for a single cylinder engine at intake stroke
2. To investigate the effect of different valve lift to the flow in the engine
3. To produce geometry drawing and analysis at intake stroke

1.3 SCOPES OF STUDY

In completion of this project, the EY20D single cylinder spark ignition engine was modeled in CATIA for further analysis. The engine dimensions was taken to produce 3D geometry drawing before using ANSYS Fluent software to analyze the air and fuel flow at intake stroke.

CHAPTER II

LITERATURE REVIEW

2.0 OVERVIEW

This chapter will cover the review on internal combustion engine, computational fluid dynamic and fluid motion within combustion chamber.

2.1 INTERNAL COMBUSTION ENGINE

Internal combustion engine (ICE) is a heat engine that converts chemical energy in a fuel into mechanical energy, usually made available on a rotating output shaft (Pulkrabek, 2008). The output of the engine which is the rotating crankshaft received energy from the mechanical linkage, where expansion process takes place due to high-pressure gas expand against the mechanical mechanisms of the engine.

The high pressure and temperature of gas is a result of thermal energy combusted or oxidized with the air inside the engine. This process is the conversion of chemical energy in the fuel to thermal energy. Results of the whole process allow the rotating crankshaft to transmit the mechanical energy through a transmission to the final use. Applications of this process include the propulsion of a vehicle or stationery engines to drive generators.

In the early development of internal combustion engine back in 1800s, the development of the automobile was also growing. During that time, the lack of good and consistent fuel was a major drawback in engine development (Pulkrabek, 2008). New discoveries of crude oil in Pennsylvania trigger the development of reliable fuels that could be useful for the founding of these new engines. The technologies that stimulate the internal combustion engine development are not only the development of reliable fuels but also the pneumatic rubber tire.

There is numerous classification of internal combustion engine which fall into types of ignition, basic design, numbers of cylinders, engine cycle and fuel used. Most of internal combustion engine are reciprocating engines where the pistons went back and forth in the cylinder. At closed end at each cylinder locates the combustion chamber. There can be a single cylinder or more than one cylinder which can reach more than 20 cylinders where the piston is connected to the crank shaft.

This engine operates on four-stroke engine. The first stroke is intake stroke where mixture of air and fuel enter the chamber. This is done when the piston decline from the top position causing the cylinder volume to increase. Atmospheric pressure at this state is higher than in the cylinder making the mixture enters the cylinder through intake port. Second stroke is compression stroke. At this stroke, intake and exhaust valve are closed and piston moves to the cylinder top compressing the mixture of fuel and air towards the cylinder head. The third stroke is the power stroke where the spark plug ignites the compressed mixture of fuel and air. Combustion occurs due to high temperature and pressure results from the compression process earlier forcing the piston to travel back down the cylinder. At this state, second revolution begins. Final stroke is exhaust stroke. Burnt air-fuel mixture goes out the exhaust valve as the piston returns to top dead center position.

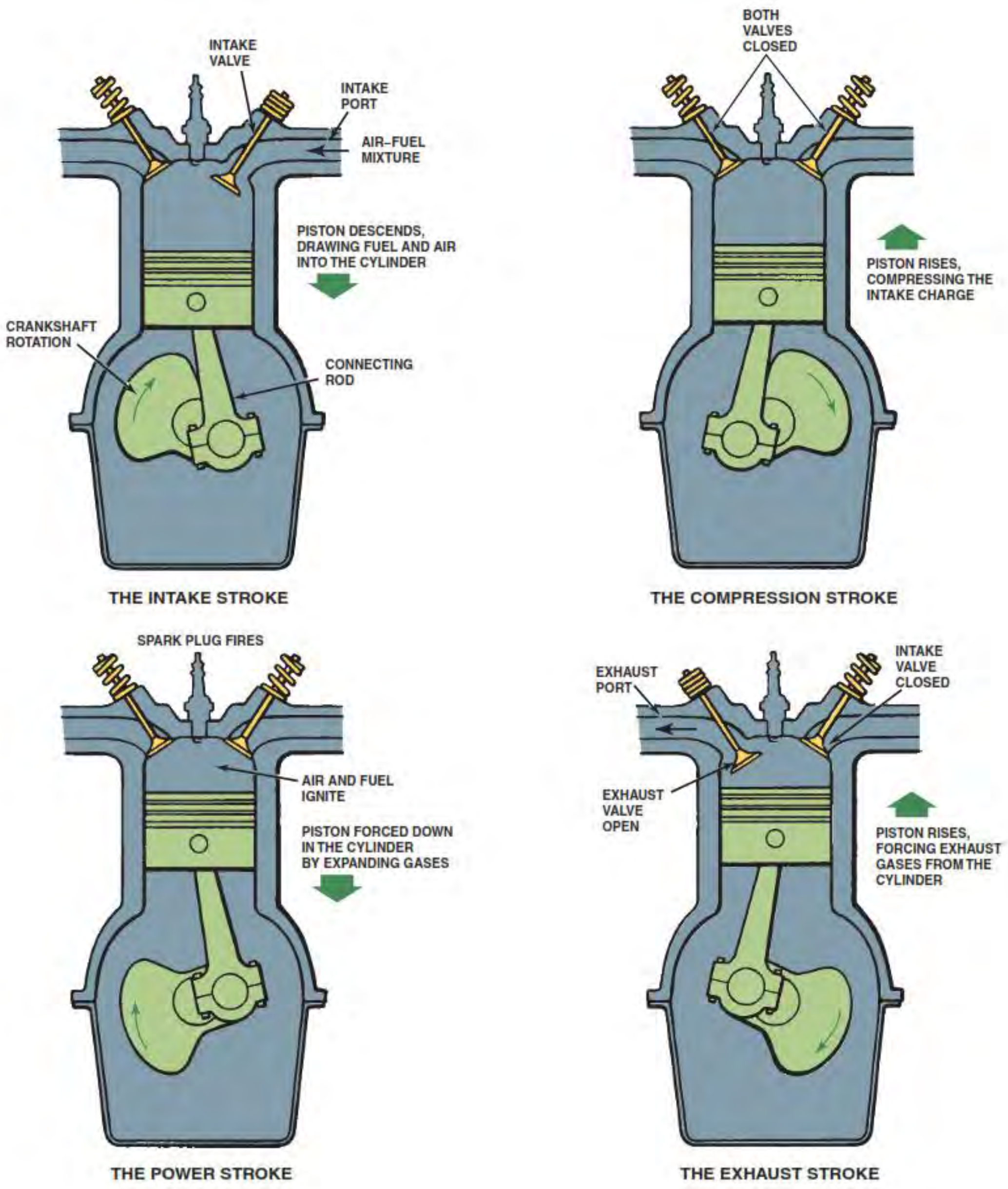

Figure 2.1: Four stroke engine operating cycle

(Source: James. D. Halderman. 2012)

Internal combustion engine can be classified based on the fuel used. Examples of fuel used are;

i. Gasoline
ii. Diesel Oil Or Fuel Oil
iii. Natural Gas
iv. Liquid Petroleum Gas
v. Alcohol (Ethyl, Methyl)
vi. Dual Fuel
vii. Gasohol

Natural gas is a mixture of components, consisting mainly of methane (60-98%) with small amount of other hydrocarbon fuel components. It contains various amounts of N_2, CO_2, He and traces of other gases (Pulkrabek, 2008). A compressible natural gas can be stored for a later used for example in vehicle. This gas is called compressed natural gas or CNG. CNG requires a much larger volume to store the same mass of natural gas and the use of very high pressure on about 200 bar or 2900 psi (Stone, 1997). Natural gas also can be stored as liquid natural gas or LNG at pressures of 70 to 210 kilo Pascal and a temperature of approximately -160°.

2.2 COMPRESSED NATURAL GAS

Natural gas is naturally occurring form of fossil energy and therefore renewable. Natural gas occurs as gas under pressure in rocks beneath the earth's surface or often in solution with crude oil as a volatile fraction of petroleum. It is naturally hydrocarbon energy formed in the earth's crust by millions of years of biological action on organic matter (Ramadhas, 2011). Thus, it does not require undergoing refining process as petroleum.

Natural gas is composed primarily of methane (60-98%) with small amount of other hydrocarbon fuel components. It contains various amounts of propane, butanes, pentanes and traces of other gases. Beside that, active compounds also can be found in the natural gas such as sulfur and inert compounds such as nitrogen and carbon dioxide. CNG has higher motor octane number making it suitable for spark ignition engine or a designed gas engine with higher compression ratio.

As been said by Bhandari, K. et al (2005), the higher octane number in Compressed Natural Gas (CNG) enable the engine to operate at higher compression ratio (CR) and it may higher efficiency and higher power generated. CNG shows higher ignition temperature compared to gasoline. Besides, it is lighter than air density. Due to those properties, CNG is likely to be safer than gasoline. Composition of natural gas in comparison with gasoline is shown in Table 2.1.

Table 2.1: Composition of natural gas in comparison with gasoline

Properties	Gasoline	CNG
Motor octane number	80-90	120
Molar mass (kg/mol)	110	16.04
Carbon weight fraction (mass %)	87	75
Stoichiometric air fuel ratio (A/F)s	14.6	16.79
Stoichiometric mixture density (kg/m^3)	1.38	1.24
Lower heating value (MJ/kg)	43.6	47.377
Lower heating value of stoic. Mixture (MJ/kg)	2.83	2.72
Flammability limits (vol% in air)	1.3-7.1	5-15
Spontaneous ignition temperature °C	480-550	645

Natural gas is compressed and stored to be used in automobiles. It is necessary to store it in compact form to reduce the weight of the vehicle. The storage capacity of CNG is in a range from 20 up to 100 liters. The cylinder storage must able to handle pressures of 600 bar. This is a safety measure if ever the storage cylinder is exposed to fire.

CNG is a safe fuel referring to its physical, chemical and combustion characteristic. Natural gas or methane is a nontoxic gas. It is lighter than air which means it will not sink to the ground like propane which is heavier than air. Natural gas will go up to the atmosphere and dissipate in the air.

Ramadhas, A. S (2011) has concluded that CNG contains the following advantages;

1. Environmental: CNG vehicles produce far less of all regulated pollutants compared to gasoline or diesel vehicles including No_x and particulate matter. Natural gas has low C-H ratio hence lower CO and HC emissions. CNG vehicles produce far less unregulated air toxics and greenhouse gases. Due to proper combustion of gas-air mixtures, reduced unburned HC emissions will reduce the environmental pollution of visible photochemical smoke.
2. Energy security: Natural gas usage reduces the consumption of gasoline and diesel fuel.
3. Operating cost: Cheaper than gasoline and diesel fuel.
4. Distribution efficiency safety: Natural gas has a higher ignition temperature than gasoline or diesel. Its density that is lighter than air makes it disperses quickly if leakage of fuel is to happen. This shows the safest and most efficient energy distribution system. The explosive limit of natural gas-air mixtures is higher than diesel-air mixtures. Natural gas requires approximately 5% of volume compared to 2% for propane and 1% for gasoline vapor for continuous flame propagation. This means natural gas is safer than other fuels.
5. Flexibility: CNG vehicles can be produces distinctively and bi-fuel versions. CNG vehicles are suitable at the area where natural gas is available. While bi-fuel vehicles can operate both natural gas and gasoline fuel as they have storage tanks on board. This kind of vehicle can operate by using natural and easily switch to gasoline if the area does not provide natural gas supply. It is economical and environmentally friendly.

However, research has also found disadvantages of using natural gas. Due to the engine’s low-volumetric efficiency and low-energy density, engine performance decreases.