UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

NUMERICAL SIMULATION OF FLOW INSIDE INTAKE MANIFOLD FOR SPARK IGNITION WITH PCC

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NUMERICAL SIMULATION OF FLOW INSIDE INTAKE MANIFOLD FOR SPARK IGNITION WITH PCC

ZULFADLI BIN MOHAMAD NAZER

A report submitted

in fulfilment of the requirements for the

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DECLARATION

I declare that this thesis entitled "Numerical Simulation of Flow Inside Intake Manifold for Spark Ignition Engine with PCC" is the result of my own research except as cited in the references. The thesis has not been accepted for any bachelor and is not concurrently submitted in candidature of any other bachelor.

Signature : ....

Name : ZULFADLI BIN MOHAMAD NAZER

Date : ....

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 Bachelor of Mechanical Engineering with Honours

Signature	: ……………………………………….
Supervisor Name	: DR. FUDHAIL BIN ABDUL MUNIR
Date	: ……………………………………….

APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality as a partial fulfillment of Bachelor of Mechanical Engineering with Honours.

Signature	: ……………………………………….
Supervisor Name	: DR. FUDHAIL BIN ABDUL MUNIR
Date	: ……………………………………….

DEDICATION

I would like to dedicate to

My father,

MOHAMAD NAZER BIN ABDULLAH

My mother,

NORAINI BINTI ZAINUL

My supervisor,

DR. FUDHAIL BIN ABDUL MUNIR

And

All my friend,

For their assistance & supportive efforts

ABSTRACT

Intake manifold is important part of an engine that provides the air and fuel to cylinder engine. It have major influence on engine performance, emission of noise and pollutants. The objectives of this research is to study the flow inside intake manifold for spark ignition engine with PCC and potential improvement in design characteristic of existing intake manifold engine. Three dimensional of intake manifold of single-cylinder were modelled using DesignModeler. For this study, six design of intake manifold were modelled. All six design of intake manifold were perform simulation of air-fuel mixture from inlet manifold into the combustion chamber by using ANSYS FLUENT 16.0. The graphical result shows the flow inside intake manifold to the combustion chamber. From the study of result, a bending angle of intake manifold affects the flow. Beside, volumetric efficiency can be increases by the new design changes of intake manifold.

ABSTRAK

Manifold pengambilan adalah bahagian penting sesebuah enjin yang membekalkan oxygen dan bahan api kepada kebuk pembakaran. Ia mempunyai pengaruh besar terhadap prestasi enjin, pelepasan bunyi dan pencemaran udara. Objektif penyelidikan ini adalah untuk mengkaji aliran di dalam manifold pengambilan bagi enjin pembakaran dalaman dan potensi peningkatan dalam ciri-ciri reka bentuk manifold pengambilan yang sedia ada. Manifold pengambilan di modelkan berbentuk tiga dimensi menggunakan DesignModeler. Dalam kajian ini, enam reka bentuk manifold pengambilan dimodelkan. Kesemua enam reka bentuk manifold pengambilan dilakukan simulasi campuran udara minyak dari kemasukan manifold hingga ke kebuk pembakaran menggunakan perisian ANSYS FLUENT 16.0. Dalam mengkaji keputusan simulasi, didapati bahawa , sudut lenturan manifold pengambilan memberi kesan kepada aliran di dalam manifold pengambilan. Selain itu, kecekapan volumetric boleh ditingkatkan dengan membuat sedikit perubahan geometri manifold pengambilan yang sedia ada.

ACKNOWLEDGEMENT

First of all, I would to say “Alhamdulillah” (Praise to Allah) with His bless. I am very thankful for giving chances and ability to complete this project. In addition, I would like to thanks fellow friends who always helps and encouraged me with this project.

Noted with thanks to my helpful supervisor, Dr. Fudhail Bin Abdul Munir whose help, stimulating suggestions and encouragement helped me in all the time of the research and writing of this “Projek Sarjana Muda”. All of the support and supervise from him is completely useful and it will not be forgotten. The opportunity he had willingly given to me is a very substantial key for me to serve better for the industry and educational field particularly.

Last but not least, I would like to give my special thanks to my parents whose patient love enabled me to complete this project, sacrifice their time and money in show of support towards me. I hope that all results obtained in this research can be used as references for the betterment of science and technology.

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LIST OF ABBRIVATIONS

PCC	-	Pre-Combustion Chamber
3D	-	Three-Dimensional
ICE	-	Internal Combustion Engine
PFI	-	Port Fuel Injection
BT	-	Brake Torque
BP	-	Brake Power
BMEP	-	Brake Mean Effective Pressure
VE	-	Volumetric Efficiency
AFR	-	Air Fuel Ratio
SI	-	Spark Ignition
CFD	-	Computational Fluid Dynamics
TKE	-	Turbulence Kinetic Energy

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Gasoline engine is a type of internal-combustion engine that produces power by burning a volatile liquid fuel, gasoline or gasoline mixture. There were several type of gasoline engine, which is four-stroke gasoline engine, two-stroke gasoline engine and rotary gasoline engine (Cromer, O.C et al., 2013). Nowadays, a four-stroke is common uses in automotive sector. Most vehicle on the road today is using Four-Stroke gasoline engine. Generally, combustion will occur inside the engine. Then, the air will pass through the intake and intake manifold before entering the cylinder engine for combustion.

An intake manifold is one of part engine that conduct air and fuel mixture from carburettor or fuel injection to the intake valve of the engine. It is essential part of engine that major effect to engine performance, emission of pollutants and noise (Priyadarsini, 2016). It is a last step before the air goes into the engine at cylinder head part. A modify of intake manifold will affect the fuel consumption. A basic characteristics design of intake manifold gasoline engine also can influence in volumetric efficiency (Tsogtjargal et al., 2012). Figure 1.1 shows intake manifold 4-cylinder engine.

Figure 1.1: Intake Manifold 4-Cylinder Engine.

Nowadays, simulation in automotive sector is not a new thing. There has been a lot of simulation process to get a variety of data and study about something cannot be seen. Simulation is the method to get exactly results flow inside intake manifold. It can illustrated how the movement of flow and the characteristic through intake manifold. The simulation can be repeated as many as needed until best result is achieved.

1.2 PROBLEM STATEMENT

Firstly, inside intake manifold is difficult to observe because it made from material that cannot be seen on the inside. The condition of air and fuel flow inside intake manifold also cannot be ascertained. These causes can be factors that will affected the engine. Flow inside intake manifold can influence the volumetric efficiency, mass flow and velocity of the flow. Performing experiments require high cost and consume time. Nowadays in industry, simulation is the one of the best method compare to actual experimental because it can save a cost and time. As the numerical model being develop, it able to perform simulation without to wait for a model to be manufactured.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To develop a workable numerical model of intake manifold for spark ignition engine with PCC
2. To perform numerical simulation using the developed numerical model

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. Utilize ANSYS FLUENT as the simulation tools
2. Establish a three dimensional (3D) geometry of single-cylinder intake manifold
3. Perform cold flow simulation at the area of intake manifold

1.5 GENERAL METHODOLOGY

The actions that need to be carried out to achieve the objectives in this project are:

1. Literature review
2. Development of the numerical model
3. Perform simulation and results analysis
4. Report writing

The methodology of this study is summarized in the flow chart as shown in Figure 1.2.

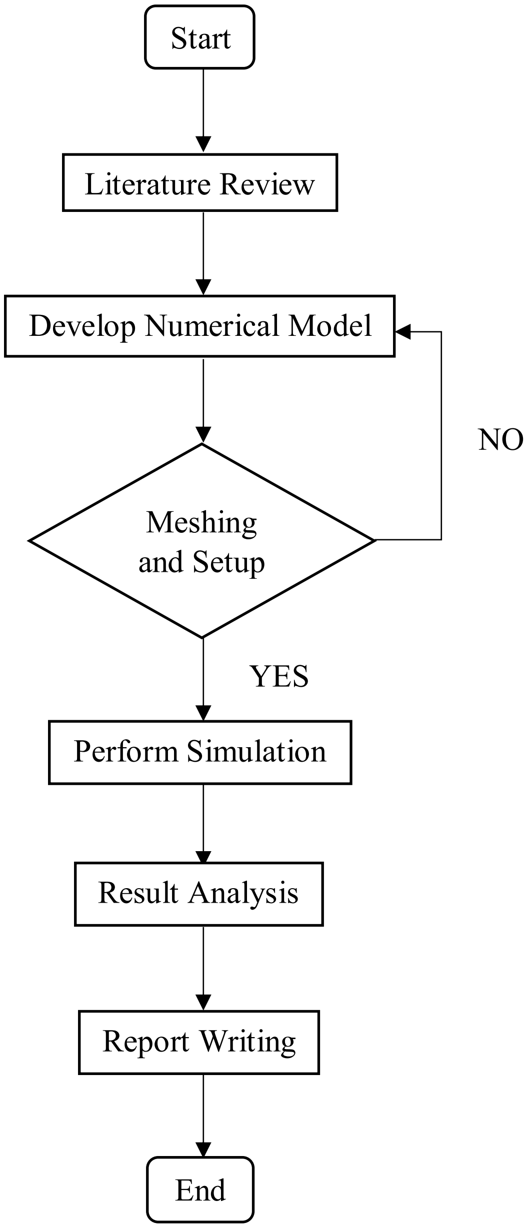

Figure 1.2: Flow Chart of the Methodology

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the literature review of numerical simulation flow inside intake manifold for gasoline engine with PCC is presented for background information in order to understand. The research presented in this paper has been reviewed from various source such as journal, article and website.

2.2 FLOW INSIDE INTAKE MANIFOLD

Researcher discovered an inlet manifold or intake manifold is the part of an engine that supplies the fuel/air mixture to the cylinders. The intake manifold is essential for the optimal performance of an internal combustion engine. An intake manifold is one of the essential parts concerning the performance of an internal combustion engine. Mostly, the intake manifold normally made up of a plenum inlet duct, connected to the plenum are runners contingent upon the number of cylinders, which leads to the engine cylinder. Intake manifolds must be intended to increase engine performance by avert the phenomena such as inter-cylinder robbery of charge, inertia of the flow in the individual branch pipes, resonance of the air masses in the pipes and the Helmholtz effect (Priyadarsini, 2016). Figure 2.1 shows the intake manifold with features

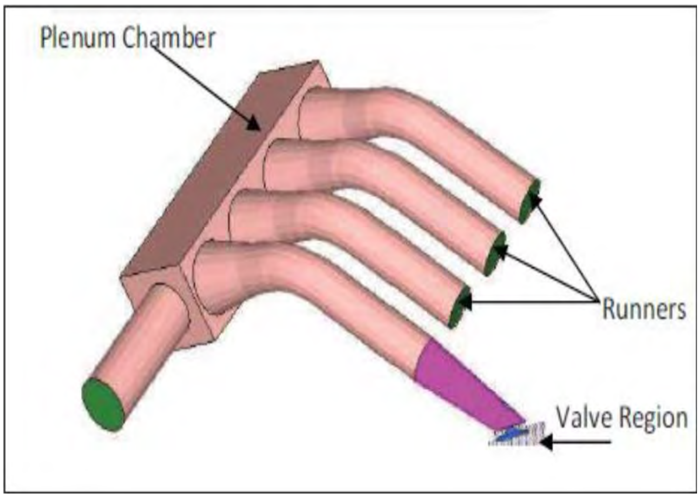

Figure 2.1: Intake Manifold with Features (Priyadarsini, 2016)

The air flow inside intake manifold convey flow evenly to the piston valve is one the important factors. Flow phenomenon inside the intake manifold should be completely enhanced to create more engine power with better ignition and decrease the emission. Researcher performed numerical analysis of flow of intake manifold by modelled three-dimensional intake and analysed by using the FLUENT software to study the pressure, velocity and flow characteristic. The anticipate result of pressure loss and total outlet mass flow. Intake pipe and plenum connection construct a back step geometry which causes more aggregate pressure loss because of flow distribution in conventional model. Further intake mass flow to devaluation in total pressure loss in the plenum chamber due to tapering geometry (Priyadarsini, 2016).

Researcher performed experimental investigations on design development intake manifold improve on fuel consumption of gasoline engine. The runner length of intake manifold is affected on volumetric efficiency and engine performance. Besides, the intake manifold of permanent length does not fit in low and high engine speed operation, lessening volumetric efficiency making it difficult to utilize engine capacity completely. From the results of the experiment, the length of runner intake manifold influences on fuel consumption (Tsogtjargal et al., 2012).

The incompressible stream in the intake pipe of laboratory-scale internal combustion engine at Reynolds numbers relating to reasonable working conditions was studied with the assistance of direct numerical simulations. The mass flow through the bended pipe remained consistent and the valve was held permanent at its halfway-open position, as is commonly done in steady flow engine test bench experiment for the improvement of intake manifold. The flow features were distinguished as the flow develops in the bended intake pipe and connects with cylindrical valve stem. Researcher discovered that the flow can become turbulent rapidly on the inflow profile forced at the pipe inlet, although no extra noise was added to impersonate turbulent velocity fluctuations. Improvement of the geometry of the intake and exhaust ports/valves, piston and cylinder has turn to an essential part of ICE development, to enhance the efficiency and decrease pollutant emissions to conform with stringent environmental regulations and to present novel combustion concept. Normally, the study and improving of the intake manifold aiming at upgrading the generation of the cylinder swirling motion, and the measurements the valve's discharge coefficient, is carried out in steady flow engine test benches at permanent valve positions (Giannakopoulos et al., 2017).

Air flow behaviour conduct an important part in order to give better air fuel mixture inside the intake manifold for port fuel injection (PFI) system before it is enter the combustion chamber (Giannakopoulos et al., 2017). In view of past studies, high angle of intake manifold will give better engine performance in terms of high brake torque (BT), brake power (BP), brake mean effective pressure (BMEP), and volumetric efficiency (VE) (Mohd Faisal Hushim et al., 2013). In addition, the intake manifold is mechanical device that plays an essential to give great air fuel ratio (AFR) to the spark ignition (SI) engine. The primary use of an intake manifold is to transfer as much air-fuel mixture to the combustion chamber as possible. Researcher analyzed computational fluid dynamics to investigate the air flow behaviour inside a different intake manifold angles. The method is using ANSYS CFX simulation tool by taking six angles of intake manifold which are 30°, 60°, 90°, 120°, 150°, and 180°. Simulation by researcher found that high intake manifold will give better air flow inside intake manifold. This is because of lower air resistance caused by the curved manifold (Mohd Faisal Hushim et al., 2016).

The intake system on an engine has primary objective, to get however much air-fuel mixture into cylinder as could be expected. The discontinuous or throbbing nature of the airflow through the intake manifold into every cylinder may create resonances may create airflow at specific speeds. These may improve the engine performance characteristics at certain engine speeds, but may diminish at other speeds, depending on manifold dimensions and shape. Researcher investigated the effects of intake plenum length/volume on the performance characteristics of spark-ignited engine with electronically controlled fuel injectors. An engine test on loaded the hydraulic dynamometer have been conducted with original intake manifold. Then, the test is repeated with different length intake plenum with same engine speeds. According to an investigation by researcher, the result show the intake manifold plenum/volume is exceedingly compelling on engine performance characteristics especially with fuel consumption parameters for SI engine with multipoint fuel injection system. The engine performance can be enhanced by using continuously variable intake plenum length (Ceviz et al., 2010). Below Figure 2.2 shows specific fuel consumption characteristic including the effects of much longer length of intake plenum

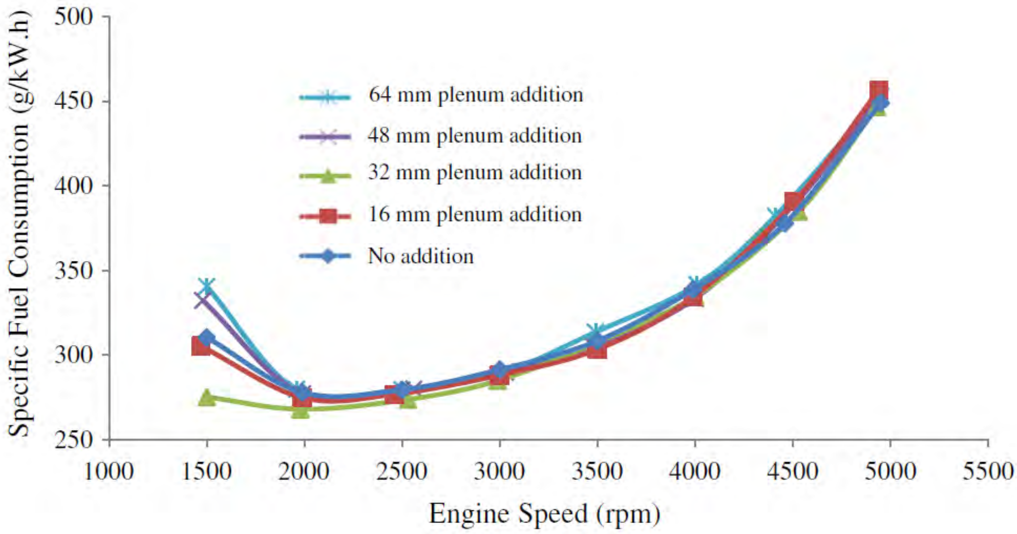

Figure 2.2: Variation of Specific Fuel Consumption with Engine Speed for Five Different Intake Plenum Volumes (Ceviz et al., 2010).

Vehicle's engine performance and emission of noise and pollutants will be affected of intake-air manifolds. In order to achieve the best volumetric efficiency and thus the best engine performance, different designs of intake manifold is required for differences in engine outputs and applications. The engine output would be expected to be higher, if the volumetric efficiency could be increased significantly even at low speeds (S.A. Sulaiman et al., 2010). In order to avoid low volumetric efficiency, the manifold have to be designed to enable the engine to ingest air and thus the inside diameter of the manifold must will be able to accommodate the bulk air flow (Pulkrabek, 2004). The manifold should have no sharp bends and the interior wall surface should be smooth, in order to minimize flow resistance. Besides, the impedance of the manifold is a function of the frequency of the pulses entering it and therefore it is possible to tune engine manifolds to give a specific power output characteristic as function of speed (Fontana et al., 2003).