INTAKE AND EXHAUST PORTS FLOW INVESTIGATION OF 4-STROKE SI ENGINE

MOHAMMAD AMIN BIN MOHAMED

Report in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering with Automotive.

Signature	:
Name of Supervisor	: MR. MOHD RAZALI BIN HANIPAH
Position	: LECTURER
Date	: 6 DECEMBER 2010

STUDENT'S DECLARATION

I declare that this report titled "*Intake and Exhaust Ports Flow Investigation Of 4-Stroke Si Engine*" is my result of my own research except as stated in the references. This report has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature	:
Name	: MOHAMMAD AMIN BIN MOHAMED
Id. Number	: MH08005
Date	: 6 DECEMBER 2010

ACKNOWLEDGEMENTS

Throughout the development of this project I have gained chances to learn new skills and knowledge. I wish to express my sincere appreciation and gratitude to my supervisor, Mr. MOHD RAZALI BIN HANIPAH for his continuous guidance, concern, encouragement and advices which gave inspiration in accomplishing my final year project.

Special thanks to University Malaysia Pahang for supporting and providing equipment and information sources that assisted my studies and projects.

My sincere appreciation to the lecturers of Faculty of Mechanical Enginnering who have put in effort to the lectures and always nurture and guide us with precious advices. Thank you for sharing those experiences.

To all my lovely current and ex roommates and friends who always willingly assist and support me throughout my journey of education, you all deserve my wholehearted appreciation. Many thanks.

Last but not least, my beloved family members who always stand by my side concerning the ups and downs of my life. Home is where I find comfort. Endless love.

ABSTRACT

This project is focused to investigate the test rate characteristics through the intake and exhaust ports of four-stroke single cylinder engine (Modenas Kriss 110cc) by using flowbench machine. This investigation is to measure the volumetric flow rate into intake and exhaust valve ports at various valve lift by using flowbench machine. The flow characteristic through the intake and exhaust valves at various engine vacuum conditions must also be investigate. This investigation is done by disassembling the engine in order to obtain the cylinder head. That cylinder head engine is mated to an adapter as replacement for the cylinder block engine. After that, the adapter and cylinder head will be mounted on flow bench machine. The test bench is prepared to vary the intake and exhaust valves lift to be mounted on the flow bench and then the flow test is conducted at various test pressures. A variety of valve opening was measured by using dial gauge and various test pressure is measured at Flowbench setting. The flow bench can read correction test flow and flow velocity. Flow will increase directly proportional to the valve lift. At the highest test pressure, flow is the greatest.

ABSTRAK

Projek ini difokuskan untuk mengetahui ciri-ciri tahap menguji melalui salur masuk udara dan salur udara keluar bagi enjin empat lejang dan satu silinder (Modenas Kriss 110cc) dengan menggunakan mesin Flowbench. Penyelidikan ini adalah untuk mengukur laju isipadu aliran udara ke dalam salur masuk dan salur keluar pada keadaan bukaan injap yang pelbagai dengan menggunakan mesin flowbench. Ciri-ciri pengaliran melalui injap masuk dan injap keluar pada keadaan vakum yang pelbagai juga perlu disiasat. Eksperimen ini dilakukan dengan membongkar mesin untuk mendapatkan kepala silinder. Kepala silinder hendaklah dipadankn dengan penyesuai sebagai pengganti untuk blok silinder enjin. Setelah itu, kepala silinder dan penyesuai akan diletak pada mesin Flowbench. Flowbench disediakan untuk mengambil bacaan injap masuk dan injap keluar yang berubah-ubah dan juga pada keadaan tekanan udara yang pelbagai. Bukaan injap yang pelbagai diukur dengan menggunakan dial gauge dan tekanan udara yang pelbagai ditentukan pada Flowbench. Flowbench boleh mencatat bacaan bagi isipadu aliran udara dan kelajuan aliran udara. Arus akan meningkat berbanding lurus dengan mengangkat injap. Pada tekanan ujian yang tertinggi, arus yang terbesar.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Project Introduction

The title of my project is Intake and Exhaust Ports Flows Investigation of 4-Stroke SI Engine. The engine used is from motorcycle engine (MODENAS KRISS 110cc). This engine is a 4-stoke cycle engine and have one cylinder. The cylinder head have 2 valves, there are intake and exhaust ports. So the intake and exhaust valves should be measured their flow rate. By the flow rate, the horsepower and the coefficient discharge will be defined. The Flow Bench Machine SF-1020 was using to complete this project.

The intake and exhaust valves design significantly affects the performance of the combustion system. Thermodynamic properties of the engine, such as power output, fuel consumption, emissions and acoustic behavior are directly influenced by the volumetric efficiency and the in-cylinder charge motion. In order to fulfill these targets, the intake port has to be appropriately designed to achieve both the required charge motion and a high flow performance. Valve performance plays a significant role in the overall power production of an engine. If the valves are too small, the air flow will be restricted, and the engine torque will decrease. The airflow through the inlet and the exhaust ports of an engine is unsteady, due to the periodic opening and closing of the inlet and the exhaust valves.

Flow testing consists of blowing or sucking air through a cylinder head at a constant pressure. Then the flow rate is measured at various valve lifts. A change can be made and the head re-tested. Greater air flow indicates an improvement. If the tests are made under the same conditions, no corrections for atmospheric conditions or machine variations are required. The results may be compared directly.

1.2 Problem Statement

In internal combustion engine, the performance of intake and exhaust valve can be determined by investigation of the cylinder head in certain engine.

Investigation of the flow characteristics of the both valves with several value of test pressure will be done by considering the greatest flow happening in the engine through the exhaust and intake valve. The performance is difference between the low test pressure and high test pressure should be determined after the experiment.

1.3 Objective of Study

i. This investigation is to measure the volumetric flow rate into intake and exhaust valve ports at various valve lift by using flowbench machine.
ii. To investigate the flow characteristics through the intake and exhaust valves at various engine vacuum conditions

1.4 Scope of Project

i. Cylinder head used is motorcycle engine (KRISS 110cc).
ii. Experimental is using Flow bench Machine SF-1020
iii. Investigate the air flow which occurs by various engine vacuums.

CHAPTER 2

LITERATURE REVIEW

2.1 FOUR-STROKE SI ENGINE CYCLE

2.1.1 Intake Stroke

Intake stroke or induction the piston travels from TDC to BDC with the intake valve open and exhaust valve closed. This creates an increasing volume in the combustion chamber, which in turn creates a vacuum. The resulting pressure differential through the intake system from atmospheric pressure on the outside to the vacuum on the inside causes air to be pushed into the cylinder. As the air passes through the intake system, fuel is added to it in the desired amount by means of fuel injectors or a carburetor.

As the piston moves upward and approaches 28° before top dead center (BTDC), as measured by crankshaft rotation, the camshaft lobe starts to lift the cam follower. This causes the pushrod to move upward and pivots the rocker arm on the rocker arm shaft. As the valve lash is taken up, the rocker arm pushes the intake valve downward and the valve starts to open. The intake stroke now starts while the exhaust valve is still open. The flows of the exhaust gasses will have created a low pressure condition within the cylinder and will help pull in the fresh air.

The piston continues its upward travel through top dead center (TDC) while fresh air enters and exhaust gasses leave. At about 12° after top dead center (ATDC), the camshaft exhaust lobe rotates so that the exhaust valve will start to close. The valve is fully closed at 23° ATDC. This is accomplished through the valve spring, which was compressed when the valve was opened, forcing the rocker arm and cam follower back against the cam lobe as it rotates. The time frame during which both the intake and exhaust valves are open is called valve overlap (51° of overlap in this example) and is necessary to allow the fresh air to help scavenge (remove) the spent exhaust gasses and cool the cylinder. In most engines, 30 to 50 times cylinder volume is scavenged through the cylinder during overlap. This excess cool air also provides the necessary cooling effect on the engine parts.

As the piston passes TDC and begins to travel down the cylinder bore, the movement of the piston creates suction and continues to draw fresh air into the cylinder.

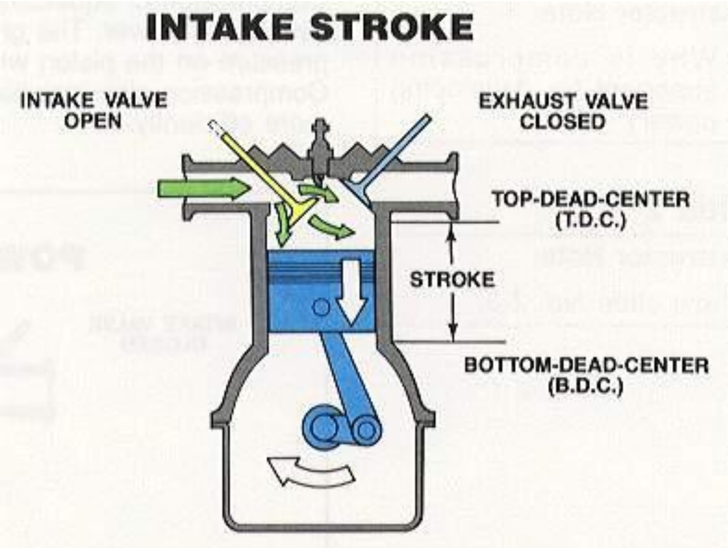

Figure 2.1: Intake stroke

Source: Howell, 2008

2.1.2 Compression Stroke

When the piston reaches BDC, the intake valve closes and the piston travels back to TDC with all valves closed. This compresses the air-fuel mixture, raising both the pressure and temperature in the cylinder. The finite time required to close the intake valve means that actual compression doesn't start until sometime BDC. Near the end of the compression stroke, the spark plug is fired and combustion is initiated.

The piston returns, still driven by the momentum of the flywheel, and compresses the charge into the combustion head of the cylinder. The pressure rises to an amount which depends on the compression ratio', that is, the ratio of the full volume of the cylinder when the piston is at the outer end of its stroke to the volume of the clearance space when the piston is at the inner (or upper) end. Unordinary petrol engines this ratio is usually between 6 and 9 and the pressure at the end of compression is about 620 to 827.4 kN/m2, with full throttle opening.

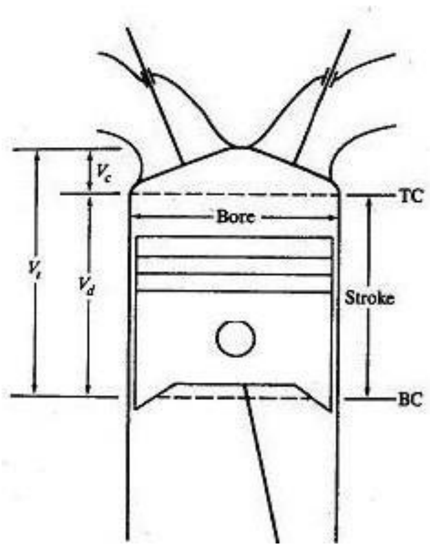

Figure 2.2: Cylinder block displacement

Source: Howell, 2008

Where

V_c : Clearance volume.

V_d : Displacment volume.

VL or VS : Total or stroke volume .

TC : Top Center.

BC : Bottom Center

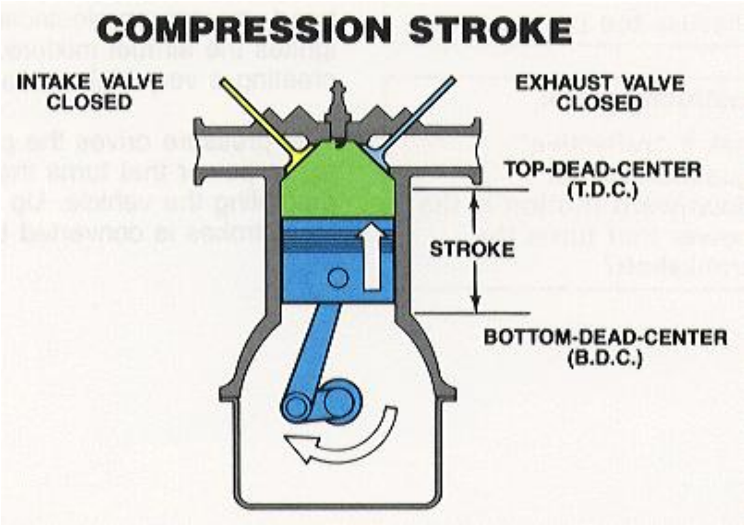

Figure 2.3: Compression stroke

Source: Howell, 2008

2.1.3 Power Stroke

With all valves closed, the high pressure created by the combustion process pushes the piston away from TDC. This is the stroke which produces the work output of the engine cycle. As the piston travels from TDC to BDC, cylinder volume is increased, causing pressure and temperature to drop. The piston returns, again driven by the momentum of the flywheel, and discharges the spent gases through the exhaust valve. The pressure will be slightly above atmospheric pressure by an amount depending on the resistance to flow offered by the exhaust valve and silencer. It will thus be seen that there is only one working stroke for every four piston strokes, or every two revolutions of the crankshaft, the remaining three strokes being referred to as idle strokes, though they form an indispensable part of the cycle. This has led engineers to search for a cycle which would reduce the proportion of idle strokes, the various forms of the two-stroke engine being the result. The correspondingly larger number of useful strokes per unit of time increases the power output relative to size of engine, but increases thermal loading.

Combustion of the air-fuel mixture occurs in a very short but finite length of time with the piston near TDC. It starts near the end of the compression stroke slightly before TDC and lasts into the power stroke slightly after TDC. Combustion changes the composition of the gas mixture to that of exhaust products and increases the temperature in the cylinder to a very high peak value. This, in turn, raises the pressure in the cylinder to a very high peak value.

Just before the end of the compression stroke, ignition of the charge is effected by means of an electric spark, and a rapid rise of temperature and pressure occurs inside the cylinder. Combustion is completed while the piston is practically at rest, and is followed by the expansion of the hot gases as the piston moves outwards. The pressure of the gases drives the piston forward and turns the crankshaft thus propelling the car against the external resistances and restoring to the flywheel the momentum lost during the idle strokes. The pressure falls as the volume increases.

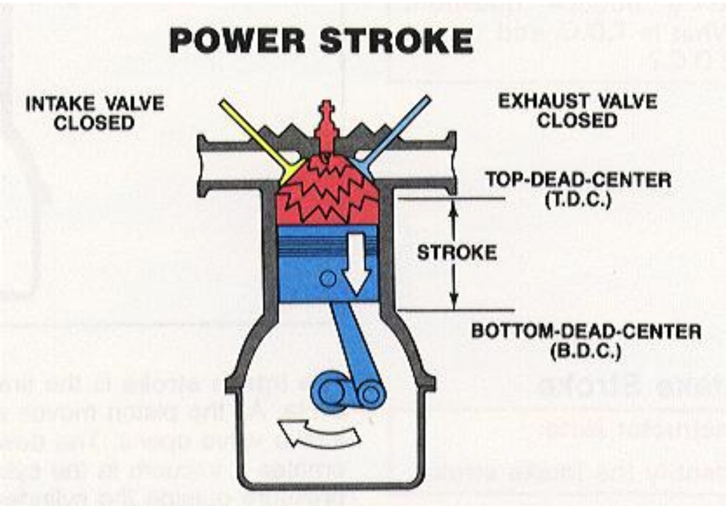

Figure 2.4: Power stroke

Source: Howell, 2008

2.1.4 Exhaust Stroke

As the piston approaches 48° BBDC, the cam of the exhaust lobe starts to force the follower upward, causing the exhaust valve to lift off its seat. As shown in Figure 2.5, the exhaust gasses start to flow out the exhaust valve due to cylinder pressure and into the exhaust manifold. After passing BDC, the piston moves upward and accelerates to its maximum speed at 63° BTDC. From this point on the piston is decelerating. As the piston speed slows down, the velocity of the gasses flowing out of the cylinder creates a pressure slightly lower than atmospheric pressure. At 28° BTDC, the intake valve opens and the cycle starts again.

The exhaust stroke completes the combustion process. The reopening of the intake valve signals the beginning of a new cycle, which occurs in each cylinder in the engine. The combustion cycle is repeated over and over at a very high rate of speed as long as the engine is running.

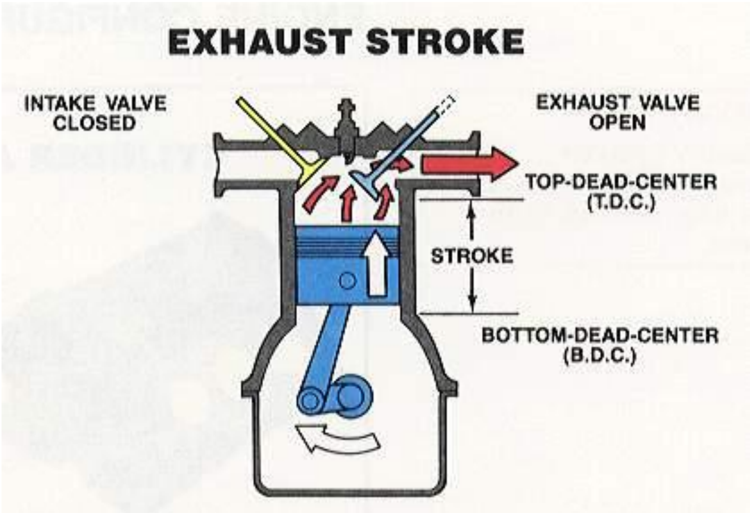

Figure 2.5: Exhaust stroke

Source: Howell, 2008

2.2 CYLINDER HEAD

In an internal combustion engine, the cylinder head is positioned on the top of the engine block. The cylinder head provides upper portions of each combustion chamber, where each upper portion corresponds to one cylinder of the engine block. The cylinder head may house intake valves, exhaust valves, camshafts, rocker arms and pushrods, and numerous other mechanisms as known in the art.

An intake manifold and an exhaust manifold are typically coupled to the cylinder head. The intake manifold is located between the carburetor and cylinder head.

In use, the intake manifold supplies an air-fuel mixture through internal intake ports in the cylinder head to each combustion chamber. In multi-port injected engines, the intake manifold holds fuel injectors that supply an air-fuel mixture to each combustion chamber.

The exhaust manifold is typically coupled to the side of the cylinder head opposite the intake manifold (i.e. the "exhaust side"). The exhaust manifold collects exhaust gases exiting from each combustion chamber through internal exhaust ports in the cylinder head and transfers these exhaust gases to an exhaust pipe of an exhaust system. The exhaust manifold has a plurality of primary pipes in fluid communication with a common exhaust pipe. Each primary pipe is coupled to the cylinder head over the outlet of a corresponding exhaust port such that each primary pipe collects exhaust gases exiting a corresponding combustion chamber and transfers them to the exhaust pipe.

The inlet end of each primary pipe is welded to a manifold inlet flange, which is subsequently bolted to the cylinder head. Since exhaust manifolds are generally constructed of cast iron, the inlet flange is relatively heavy and adds a substantial amount of weight to the engine. In addition, welding the primary pipes to the flange is difficult and complicated as it is necessary to provide a weld about the circumference of each pipe. Since there are usually a number of pipes, adjacent pipes interfere with each other during welding. Thus, welding about the entire circumference of each tube is difficult, expensive and time consuming.

Furthermore, once the primary pipes are welded to the flange, a separate machining or smoothing of the flange is required in order to ensure that the cylinder head contacting surface of the flange is smooth and flat, thereby allowing for the secure formation of a sealing attachment of the flange to the cylinder head. The exhaust side of the cylinder head requires similar machining or smoothing in order to provide a corresponding smooth and flat contacting surface of the cylinder head. Since the machining of these materials is difficult and time consuming, the overall cost of producing the engine is higher. Moreover, even with the machining or smoothing of the surfaces, a manifold gasket is required to ensure a good seal between the cylinder head and exhaust manifold. Further, this manifold gasket adds additional weight to the engine, and, over time, the manifold gasket may fail requiring expensive replacement (Schmidt, et. al., 2008).

A cylinder head has an intake port with an intake valve for selectively closing the intake port at an end thereof at an intake valve seat. The intake port has a substantially circular cross section in an area adjacent the intake valve seat. The intake port cross section transitions from the substantially circular cross-section at the intake valve seat, into a substantially oblong cross-section (Ladell, et. al., 2001).

2.3 CYLINDER HEAD FOR 4-STROKE SINGLE CYLINDER ENGINE

An internal combustion engine includes a cylinder head and rocker box assembly that includes a duct arrangement that removes blow-by gases. In a first embodiment, a duct is formed from the upper surface of the cylinder head aligned with an opening in the bottom of the rocker box and proceeds to horizontal sections leading to a fitting with a line leading to an intake manifold. In a second embodiment, a single straight duct includes a straight angled portion extending downward at an oblique angle to the upper surface of the cylinder head to an intake port in the cylinder head. Action of the engine draws the unwanted gases from the rocker box through the opening of the ducts to an intake of the engine. Internal combustion engines produce gases in the combustion chamber that are forced under pressure past the piston and into the engine's crankcase. Such gases are typically an oil-laden mist and are often referred to as “blow-by” gas. The piston motion causes pressure fluctuations in the crankcase forcing the blow-by gases to be routed back toward the engine carburetor. Such leakage leads to accumulations of oil in the combustion chamber and elsewhere and may interfere with engine operation. Such blow-by may also lead to a buildup on the air filter and a decrease in engine performance. The air filter, seals and other components may have to be replaced after a much shorter interval due to blow-by. It can be appreciated that a blow-by removal system is needed that overcomes the problems associated with the prior art. Such a system should provide for simple manufacture and positive removal of the blow-by gases. Such a system should provide for improved removal efficiencies while maintaining the structural integrity of the cylinder head and avoiding difficult to manufacture channels. The present invention addresses these as well as other problems associated with removal of blow-by gases in internal combustion engines (Sjovall, et. al., 2005).

2.4 INTAKE AND EXHAUST PORTS FLOW

Engine cylinder intake ports, may be configured to induce rotation or swirl of the fuel/air intake change as it is supplied to the combustion chamber. Generally, intake port designs which are intended to induce such charge swirl lack effectiveness across the full operating or lift range of the engine intake valves. While some designs are effective to induce swirl at low valve lift, they lose substantial effectiveness at high valve lift. Similarly, intake port designs intended to induce charge swirl at high valve lift have had little effect on the charge flow direction at low valve lift. In general, intake port configurations, which have been effective in creating significant charge swirl during both low and high valve lift operation, have also due to increased resistance to flow, resulted in a reduction of the fuel/air charge mass entering each cylinder during the intake stroke, reducing the volumetric efficiency of the engine.

In a single cylinder engine, the maximum output performance achievable is related to the amount of air that is trapped in the combustion chamber. This is defined by volumetric efficiency, which is the ratio of the mass of air trapped in the cylinder to that contained in the swept volume of the cylinder at inlet manifold density. If the volumetric efficiency could be increased significantly even at low speeds, the engine output would be expected to be higher.

It has long been realized that the design of air intake manifolds has a large effect on the performance of reciprocating engines. The unsteady nature of the induction means that the effect of the manifold on charging and discharging is dependent on the engine speed. The manifold must be designed to enable the engine to ingest air (Willard W. P., 2004), and thus the inside diameter of the manifold must be able to accommodate for the bulk air flow in order to avoid low volumetric efficiency. On the other hand, if the manifold flow path is too restrictive, the desired high air velocity and turbulence cannot be assured, and this will consequently affect its capability in carrying fuel droplets as well as in enhancing evaporation and air-fuel mixing (Winterbone, et. al., 1999). In order to minimize flow resistance, the manifold should have no sharp bends and the interior wall surface should be smooth. Furthermore, the impedance of the manifold is a function of the frequency of the pulses entering it (Fontana, et. al. 2003), and thus it is possible to tune engine manifolds to give a particular power output characteristic as a function of speed.

Study on the effect of geometry of intake manifold was previously done using various designs, without changing the engine specifications, at wide open throttle condition (Winterbone, et. al., 1999). The intake manifold used was of a modular construction so that the primary pipe length, plenum volume and secondary pipe length could be varied. It was reported that the plenum volume could have a profound effect on the control at idling speed, which could be beneficial, although it reduced the engine's performance. The motion of fluid into the combustion chamber is important to speed up the evaporation of fuel, to enhance air-fuel mixing and to increase combustion speed and efficiency (Kay, I.W., 1978). Due to the high velocities involved, the air flows within the engine system is turbulent, which causes the thermodynamic heat transfer rates within the engine to increase by an order of magnitude. As the engine speed increases, the flows rate increases, and consequently increases the swirl, squish and turbulence intensity (McLandress, et. al., 1996). This increases the real time rate of fuel evaporation, mixing of the fuel vapor and air and combustion. The high turbulence near the top-dead-center when ignition occurs is very desirable for combustion, as it breaks up and spread the flame front many times faster.

Shown in Figure 2.6 is the variation of air flow rate into the combustion chamber with the valve lift, as measured in the experiment. In general, it is shown that the trend of increment of flow rate with valve lift is similar for all test variation. Nevertheless, the rate change of flow rate can be divided into three regimes: A, B and C.