BORANG PENGESAHAN STATUS TESIS

JUDUL: **MODELLING AND FABRICATION OF INTAKE VALVE FOR PERODUA KANCIL ENGINE**

SESI PENGAJIAN: **2007/2008**

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MODELING AND FABRICATION OF INTAKE VALVE FOR PERODUA KANCIL ENGINE

NOR NASHRIQ AZIZI B ABD SHUKOR

A report submitted in partial fulfillment of the requirements for the award of the Diploma of Mechanical Engineering

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

NOVEMBER 2007

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SUPERVISOR'S DECLARATION

I hereby declare that I have read this project thesis and my opinion this project thesis is sufficient in terms of scope and quality for the award of the Diploma of Mechanical Engineering.

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Date : ..21/11/2007...............

DECLARATION

I hereby declare that this report entitled "Modeling and Fabrication of Intake Valve for Perodua Kancil Engine" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently.

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Date : 21 NOVEMBER 2007

DEDICATION

To my beloved parents, Mr. Abd Shukor B Lodin and Mrs. Rohaya Bt. Samad, family and friends, without whom and his/her lifetime efforts, my pursuit of higher education would not have been possible and I would not have had the chance to study for a mechanical course. Also to my supervisor, Mr. Nik Mohd Izual B Nik Ibrahim and Mechanical Staff, without whose wise suggestions, helpful guidance and direct assistance, it could have neither got off the ground nor ever been completed. Thanks a lot to my university and my friends in their support and advice towards this project. Thanks to all for your enduring patience and continuous encouragement.

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ABSTRACT

This project tell about how to produce intake valve for Perodua Kancil engine. Objective for this project is to modeling and fabricating intake valve. The material that use is aluminium. Idea to fabricate this intake valve come after have many new model and shape in market. In that case, the information about how to produce the intake valve easy to get in internet. Three dimensional drawing for this intake valve is using Solidwork software, COSMOS Flow software to analysis about flow movement and produce by CNC Lathe Machine. In market, this intake valve is made by casting proses and finalize by turning (lathe) process. But, for this project, the intake valve is fully produce by CNC Lathe Process (turning process)

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Final year project is one of the subjects for this semester. In this subject, a project needs to do to fulfill the subject requirement. This project involves modeling and fabrication of intake valve for perodua kancil engine.

1.2 Problem Statements

In industry, valve normally produced by casting process. In this project, the valve is made by CAM method using CNC Lathe Machine.

1.3 Project Objectives

This project should be finished until the defect can be minimized. This project is apply the lesson and knowledgeable that we learn before. Then, we can practice the skill and solving the problem using academic study. This project also, to enhance a student skill and ability to work individually and work as a team. It also gives us, an experience and knowledge. So the objectives of this project are to fabricate intake valve for 660cc Perodua Kancil engine.

1.4 Project Scope

Basically, this project is base on these scopes of work:

a) 3D CAD modeling of the original production intake valve
b) 3D CAD modeling of the modified intake valve
c) Simulate flow around the valve using COSMOS flow
d) Machining of the original and modified intake valve using CAM Method

1.5 Project Organization

Chapter 2: Literature review. This chapter show about basic components in valve train, the main function of each component, valve clearance and other type of valve.

Chapter 3: Methodology. First, the intake valve is measured by vernier caliper and draw in Solid Works Software. The modified valve must be drawing basic on original production valve. Then simulate the drawings using Cosmos Flow Software. After that, CNC code (G-codes) must be created before transfer to machine.

Chapter 4: Result discussion. The result is get from CFD simulation like cut plot, flow trajectories, graph pressure versus curve length and velocity versus curve length.

Chapter 5: Conclusion. Valve can be fabricate using machining process (CNC lathe machining) and simulate flow inside the cylinder can be done using Cosmos Flow Software (CFD).

Table 1.1: Project planning

Activities	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Title														
Verify main supervisor														
Verify project title														
Verify objectives & scope of project														
Literature review														
Valve train components														
Operating principle														
Get article from sciencedirect.com														
Methodology														
Measuring intake valve														
Engineering drawing														
CFD simulation														
Fabrication														
Result & discussion														
Conclusion														
Final presentation & complete report														

CHAPTER 2

LITERATURE STUDY

2.1 Introduction

This chapter contains about internal combustion engine, 4-stroke principle, companion cylinder, valve train and CNC Lathe machine. There are 7 basic components in valve train like valve, spring, rocker arm, lifters, camshaft, timing belt and crankshaft. Each engine cylinders have at least two valves, an intake valve and exhaust valve. The intake valves open just before the intake stroke begins. These allow the air-fuel mixture to enter the cylinder. The exhausts open just before the exhaust stroke begins so the burn gases can escape from the cylinder. 4 stroke cycle requires two 360° revolutions (720°) of the crankshaft. At the same times, the intake and exhaust valve each open once. Valves are opened by the camshaft. The camshaft and crankshaft are connected by timing belt or chain. There are half as many teeth on the crank drive on the cam drive.

2.2 Internal Combustion Engine

An engine is a machine that converts heat energy into mechanical energy. The heat from burning a fuel produces power which moves the vehicle. Sometimes the engine is called the power plant. Automotive engines are internal-combustion (IC) engines because the fuel that runs them is burned internally, or inside the engines. There are 2 types [1];

a. *Reciprocating engine* (Figure 2.1) – means moving up and down or back and forth. Most automotive engines are reciprocating. They have pistons that move up and down or reciprocate, in cylinders. These are piston engines

b. *Rotary engine* (Figure 2.2) – have rotors that spin or rotate. The only such engine now used in automobiles is the Wankle engine

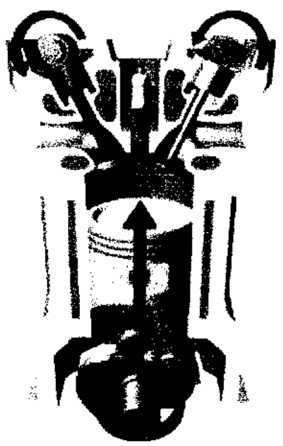


Figure 2.1: Reciprocating engine

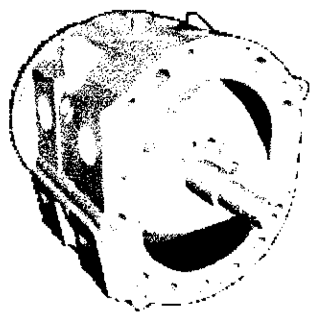


Figure 2.2: Rotary engine

2.3 4-Strokes Engine

A stroke is the movement of the piston from TDC (top dead center) to BDC (bottom dead center). They are 4 strokes in one 4 strokes cycle of the engine. They are called the intake stroke, compression stroke, power stroke and exhaust stroke [2].

i. *Intake stroke* – petrol will not burn unless it is mixed with the correct amount of air. It is very explosive when one part is mixed with about 15 parts of air. As the crankshaft turns, it pulls the rod and piston down in the cylinder. This action creates a suction known as engine vacuum, which draws in a mixture of air and fuel through the open intake valve. About 10,000 gallons of air is drawn in for every 1 gallon of fuel. The air and fuel mixture is supplied by the carburetor or by the fuel injection system. The ideal mixture (called stoichiometric) for the combined purpose of engine performance, emission control and fuel economy is about 14:7:1 [2].

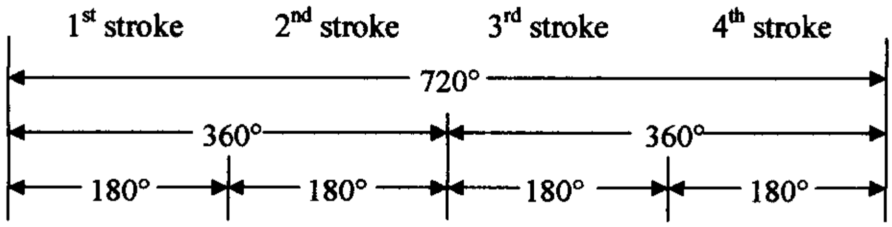
ii. *Compression stroke* - a puddle of petrol that is lit on fire in open air does not produce power. If it is confined in a cylinder, usable power can be produced. Compressing the mixture of air and fuel into a smaller area makes it easier to burn. The compression stroke begins at BDC after the intake stroke is complete. The intake valve closes and the piston moves up in the cylinder, compressing the air and fuel mixture. As the piston moves toward TDC, the mixture is compressed to about 1/8 of the volume is occupied when the piston was at BDC. In this case, the compression ratio is said to be 8:1. If the mixture is compressed to 1/12 its original volume, the compression ratio is then 12:1 [2].

iii. *Power stroke* – as the piston approaches TDC on its compression stroke, the compressed air and fuel mixture becomes very explosive. When the ignition system generates a spark at the spark plug, the fuel ignites. As the fuel mixture burns, it expands, forcing the piston to move down in the cylinder until it reaches BDC. The action of the piston turns the crankshaft to power car. The power stroke is sometimes called the expansion strokes [2].

iv. *Exhaust stroke* – as the piston near BDC on the power stroke another valve open, allowing the spent gases to escape. Because the burning gases are still expanding, they are force out trough the open exhaust valve. As the crank continues to turn past BDC, the piston moves up in the cylinder, helping to force the remaining exhaust gases out trough the open exhaust valve. A few degrees after the piston passes TDC, the exhaust valve closed. The entire 4 stroke cycle repeats itself [2].

2.4 Companion cylinders

Any engine with an even number of cylinders will have pairs of cylinder called companion cylinders, or running mates. The pistons go up and down in pairs. When one piston is starting its power strokes, its companion piston is at the start of its intake stroke. To find out which cylinder are companions, take the first half of the engine's firing order and place it above the second half [2].



	1st stroke	2nd stroke	3rd stroke	4th stroke
1st cylinder	Power	Exhaust	Intake	Compression
2nd cylinder	Compression	Power	Exhaust	Intake
3rd cylinder	Intake	Compression	Power	Exhaust
4th cylinder	Exhaust	Intake	Compression	Power

Figure 2.3: Companion cylinders

Figure 1.31 it appears that the same carburetor for a single cylinder engine could theoretically be use to operate a four cylinder engine that had cylinders of nearly the same displacement. It appears that the 4 stroke engine only uses the carburetor during the intake stroke. But the engine actually breathes air and fuel for a period of time longer than the intake stroke's 180° of crankshaft rotation. The valves start to open before TDC and closes after BDC when crankshaft has traveled considerably into the compression stroke. The reason for this is to allow the cylinder to fill with as much air and fuel mixture as possible. A single carburetor on this engine would have to be larger so it could serve more than one cylinder at a time because of the overlapping intake strokes.

2.5 Valve

Each engine cylinder has at least 2 valves, an intake valve and exhaust valve. The intake valves open just before the intake stroke begins. These allow the air-fuel mixture to enter the cylinder. The exhaust valve opens just before the exhaust stroke begins so the burned gases can escape from the cylinder. The intake valve is usually larger than the exhaust. The reason is that when the intake valve is open, the only force moving air-fuel mixture into the cylinder is atmospheric pressure. When the exhaust valve opens on the exhaust stroke, there is still high pressure in the engine cylinder. A smaller exhaust valve provides enough space for the high pressure exhaust gases to get out of the cylinder. Some valves have chrome-plated stems and a hard alloy tip welded onto the stem end. This reduces wear on these two areas. Other valves have a hollow stem to reduce valve weight. Lighter valves reduce the effects of inertia. These increase engine power and responsiveness [1].

2.5.1 Valve Arrangement

a) *L-Head Engines* – The L-head engine has the valves and the camshaft in cylinder block. This arrangement was once popular for automotive engine. Now, it is used only in small engine for lawn mowers and similar equipment. These are applications where light weight and simplicity are important. The L-head engine has two drawbacks for automotive use. First, it cannot be designed to have a high compression ratio. The higher compression ratio, the more power the engine produces. Second, the L-head engine has excessive exhaust emissions. The exhaust gas contains too much unburned and partly burned fuel. The reason is that the combustion chamber surface are large and relatively tool. This prevents combustion of the layers of air-fuel mixture close to those surfaces.

b) *Overhead-Valve Engine* – In an overhead valve or pushrod engine, the camshaft is in the cylinder block and the valves are in the cylinder head. Overhead-valve engine have higher compression ratios than L-head engines. Locating the valves directly over the piston permits the clearance volume to be smaller. This is the volume above the piston at TDC. When the air-fuel mixture is compressed into a smaller space, the compression ratio is higher. This means more engine torque and power. Some overhead-valve engines have *valve reliefs* cut into the piston heads. The valve reliefs provide space into which the valves can open without striking the piston.

c) *Overhead-Camshaft Engines (OHC)* – Many newer engine designs place the camshaft on the cylinder head. One reason for the shift to OHC engine is that pushrod and rocker arms have inertia. They resist changing speed and direction. Pushrod and rocker arm inertia effect valve action. They resist moving until sufficient force is applied to them. As a result, the rocker arm and pushrod bend or flex before they open the valve. With the camshaft on the cylinder head, the cams can act directly on the bucket tappets or rocker arms.

d) *Multi-Valve Engine* – Engine with more then two valves per cylinder are referred to as multivalve engine. The additional valves allow more air-fuel mixture to enter and the exhaust gas to escape more easily. This improves the volumetric efficiency of the engine. Also, the valve head diameter is smaller and the valves weight less. This reduces the effects of inertia and reduces the valve-spring force needed to closer a larger valve at high engine speed.

2.6 Valve Train

i. *Crankshaft* – Sometimes casually abbreviated to crank, is the part of an engine which translates reciprocating linear piston motion into rotation. It typically connects to a flywheel, to reduce the pulsation characteristic of the four-stroke cycle, and sometimes a torsional or vibrational damper at the opposite end, to reduce the torsion vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the torsional elasticity of the metal [3].

ii. *Timing Belt* - A timing belt is a part of an internal combustion engine that controls the timing of the engine's valves. The term "timing belt" is also used for general case of any flat belt with integral teeth. Such belts are used for power transmission or to interchange rotary motion and linear motion. A common non-automotive application is in linear positioning systems. Such belts have also been used in efforts to make a cleaner, lower-maintenance bicycle transmission but have never become popular in this application. In the internal combustion engine application, the timing belt connects the crankshaft to the camshaft(s) which in turn controls the opening and closing of the engine's valves. A four-stroke engine requires that the valves open and close once every other turns of the crankshaft. The timing belt does this. It has custom teeth to turn the camshaft(s) synchronized with the crankshaft and is specifically designed for a particular engine. In some engine designs, the timing belt may also be used to drive other engine components such as the water pump and oil pump [4].

iii. *Camshaft* - The camshaft is an apparatus often used in piston engines to operate poppet valves. It consists of a cylindrical rod running the length of the cylinder bank with a number of oblong lobes or cams protruding from it, one for each valve. The cams force the valves open by pressing on the valve, or on some intermediate mechanism, as they rotate [5].

iv. *Rocker arms* – A rocker arm is a pivoted lever that transfers cam or pushrod motion to the valve stem. Many rocker arms are made of stamped steel. Others are forged or cast aluminum. Some rocker arms are adjustable. One type of stud mounted rocker arms is adjusted by turning the stud nut. Other rocker arms have an adjustment screw or nut in one end [1].

v. *Valve Lifters (Tappets)* - In some OHC engine, the cam lobe motion is sent directly to the valve stems by bucket tappets. Other OHC engine transmits cam lobe motion through rocker arms to the valve stems. There are 2 types of valve lifters. These are mechanical and hydraulic [1].

vi. *Springs* – There are many types of valve springs. A simple spring has a uniform pitch (rate). Other springs have a variable pitch that changes as the spring is compressed [2].

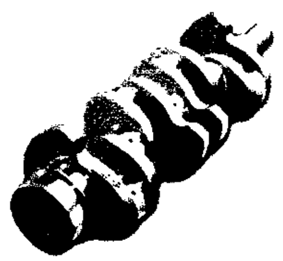


Figure 2.4: Crankshaft

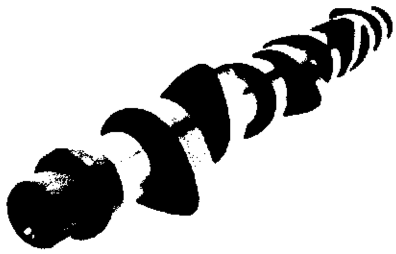


Figure 2.5: Camshaft

Figure 2.6: Valve

Figure 2.7: Spring

Figure 2.8: Valve lifters

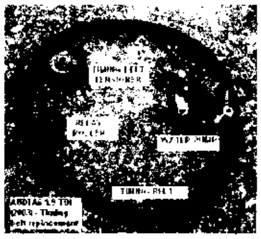


Figure 2.9: Timing belt

Figure 2.10: Rocker arms

2.7 Valve Clearance Measurement

Valve clearance is measured with the valve closed, typically at Top dead centre of the compression stroke. The tappet will be resting on the heel of the cam lobe. A feeler gauge must pass through the clearance space. The feeler gauge should fit in and out with a slight drag. If the feeler gauge will not fit in, then the clearance is too small. If the blade of the feeler gauge fits in too loose then the clearance is too big [6].

2.8 Valve Clearance Adjustment

Valve clearance refers to the small gap between valve lifter and valve stem (or rocker arm and valve stem) that ensures that the valve completely closes, an expansion joint in the valve train. Most engines have the valve clearance set by grinding the end of the valve stem during engine assembly, overhead cams not needing subsequent adjustment. In earlier engines, (mostly with push rods and rocker arms) used adjustable tappets or hydraulic tappets to adjust for valve and cam wear. Lack of valve clearance will prevent valve closure causing leakage and valve damage [6].

2.9 Port Flow

There are many common design and porting strategies to increase flow. Increasing the diameter of the valves to take up as much the cylinder diameter as possible to increase the flow through the intake and exhaust ports is one method. However, increased valve size can decrease valve shrouding (the impedance of flow created by the cylinder floor.) To counter this, valves are commonly designed to open into the middle of the cylinder (such as the Chrysler Hemi or the Ford Cleveland engines with canted valves). Also, increasing valve lift, or the distance valves are opened into the cylinder or using multiple smaller valves can increase flow. With the advent of computer technology, in modern engines valves events can be controlled directly by the engine's computer, minimizing engine operation at any speed or load [6].

2.10 CNC Lathe Machine

CNC Lathes machines – a conventional engine lathe or turret lathe is a common machine is just about every machine shop. A lathe is used for machining cylindrical or conical work, such as shafts, rings, wheels, bores, threads, etc. The most common lathe operation is removal of material from a round stock, using a turning tool for external cutting. A lathe can also be used for internal operations such as boring, as well as for grooving, threading, if a proper cutting tool is used. Engine lathes has often only one or two cutting tools mounted at a time, but have more machining power [7].

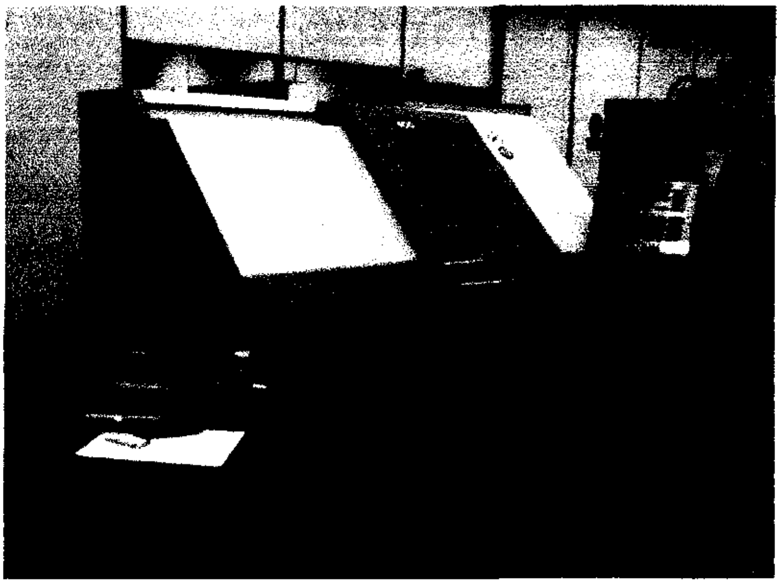


Figure 2.11: CNC lathe machine (DMG Fanuc)

2.11 Summary

Internal combustion engine is converts heat energy into mechanical energy. They are 4 strokes in one 4 strokes cycle of the engine. They are called the intake stroke, compression stroke, power stroke and exhaust stroke. Each engine cylinder has at least 2 valves, an intake valve and exhaust valve. Valve train has 7 basic parts: crankshaft, timing belt, camshaft, rocker arms, lifters, spring and valve. A CNC lathe machine is used for machining cylindrical or conical work, such as shafts, rings, wheels, bores, threads and etc.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter contains about how to measure and design the intake valve. The intake valve is draw using Solidworks software and CosmosfloWorks software to make a simple analysis about flow movement in combustion chamber four strokes engine. It takes a several step to obtain the result. Also, this chapter shows the G-Code for original intake valve and modified intake valve follow the DMG Fanuc rules. Lastly, machining process is continued to produce the intake valve.

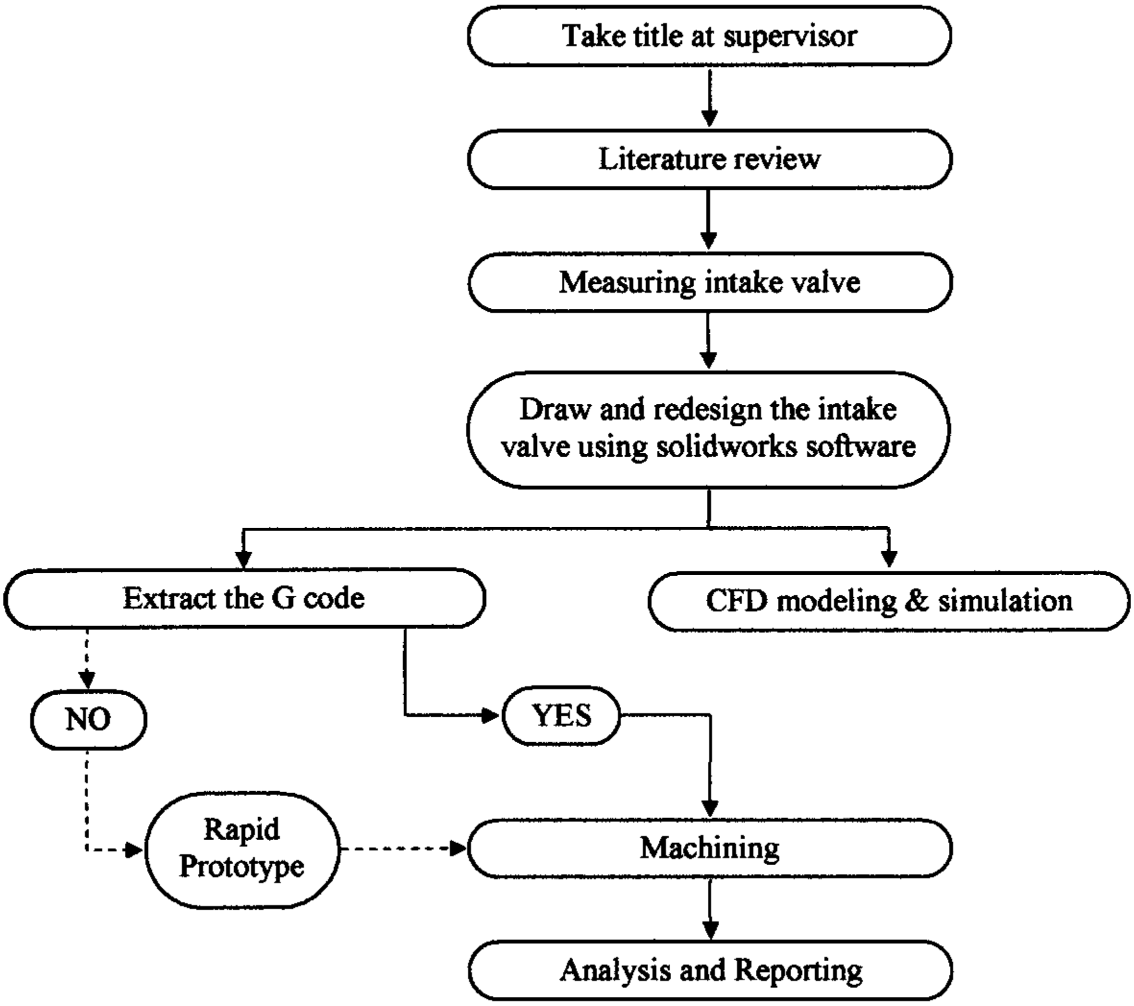


Figure 3.1: Planning process

3.2 Measuring Intake Valve

The equipment that use is vernier calipers with scale 0.02 millimeter.

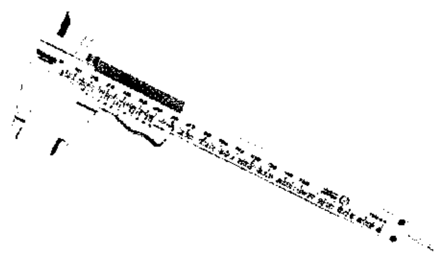


Figure 3.2: Vernier caliper

3.3 Engineering Drawing

Solidworks software is used to draw all 4 valves with different shape and size. The drawings include two and three dimensional view.

3.3.1 Original Intake Valve

The precise of this drawing is two decimal points. The dimension is fully same like original intake valve and not modified. Figure 3 show the three dimensional view while figure 4a and figure 4b show the two dimensional view.

Figure 3.3: Three dimensional drawing of original intake valve

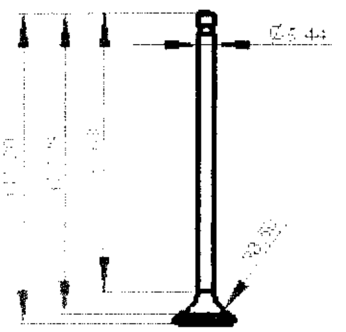


Figure 3.4: Two dimensional drawing of original intake valve

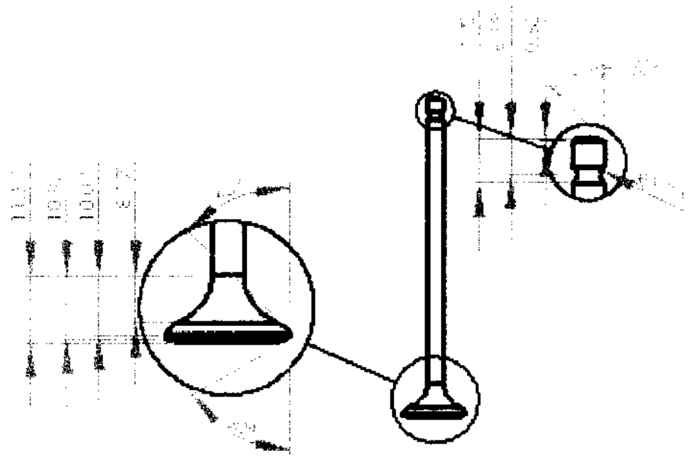


Figure 3.5: Two dimensional drawing of original intake valve (detail view)

3.3.2 Redesign Intake Valve

a. Original Intake Valve with Fin

The shape and size is quite same like original intake valve (Figure 3.2), but a pair of fin is added in bottom side.

Figure 3.6: Three dimensional drawing of original intake valve with fin

b. Modified Intake Valve

The chamfer in top side is discarding and diameter in bottom side is decrease with 0.5 millimeter.

Figure 3.7: Three dimensional drawing of modified intake valve

c. Modified Intake Valve with Fin

The shape and size is quite same like modified intake valve (Figure 3.5), but a pair of fin is added in bottom side.

Figure 3.8: Modified intake valve

3.4 CFD Modeling and Simulation

COSMOSFloWorks is software to obtain fundamental fluid flow analysis capabilities such as internal and external steady state flow, incompressible and compressible flow, mixing of multiple fluids, heat transfer in solids, porous media, time-dependent analyses, gravitational effects, fans, volume sources, wall roughness, and advanced capabilities such as particle tracking, animation. It have a few step to crop the result. The step is [11];

a. Create a COSMOSFloWorks Project

i. Click **FloWorks, Project, Wizard.**

ii. Once inside the Wizard, select **Create new**

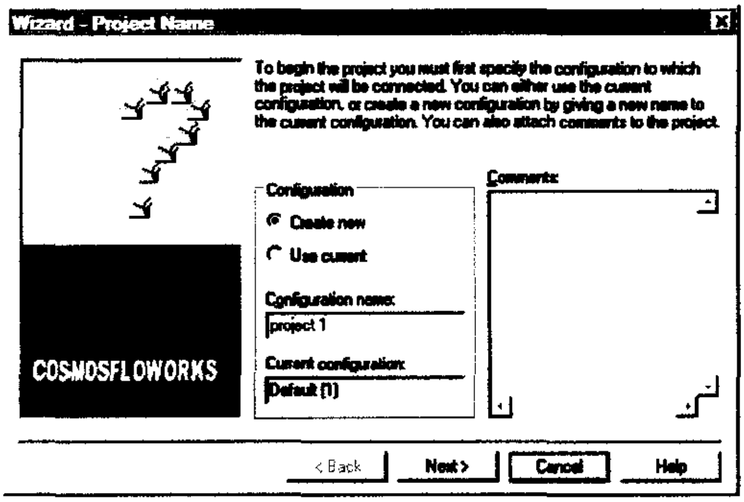


Figure 3.9: Project name

iii. Choose the system of units (**SI** for this project).

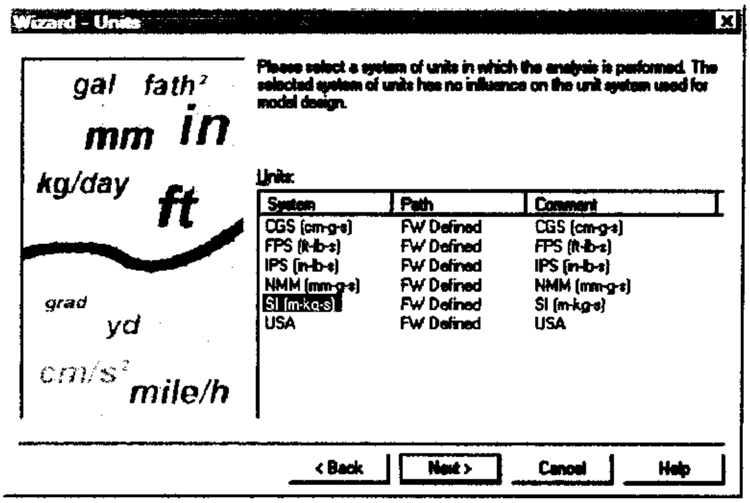


Figure 3.10: Units selected

iv. Set the fluid type to **Liquid**.

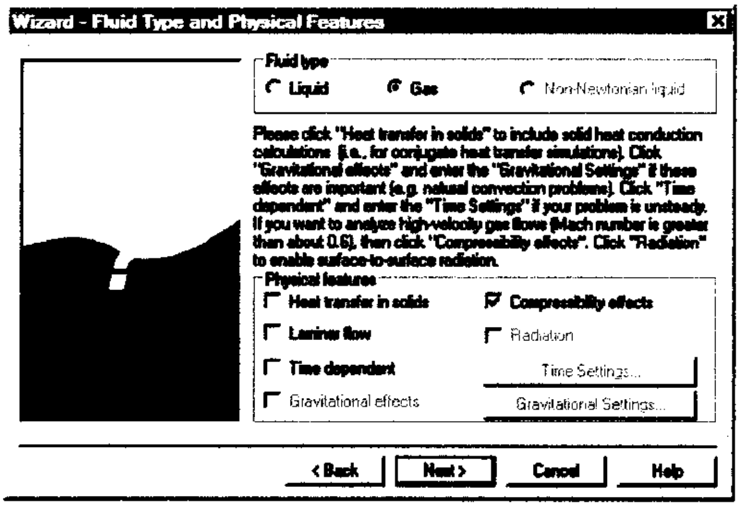


Figure 3.11: Fluid type and physical features

v. Set the analysis type to **Internal.**

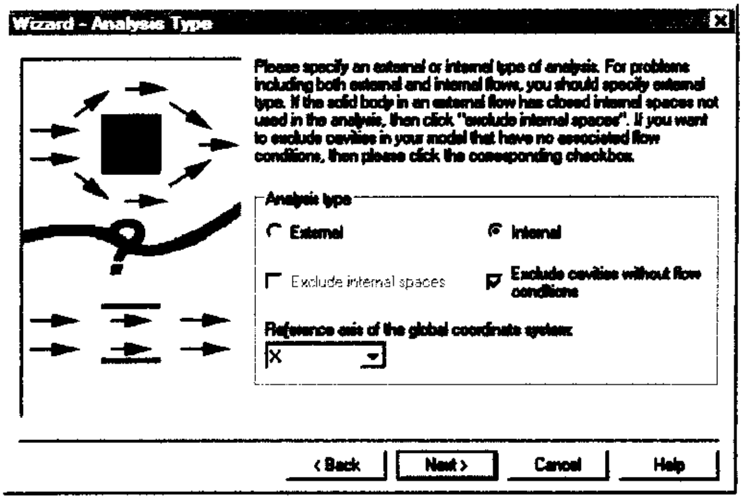


Figure 3.12: Analysis type

vi. Click **Next** to accepting the default zero roughness value for all model walls.

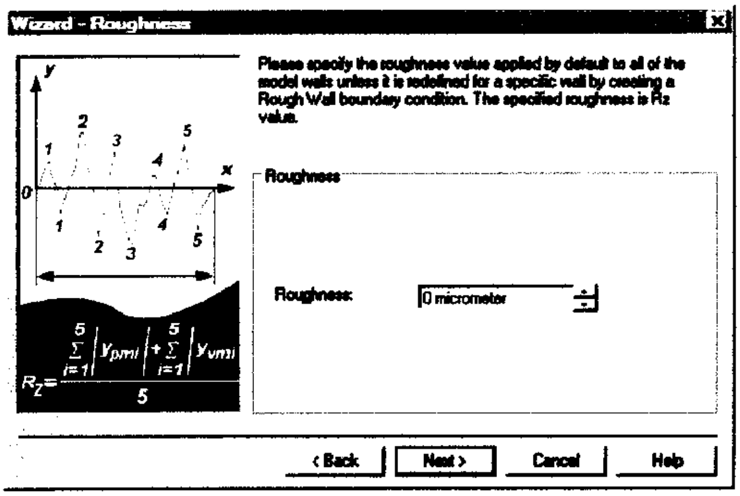


Figure 3.13: Roughness value

vii. Choose **Water SP** as the fluid. You can either double-click Water SP or select the item in the left column and click **Add**.

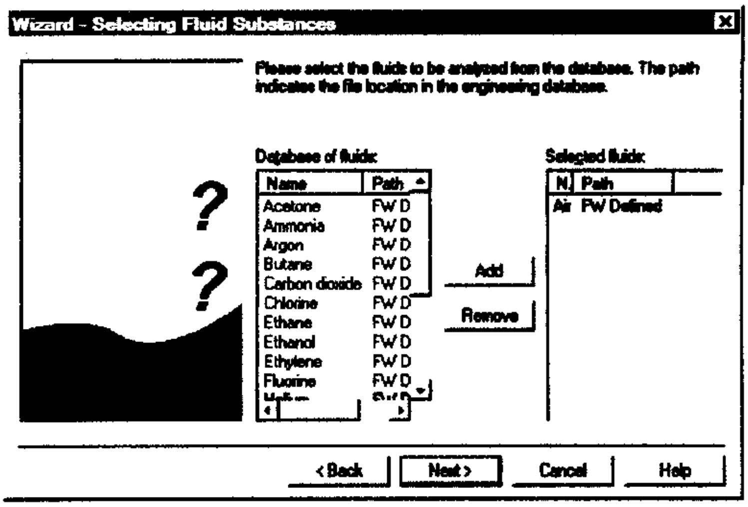


Figure 3.14: Selecting fluid substances

viii. Click **Next** accepting the default wall conditions.

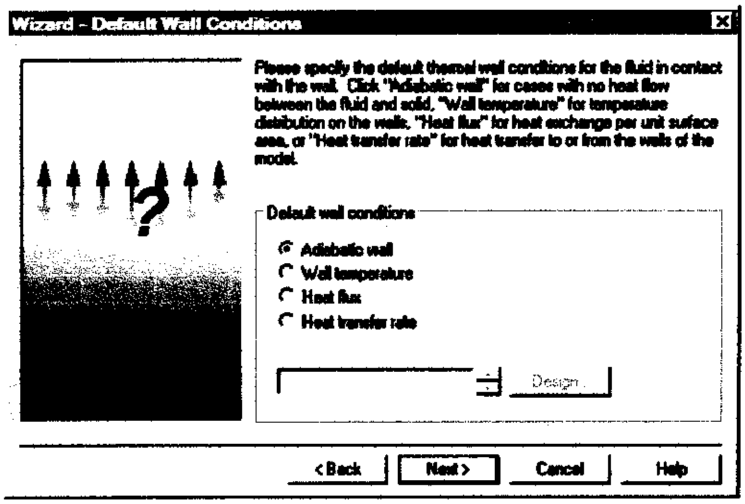


Figure 3.15: Default wall conditions

ix. Click **Next** accepting the default for the initial conditions.

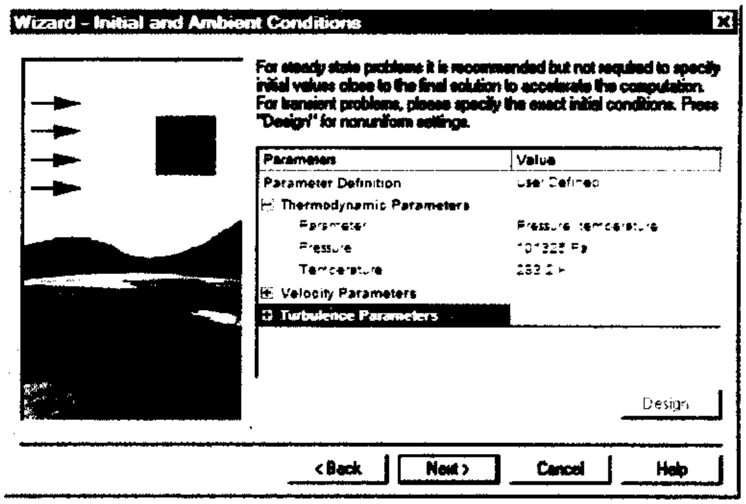


Figure 3.16: Initial and ambient conditions

x. Accept the default for the **Result Resolution**.

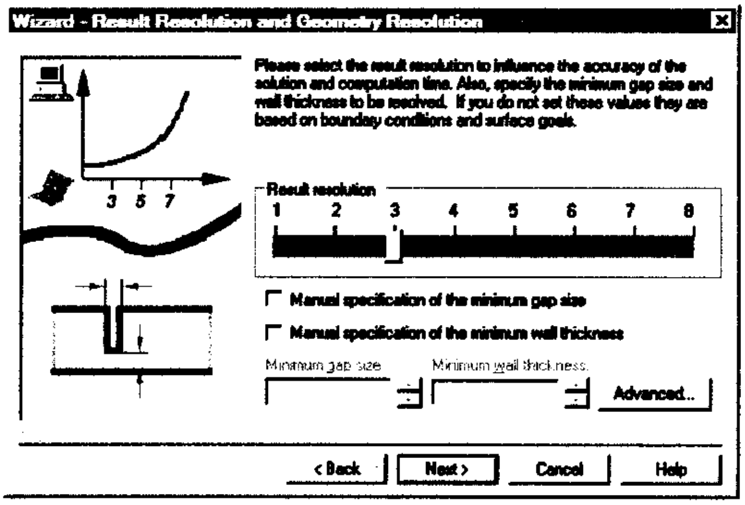


Figure 3.17: Result resolution and geometry resolution

xi. Click **Finish.**

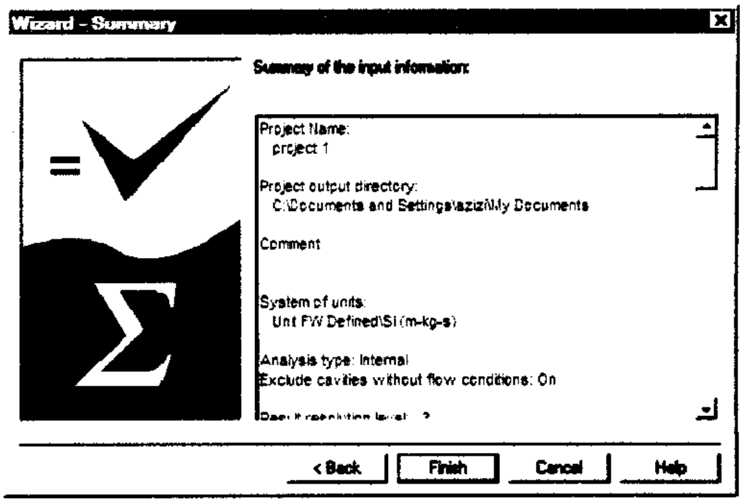


Figure 3.18: Summary

b. Show and set up the project

i. Click on the Solid Works **Configuration Manager** to show the new configuration.

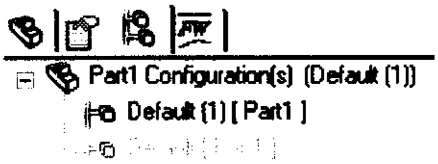


Figure 3.19: Configuration manager

ii. Go to the **COSMOSFloWorks Design Tree** and open all the icons.

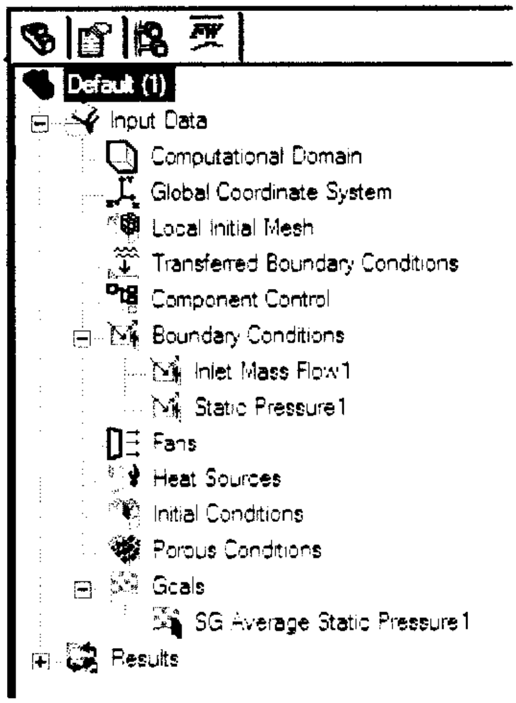


Figure 3.20: Design tree

iii. Right-click the **Computational Domain** icon and select **Hide** to hide the black wire frame box.

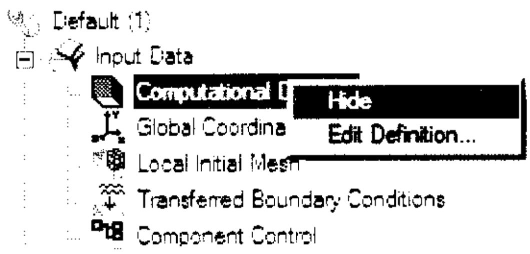


Figure 3.21: Computational domain

3.4.1 Boundary Conditions

Boundary Conditions is to create flow inlet and outlet boundary conditions, as well as wall conditions on selected fluid-contacting faces for both Internal and External flow analyses. Also thermal wall conditions can be created on selected external walls for internal flow analyses with "Heat transfer in solids". There are 10 steps;

i. In the COSMOSFloWorks Design Tree, right click the **Boundary Conditions** icon and select **Insert Boundary Condition.**

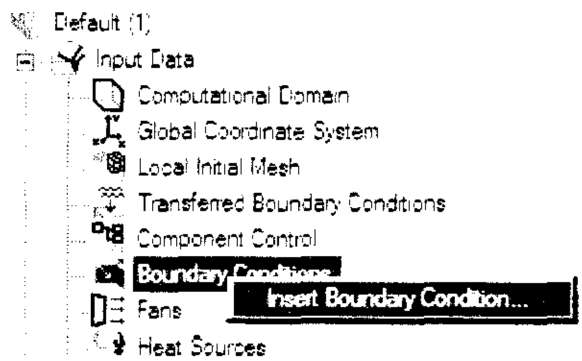


Figure 3.22: Boundary conditions inserted

ii. Select the **inner** face of the **Lid 1** part as shown.

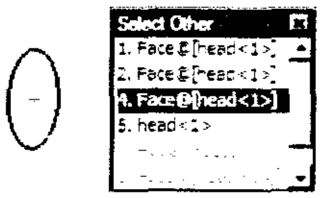


Figure 3.23: Inner face selected

iii. Select Flow **openings** and **Inlet Mass Flow**.

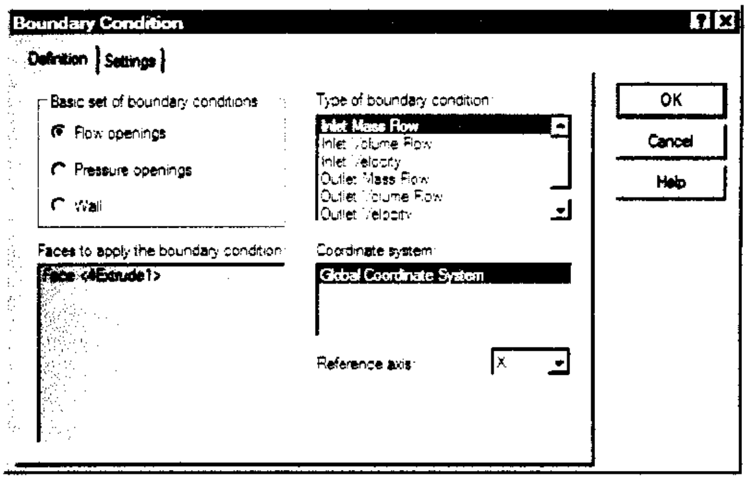


Figure 3.24: Flow openings

iv. Set the **Mass flow rate normal to face** to 0.5 kg/s under the **Settings** tab.

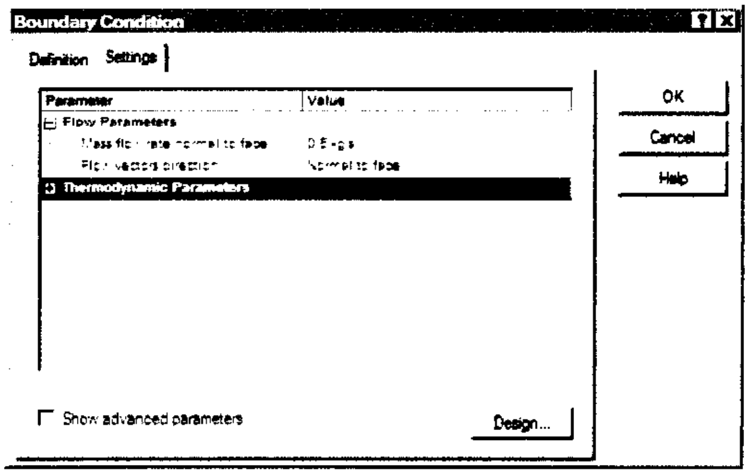


Figure 3.25: Boundary conditions (Settings Tab)

v. Click **OK**. The new **Inlet Mass Flow1** item appears in the COSMOSFloWorks Design Tree.

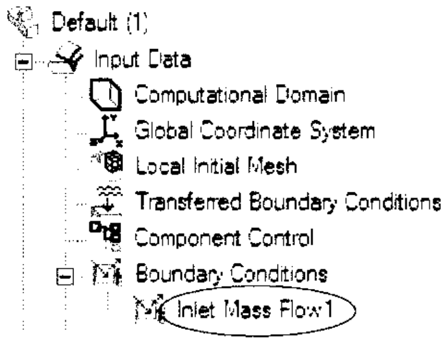


Figure 3.26: New inlet mass flow1

vi. Select the **inner** face of the **Lid 2** part as shown.

vii. Right-click the **Boundary Conditions** icon and select **Insert Boundary Condition**.

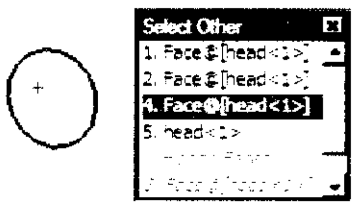


Figure 3.27: Inner face selected

viii. Select **Pressure openings** and **Static Pressure.**

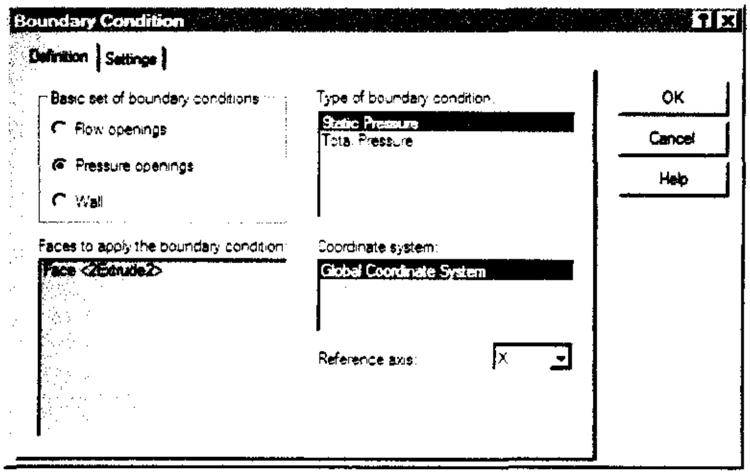


Figure 3.28: Pressure openings

ix. Keep the defaults under **Settings.**

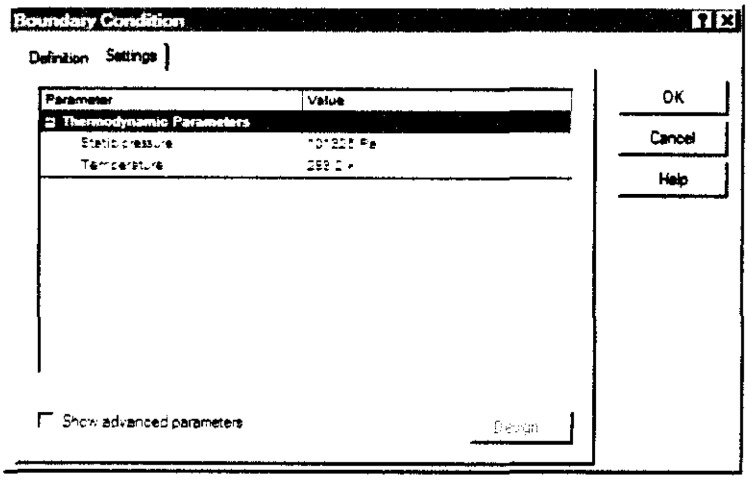


Figure 3.29: Boundary conditions (settings tab)

x. Click **OK**. The new **Static Pressure1** item appears in the COSMOSFloWorks Design Tree.

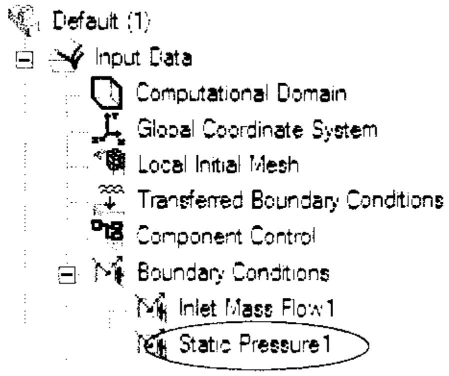


Figure 3.30: New static pressure1

3.4.2 Define the Engineering Goal

Surface Goal is a physical parameter calculated on a user-specified face of the model. There are total 6 steps and the steps are;

i. Right-click the COSMOSFloWorks Design Tree **Goals** icon and select **Insert Surface Goal.**

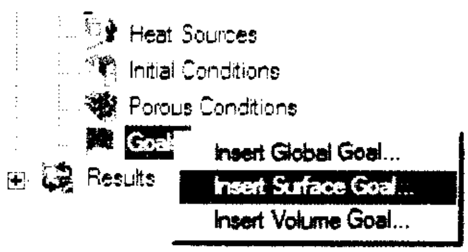


Figure 3.31: Surface goal inserted

ii. Click the **Inlet Mass Flow1** item to select the face where it is going to be applied.

iii. Select **Static Pressure** as **Goal type**.

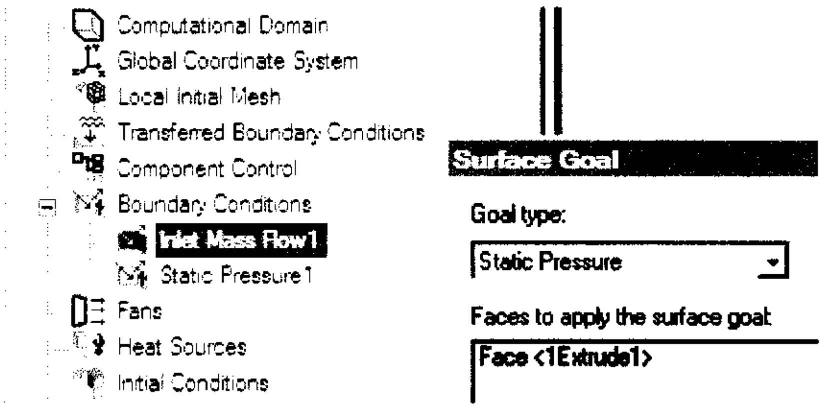


Figure 3.32: Goal type.

iv. Accept to **Use the goal for convergence control**. And keep the **Average Value.**

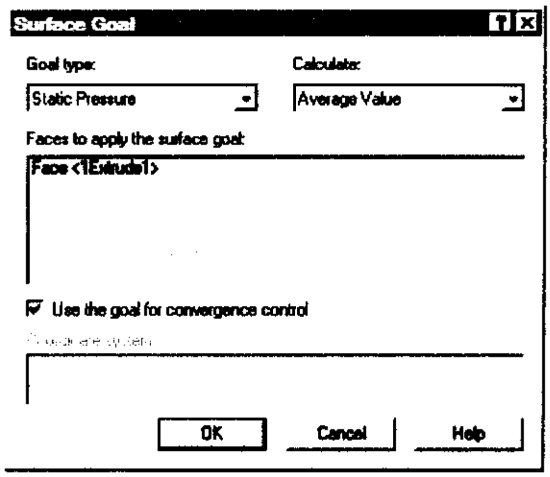


Figure 3.33: Surface goal

v. Click **OK**. The new **SG Average Static Pressure1** item appears in the COSMOS FloWorks Design Tree.

Figure 3.34: SG average static pressure1

vi. Click **File, Save.**

3.4.3 Solution

i. Click **FloWorks, Solve, Run.**

ii. Click **Run**.

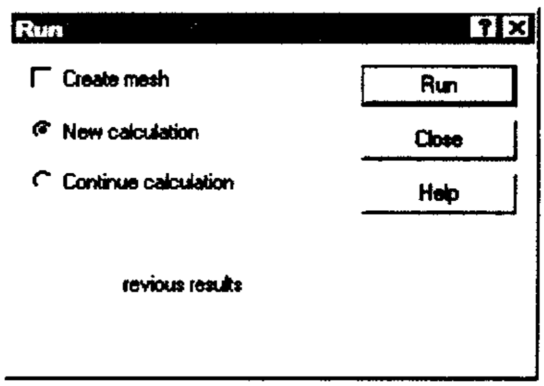


Figure 3.35: Solver

3.4.4 Monitor the Solver

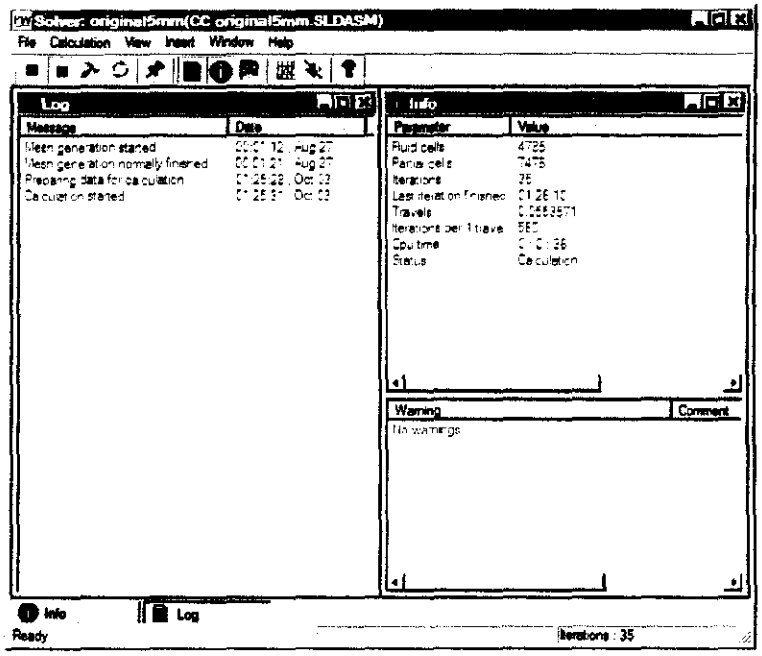


Figure 3.36: Click insert goal plot on the solver toolbar. The add/remove goals dialog box appears

i. Double-click the **SG Average Static Pressure1** in the **Available goals** list and click **OK**.

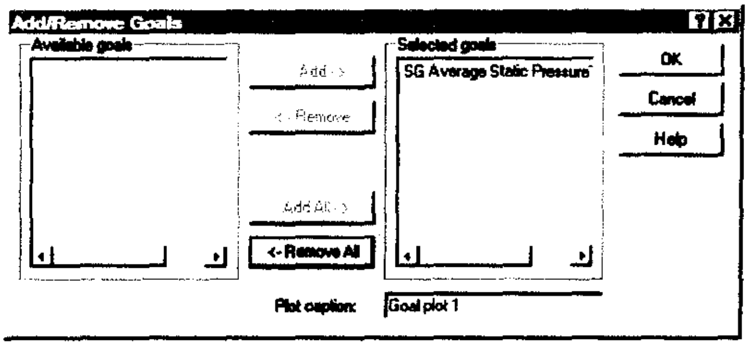


Figure 3.37: Add/remove goals

ii. Goal Plot 1 will appears

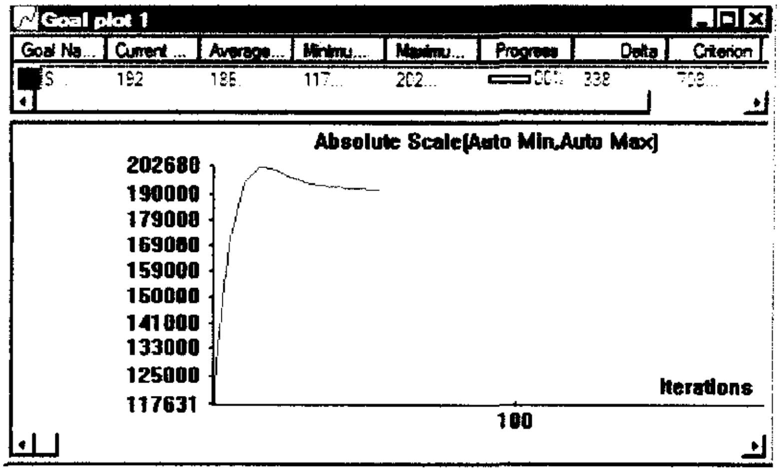


Figure 3.38: Goal plot 1

iii. Click **Insert Preview** on the **Solver** toolbar.

iv. This is the **Preview Settings** dialog box.

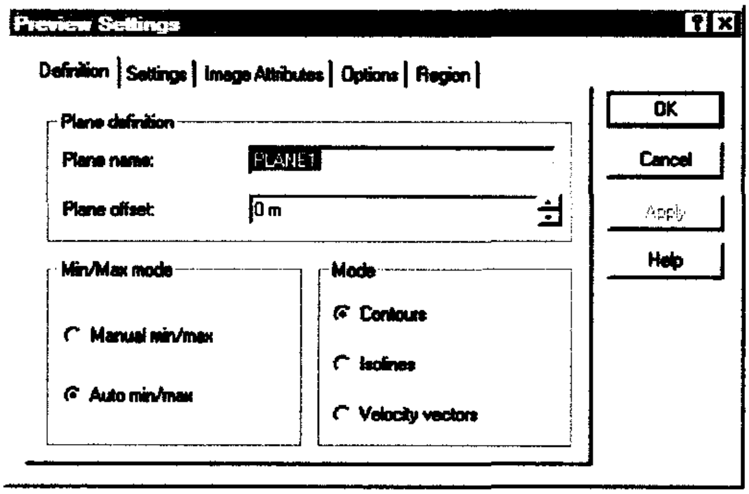


Figure 3.39: Preview settings

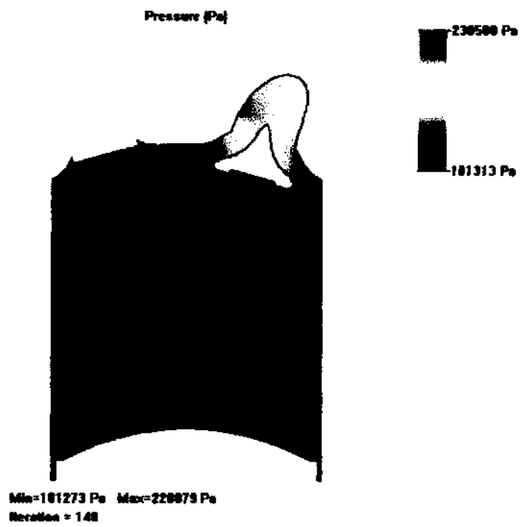


Figure 3.40: Pressure variation

v. When the solver is finished, close the monitor by clicking **File, Close**

3.4.5 Access the Results

i. Click **FloWorks, Results, Display, Transparency** and set the model transparency to 0.75.

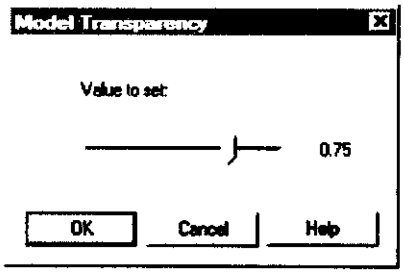


Figure 3.41: Model transparency

ii. Right-click the **Results** icon and select **Load Results** to activate the post processor.

Figure 3.42: Load the results

3.4.6 Cut Plots

Cut plot displays a section view of a parameter distribution. The parameter can be represented as a contour plot and as isolines. There are total 7 steps and the steps are;

i. Right-click the **Cut Plots** icon and select **Insert.**

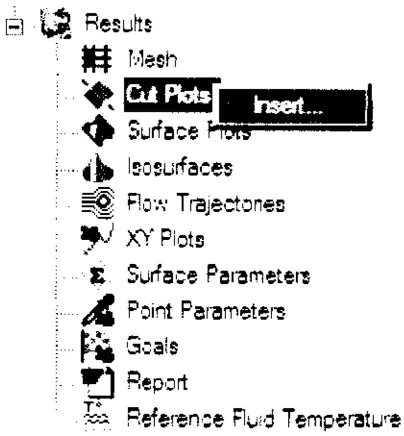


Figure 3.43: Cut plots inserted

ii. Specify a plane. Choose **Plane 1** as the cut plane. To do this, click on the Solid Works Feature Manager tab and select **Plane 1**. Click **OK**.

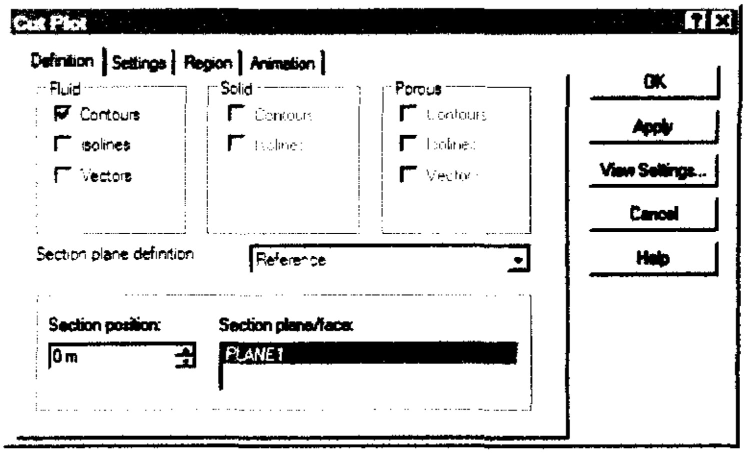


Figure 3.44: Cut plot

iii. To access additional options for this and other plots, either double-clicks on the color scale or right-click the **Results** icon and selects **View Settings**.

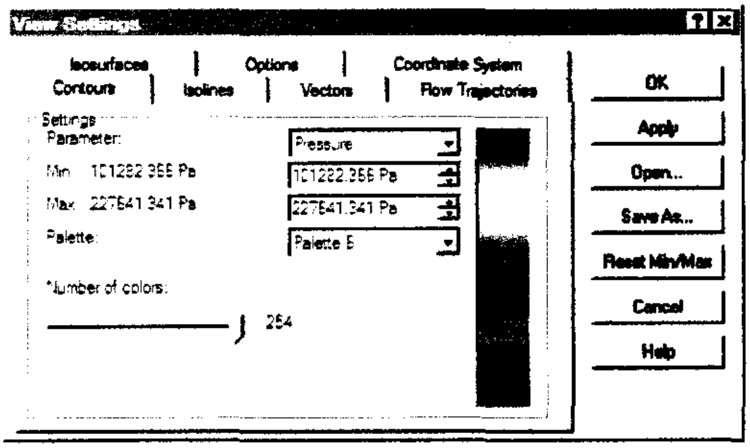


Figure 3.45: Contours setting

iv. Change the contour cut plot to a vector cut plot. To do this, right-click the **Cut Plot 1** icon and select **Edit Definition.**

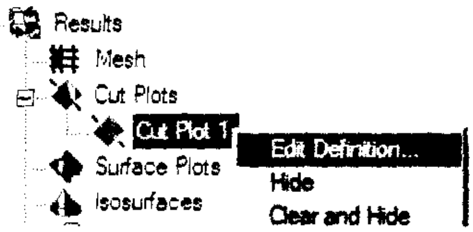


Figure 3.46: Edit definition for cut plot 1

v. Clear **Contours** and select **Vectors** in the plot definition.

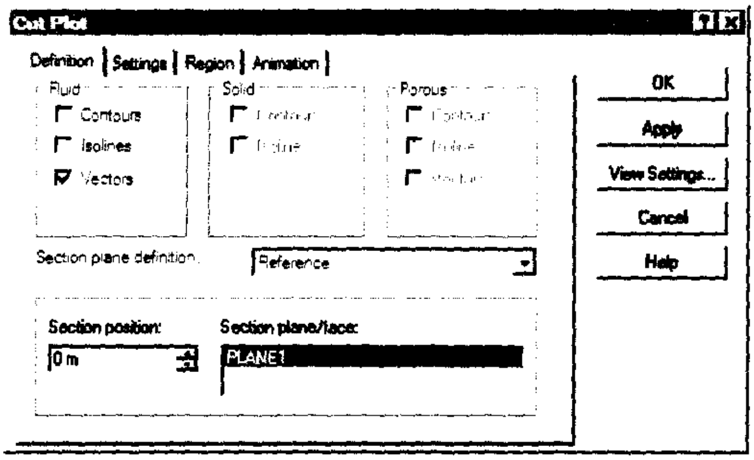


Figure 3.47: Cut plot (vectors)

vi. Click **OK**.

3.4.7 Surface Plots

Surface plot displays the parameter distribution on the selected model faces or SolidWorks surfaces. There are total 4 steps and the steps are;

i. Right-click the **Cut Plot 1** icon and select **Hide.**

ii. Right-click the **Surface Plots** icon and select **Insert.**

Figure 3.48: Surface plots inserted

iii. Select the **Use all faces** and **Contours** check box.

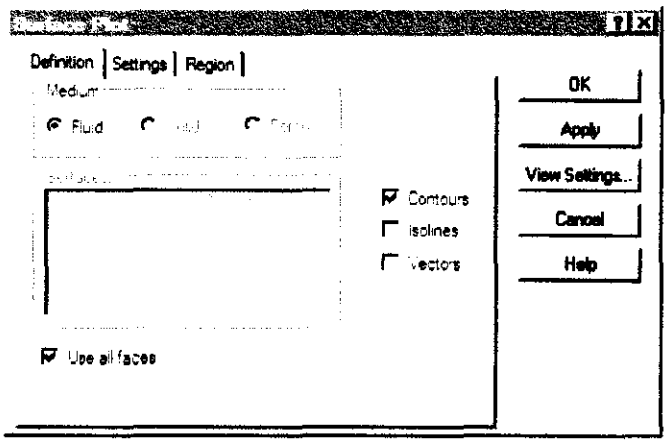


Figure 3.49: Surface plot

iv. Click **OK**

3.4.8 Flow Trajectory Plots

Flow Trajectory Plots display flow streamlines or as trajectories of physical particles. Flow streamlines are lines where the flow velocity vector is tangent to that line at any point of the line. Physical particles are spherical particles of specified material (liquid or solid) and constant mass. There are total 5 steps and the steps are;

i. Right-click the **Isosurfaces** icon and select **Hide.**

ii. Right-click the **Flow Trajectories** icon and select **Insert.**

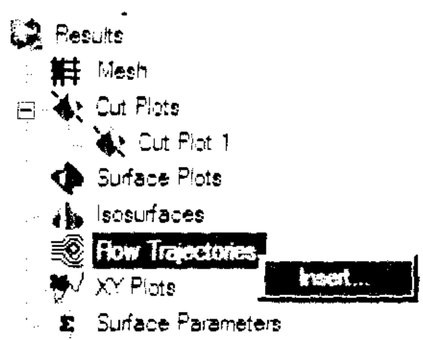


Figure 3.50: Flow trajectories inserted

iii. In the COSMOSFloWorks Design Tree, click the **Static Pressure1** item to select the **inner** face of the outlet **Lid 2** part.

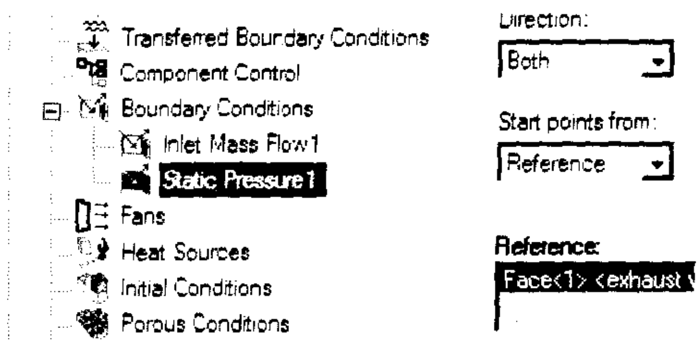


Figure 3.51: Flow trajectories

iv. Set the **Number of trajectories** to 16.

v. Click **OK**

3.4.9 XY Plots

XY-Plot is to see how a parameter changes along a specified direction. The data are exported into an Excel workbook, where parameter charts and values are displayed. There are total 3 steps and the steps are;

i. Right-click the **XY Plots** icon and select **Insert**.

ii. Choose **Velocity** and **Pressure** as **Physical parameters** (either double-click on them or mark and pick **Add**). Select **Sketch1** from the Solid Works Feature Manager. Leave all options as defaults.

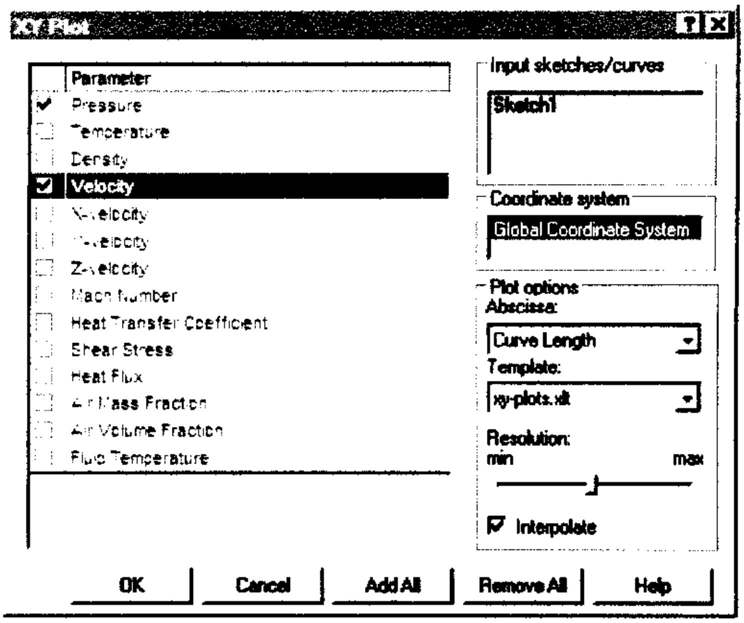


Figure 3.52: XY plot

iii. Click **OK**. MS Excel will open and generate two lists of data points as well as two graphs, one for Velocity and the other for Pressure. You will need to toggle between different sheets in Excel to view each graph.

3.5 Machining Process

The material that use is aluminium with 30 milimeter diameter. First, measure and cutting the material to 150 milimeter length using bansaw machine [Figure 3.43(b)]. Than, extract the G-Code follow the list from DMG Fanuc guide book. There are two G-Code, for original production valve and redesign valve. After that, put the G-Code in the simulator to simulate whether the code is valid to machining (Figure 3.44). After the G-Code validated, the machine can be settings like *clamper openings*, *tool offset* and *home position*. Than, the machine start to turning and cuting the aluminium like in Figure 3.45(a), until actual shape is produce. But, the product not fully finished [Figure 3.45(b)] because the clamp and center drill side cannot be machining. Next, remove unnecessary part using saw (Figure 3.46) and lastly, smooth the rough part using grinder machine and sand paper [Figure 3.47(a) and 3.47(b)]

a) Cut the aluminium using bansaw machine

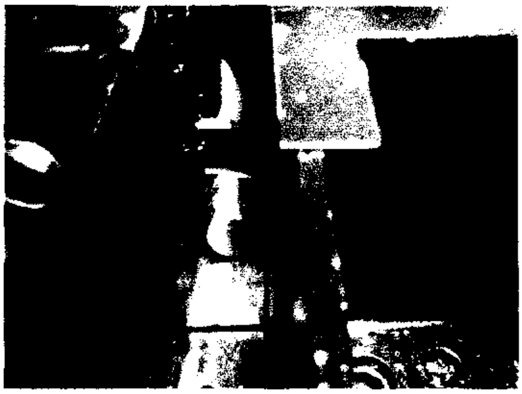


Figure 3.53: Cutting process

Figure 3.54: Bansaw machine

b) Extract the G-Code

i. G-Code for original production valve

```
O2021 (ORIGINAL PRODUCTION VALVE);
G90 G00 G40 G80;
G00 X300 Z30;
G92 S2000;
T505;
G96 S120 M04;
G00 X31.5 Z2.0 M08;
G71 U0.3 R0.5;
G71 P10 Q20 U0.2 W0.2 F0.25;
N10 G00 G42 X31.0 Z1.0;
G01 X29.0 Z0;
X4.5 Z-20.0;
X5.5 Z-20.5;
Z-25.0;
G02 X5.5 Z-27.0 R1.5;
G01 X5.5 Z-120.0;
G02 X17.5 Z-127.5 R8.5;
G01 X21.5 Z-129.5;
Z-130.5;
X20.0 Z-131.0;
X29.0 Z-135.0;
N20 G00 X30;
G70 P10 Q20 F0.1;
G00 X300 Z30 M09;
M05;
M30;
```

ii. G-Code for modified valve

```
O2022 (MODIFIED VALVE);
G90 G00 G40 G80;
G00 X300 Z30;
G92 S2000;
T505;
G96 S120 M04;
G00 X55.0 Z2.0 M08;
G71 U0.3 R0.15;
G71 P10 Q20 U0.2 W0.2 F0.25;
N10 G00 G42 X54.0 Z1.0;
G01 X51.0 Z0;
X5.5 Z-20.0;
Z-25.0;
G02 X5.5 Z-27.0 R1.5;
G01 Z-98.5;
X5.0 Z-101.0;
Z-125.0;
G02 X10.0 Z-127.5 R2.69;
G01 X17.5;
X21.5 Z-129.5;
Z-131.0;
X20.0 Z-135.0;
X51.0 Z-140.0;
N20 G00 X65;
G70 P10 Q20 F0.1;
G00 X300 Z30 M09;
M05;
M30;
```

c) Put the G-Code into the simulator

Figure 3.55: Simulation process

d) The CNC Lathe Machine cut the aluminium based on G-Code that had put in simulator.

Figure 3.56: Machining process

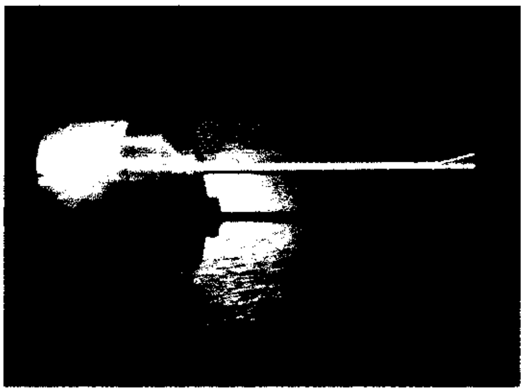


Figure 3.57: Product of lathe machining

e) Remove the unnecessary part.

Figure 3.58: Sawing excess material.

f) Smooth the rough part using grinder machine and sand paper

Figure 3.59: Initial polishing

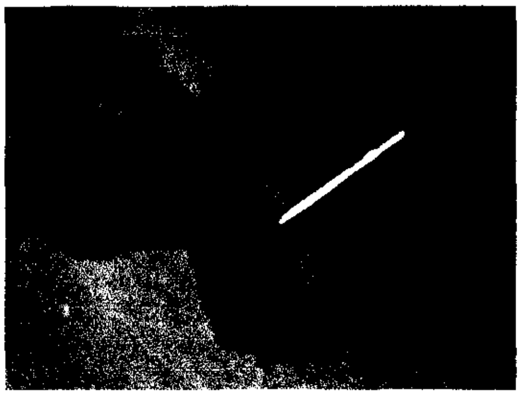


Figure 3.60: Final polishing

3.6 Summary

This chapter concludes about how to measuring draw the intake valve using Solidworks, create a CosmosFloworks project, extract the G-Codes, and finishing the valve.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Chapter 4 contains about result of domain and flow analysis. There are four flow analysis results for every four intake valve like cut plots, surface plots, flow trajectory plots and XY plots. For machining results, two products have been produce by CNC Lathe Machine. But, the modified intake valve is defect because of the cutting tool problem.

4.2 Domain Analysis Result

Domain analysis is to create fluid body assembly include or exclude cavities without flow conditions. Fluid body assembly is volume of liquid or gas contained in cavity while solid body assembly is like a mould to make cavity. If no result outcome, the solid body assembly is leakage.

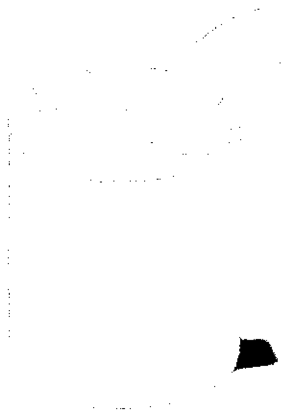


Figure 4.1: Fluid body assembly

4.3 CFD Modeling

This is solid body assembly that use to analysis the original intake valve and modified intake valve to obtain flow and pressure inside combustion chamber.

Figure 4.2: CFD modeling

4.4 Flow Analysis Result

After make a flow analysis, there are 5 results in every 4 valves. There is the report from analysis of original intake valve where the valve clearance is 1 millimeter;

Table 4.1: COSMOS Flow Report

Item	Description
General Info	
Units system	SI (m-kg-s)
Analysis type	Internal
Exclude cavities without flow conditions	On
Physical Features	
Heat transfer in solids	Off
Gravitational effects	Off
Laminar flow	Off
Compressibility effects	On
Fluids	Air
Initial Conditions	
Static Pressure	101325 Pa
Temperature	293.2 K

Default wall condition	On
Adiabatic wall	On
Boundary Conditions	
Type	Inlet Mass Flow (inlet)
	Static Pressure (outlet)
Flow vectors direction	Normal to face
Mass flow rate normal to face	0.1 kg/s
Boundary layer type	Turbulent
Results	
Iterations	2856
Minimum Pressure [Pa]	61767.7
Maximum Pressure [Pa]	1.21963e+006
Minimum Temperature [K]	214.197
Maximum Temperature [K]	414.827
Minimum Velocity [m/s]	0.0119664
Maximum Velocity [m/s]	585.603

4.4.1 Cut Plots

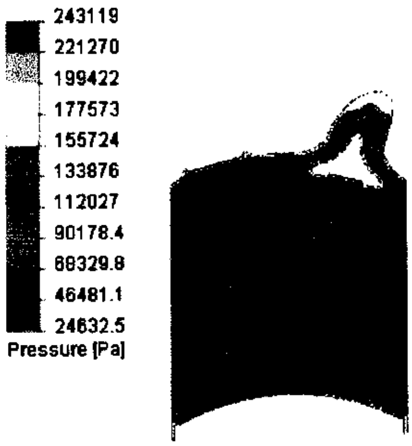


Figure 4.3: Pressure contour (original intake valve)

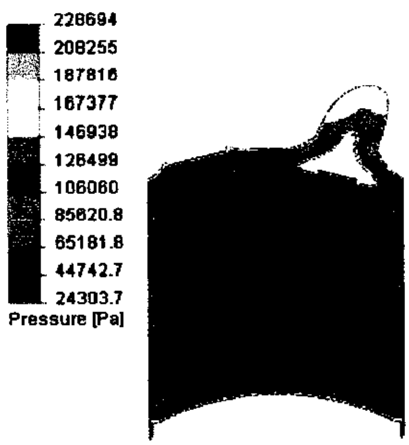


Figure 4.4: Pressure contour (original intake valve with fin)

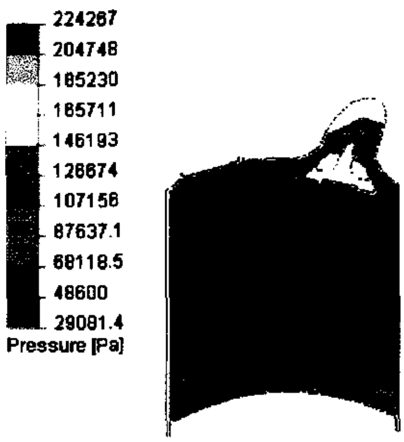


Figure 4.5: Pressure contour (modified intake valve)

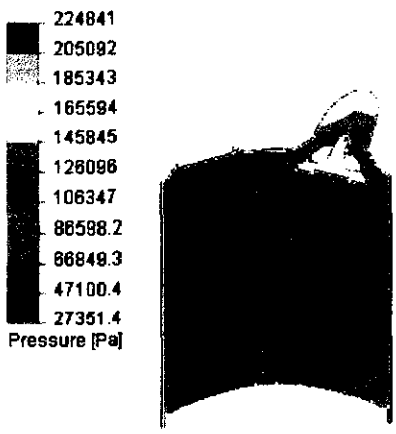


Figure 4.6: Pressure contour (modified intake valve with fin)

4.4.2 Surface Plots

Figure 4.7: Pressure counter at wall (original intake valve)

Figure 4.8: Pressure counter at wall (original intake valve with fin)

Figure 4.9: Pressure counter at wall (modified intake valve)

Figure 4.10: Pressure counter at wall (modified intake valve with fin)

4.4.3 Flow Trajectory Plots

Figure 4.5(b) show the tumble movement of flow when enter the combustion chamber. This criterion is needed to influence the pressure in combustion chamber. Modified intake valve in Figure 4.5(c) is produce good tumble while modified intake valve with fin in Figure 4.5(d) produce wider flow.

Figure 4.11: Flow trajectory (original intake valve)

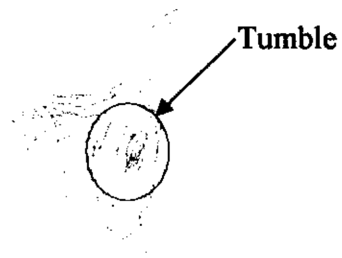


Figure 4.12: Flow trajectory (original intake valve with fin)

Figure 4.13: Flow trajectory (modified intake valve)

Figure 4.14: Flow trajectory (modified intake valve with fin)

4.4.4 XY Plots

There are two types of graph, curve length versus velocity and curve length versus pressure. The curve length is shown in Figure 4.6 below.

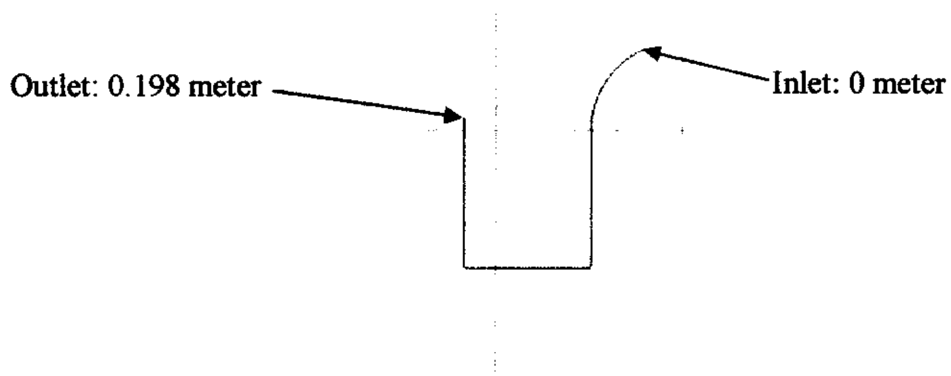


Figure 4.15: Curve length (green line)

a) Curve length versus velocity

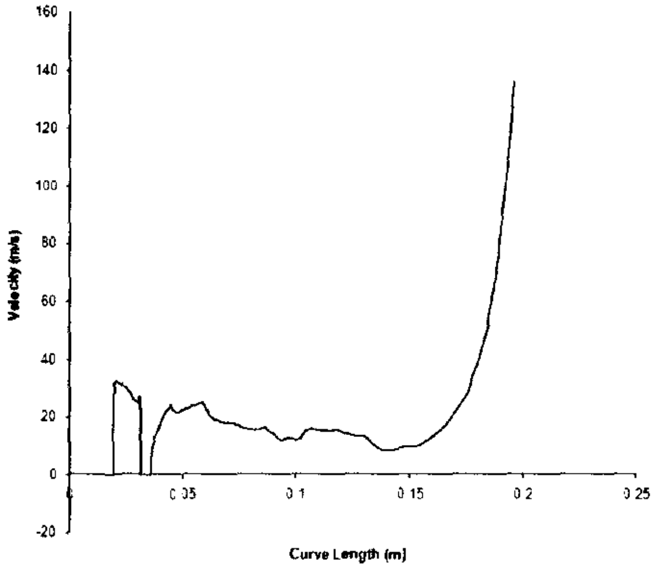


Figure 4.16: Curve length versus velocity (original intake valve)

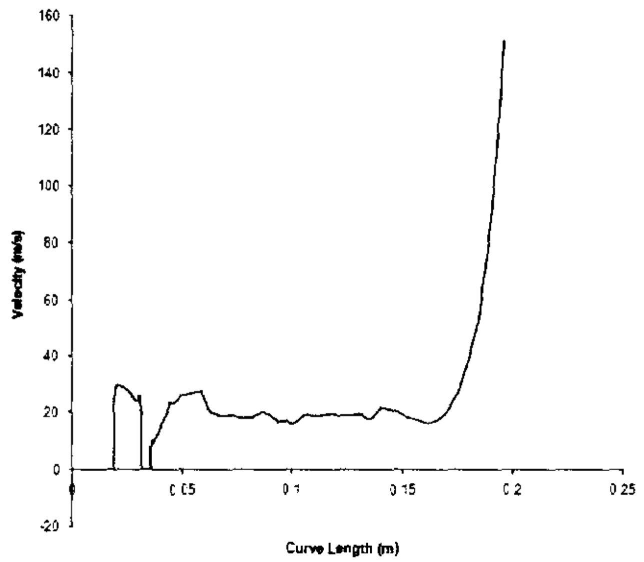


Figure 4.17: Curve length versus velocity (original intake valve with fin)

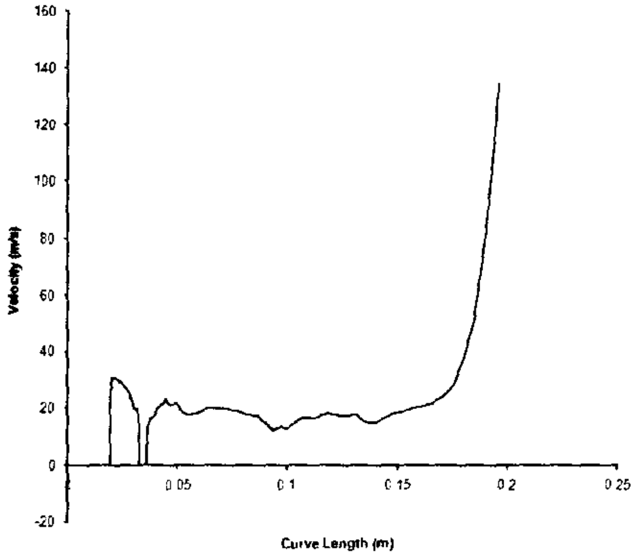


Figure 4.18: Curve length versus velocity (modified intake valve)

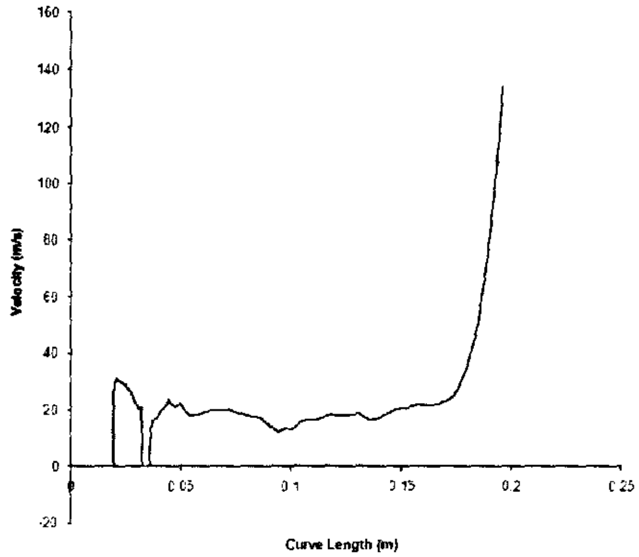


Figure 4.19: Curve length versus velocity (modified intake valve fin)

a) Curve length versus pressure

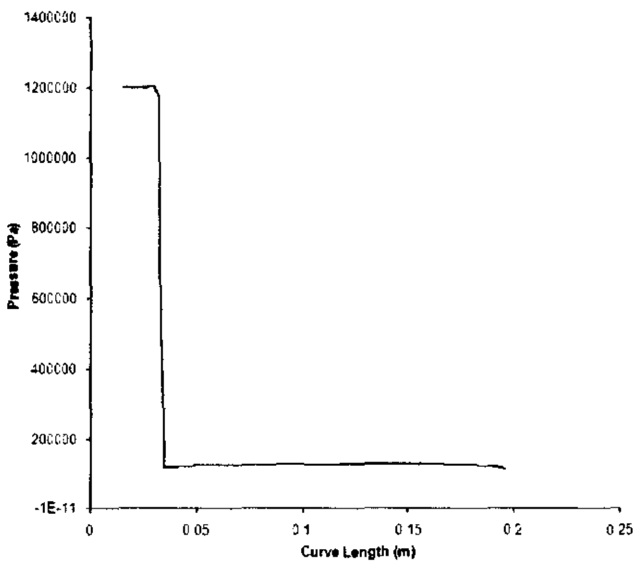


Figure 4.20: Curve length versus pressure (original intake valve)

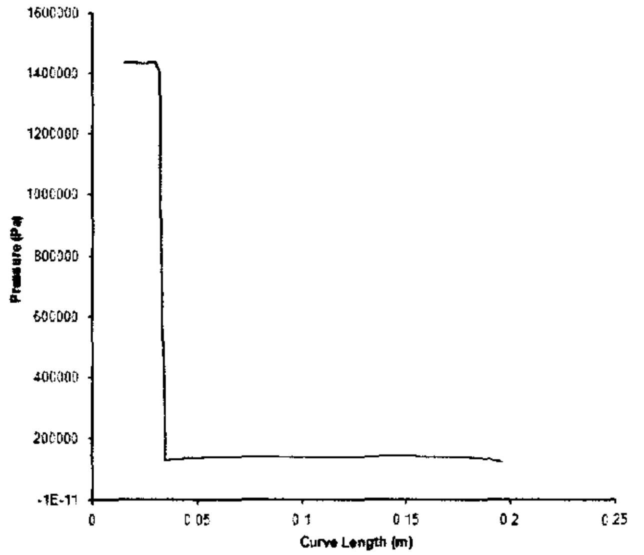


Figure 4.21: Curve length versus pressure (original intake valve with fin)

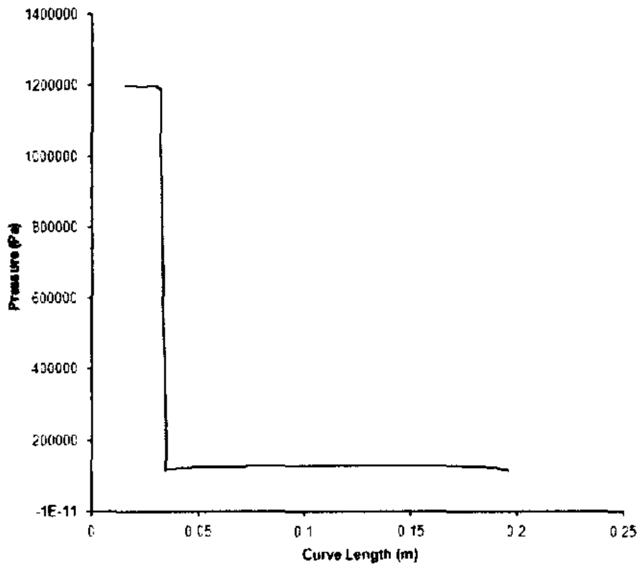


Figure 4.22: Curve length versus pressure (modified intake valve)

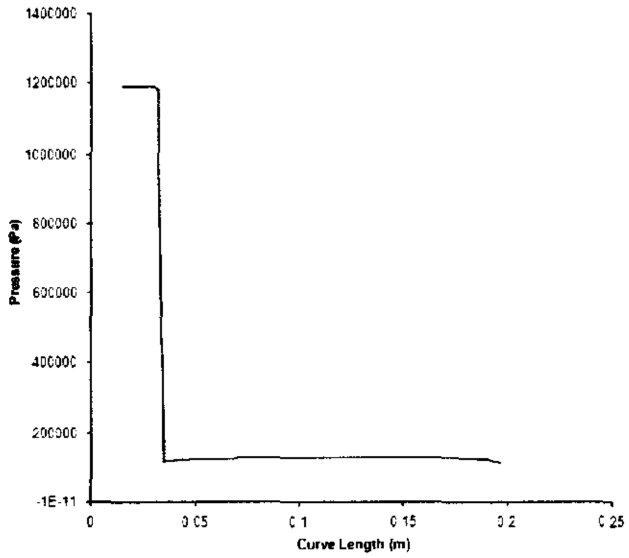


Figure 4.23: Curve length versus pressure (modified intake valve with fin)

4.5 Machining Result

Figure 4.24: Original production valve

Figure 4.25: Modified production valve

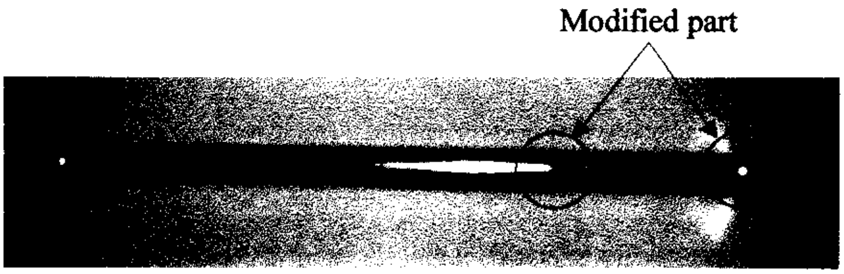


Figure 4.26: Modified parts

4.6 Discussion

When the modified valve is machined, some problem is detected. The bottom part is not following the actual design (**Figure 4.13**) because the cutting tool is not appropriate (**Figure 4.12**). The finishing cutting tool cannot cut with angle 90° (horizontal). Finally, modified intake valve defect and cannot be use. So, the machining process was repeated with same G-Code but use other cutting tool (**Figure 4.14**).

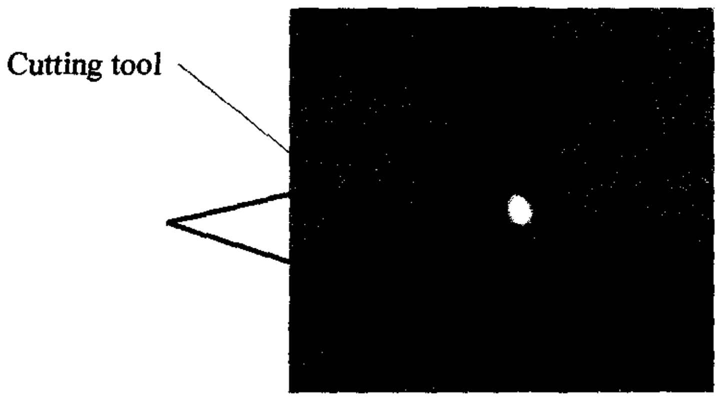


Figure 4.27: Wrong cutting tool.

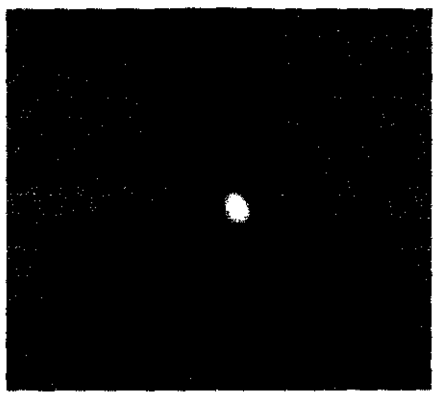


Figure 4.28: Actual shape (red line).

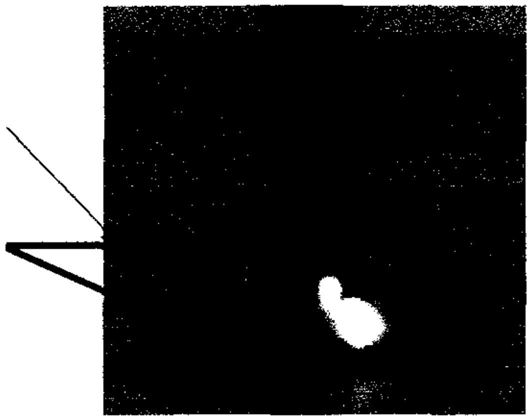


Figure 4.29: Right cutting tool.

4.7 Conclusion

This chapter concludes about analysis result to choose the efficient intake valve. So, from this basic analysis show that the good valve is *modified intake valve with fin.* Than, the intake valve can be produce by CNC Lathe Machine but with supplement work. The cutting tool must appropriate to avoid a defect after machining process.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter is about the problem that this project encounters before, during and after the project. This chapter also discuss about the conclusion and recommendation of the project. Problem that will be discussed here is the entire problem encountered in every task the project. Problem that will be discussed here is the entire problem encountered in every task in the project.

5.2 Project Problems

5.2.1 Literature Review Problems

The problem encountered during literature review is mainly about the difficulty to information about this project. The problem is like, limited resources to get the relevant material such as books and internet connection problem. . It also include the material choose and process fabrication for the project.

5.2.2 Designing and Sketching

It very hard to choose the good design because didn't have any reference as needed. The student had to sketch as many as can design to choose the good model. Because of the idea were from the student directly, so there are no references that can be referred. All the drawing and dimension need to generate by student itself.

5.2.3 Fabrication Processes Problem

The fabrication processes were quite difficult to be completed because a lot procedures and forms to be filled up just to borrow tools. This slows the project and the time to complete the tasks in the project.

5.3 Recommendation

Several recommendations I would like to express for myself and the faculty for future final year project is:

1. More time given to the project, it include the final year student should more focus on final year project only or give two semester to doing the final year project. This could make the result of the project finish on time and have better result.
2. The planning of the project must be done before the project started
3. The task for every student must be explain more detail
4. Make sure that the machine and their apparatus that want to use is in good condition.

5.4 Future Work

Future planning for the intake valve is to develop the function of *fin*, use CFD Fluent software, using good material (example Stainless Steel) and test the valve in real engine. If the upgrade can be done the intake valve can have better performance, more light and last longer.

5.3 Conclusion

For the conclusion, overall perception of the project carried out was good. This project gains my knowledge by searching information in the internet. The project also generates my capability to make a good research report in thesis form or technical writing. I also get all the objectives of this project are accomplished, which are to design original production intake valve and modified intake valve.

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APPENDIX A

Basic Part of Engine

Block

Exhaust valve

Cylinder head

Piston

Piston ring

APPENDIX B

G-Codec and M-Codes for DMG Fanuc Turning Machine

G0	Linear axis movement in the rapid traverse.
G1	Linear axis movement with work speed.
G2	Circular interpolation in clockwise direction.
G3	Circular interpolation in anti-clockwise direction.
G4	Dwell time.
G10	Data input via the program.
G11	Cancels the data input mode via the program.
G18	Selection of the machining area Z X.
G28	Return to the reference point (with optional C axis)
G33	Thread-cutting movement.
G40	Deactivation of the radius compensation.
G41	Tool radius compensation with workpiece on the right-hand side of the profile.
G42	Tool radius compensation with the workpiece on the left-hand side of the profile.
G52	Absolute programmable zero point displacement.
G53	Activates shifts with reference to the machine zero point.
G54	Changeable zero point displacement.
G55	Changeable zero point displacement.
G56	Changeable zero point displacement.
G57	Changeable zero point displacement.
G58	Changeable zero point displacement.
G59	Changeable zero point displacement.
G70	Finishing cycle.
G71	Material abrasion during the turning process.
G72	Material abrasion during the surfacing process.
G73	Contour repetition.
G76	Thread-cutting cycle in various passes.
G80	Cancels the fixed cycles for frontal drilling.
G83	Fixed cycle for frontal drilling.
G84	Fixed cycle for frontal tapping.
G85	Fixed cycle for frontal drilling
G87	Fixed cycle for lateral drilling.
G88	Fixed cycle for lateral tapping.
G89	Fixed cycle for lateral drilling.
G90	Programming with absolute coordinates.
G91	Programming with incremental coordinates.
G92	Limitation of the spindle speed.
G94	Programming of the feed in mm/min.
G95	Programming of the feed in mm/rev.
G96	Programming of the constant cutting speed in m/min.
G97	Programming of the spindle rotation with fixed speed rev/min
G107	Cylindrical interpolation.
G112	Interpolation in polar coordinates.
G113	Deletes the interpolation in polar coordinates.
G174	Roughing/pre-turning cycle radial grooves.
G175	Finishing cycle radial grooves.
G176	Roughing/pre-turning cycle axial grooves
G177	Finishing cycle axial grooves.

M0 => Program stop
M1 => Optional program stop
M2 => Program end (without rewind program)
M3 => Spindle rotation in clockwise direction
M4 => Spindle rotation in anti-clockwise direction
M5 => Spindle stop
M7 => Coolant activation, not due to spindle rotation
M8 => Coolant activation, due to spindle rotation
M9 => Coolant de-activation
M10 => Air jet activation for cleaning the clamping jaws (activation of the spindle rotation with open clamping jaws)
M11 => Air jet de-activation for cleaning the clamping jaws (de-activation of spindle rotation with open clamping jaws)
M12 => Decrease of the clamping pressure on the clamping chuck (option)
M13 => Clockwise spindle rotation and coolant delivery
M14 => Spindle rotation in counter-clockwise direction and coolant delivery
M16 => Enforcement of turret head rotation in clockwise direction
M18 => Reset normal clamping pressure of the clamping chuck (Option)
M19 => Spindle orientation (M19 Sxx lines spindle with xx straight line)
M20 => Activation of the spindle brake (option)
M21 => De-activation of the spindle brake (option)
M22 => Conditional advance of the counter-head quill (active in case of quill thrust)
M23 => Conditional backward movement of the quill counter-head (active in case of a quill thrust)
M24 => Unconditional advance of the quill of the counter-head (active in case of a quill thrust)
M25 => Unconditional return movement of the quill of the counter-head (active in case of a quill thrust)
M26 => Opening of the automatic anti-skid door (option)
M27 => Closing of the automatic anti-skid door (option)
M30 => End of program (with reverse van)
M31 => Cancelling of the conditions fort he next tool change
M36 => Uncoupling C axis (option)
M37 => Coupling C axis (option)
M46 => Enforcement of the turret head direction of rotation in counter-clockwise direction
M62 => Increase of the piece counter on the monitor (only active in the automatic mode)
M65 => Interrogation end bar (option)

M66 => Handshake function (option)
M68 => Close chuck / collet
M69 => Open chuck / collet
M88 => Move arm into neutral position for workpiece removal, bottom (option)
M89 => Move arm to work position for workpiece removal, top (option)
M90 => Saving of the probe parameter in the PMC (from #815 to #818)
M100 => Temporary saving of the active S