UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: DESIGN AND BUILD A TURBOCHARGER AND AIRFLOW CIRCUIT PIPING FOR AN AUTOMOTIVE TURBOCHARGER TESTING APPARATUS

SESI PENGAJIAN: 2006/2009

Saya, **MOHAMMAD ISKANDAR OTHMAN (880116-52-5203)**
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Alamat Tetap:

No 478A Kampung Baru
97000 Bintulu
Sarawak

ISMAIL BIN ALI
(Nama Penyelia)

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DESIGN AND BUILD A TURBOCHARGER STAND AND AIRFLOW CIRCUIT PIPING FOR AN AUTOMOTIVE TURBOCHARGER TESTING APPARATUS

MOHAMMAD ISKANDAR BIN OTHMAN

Report submitted in partial fulfilment of the requirements
for the award of Diploma in Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2008

SUPERVISOR'S DECLARATION

I declare that I have read this thesis and in my opinion, this thesis is enough to fulfill the purpose for the award for the diploma of mechanical engineering from the aspects of scope and quality.

Signature

Name of Supervisor: Mr. Ismail Ali
Position: Instructor Engineer
Date: 7 November 2008

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

Signature
Name: Mohammad Iskandar Othman
ID Number: MB06028
Date: 7 November 2008

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ABSTRACT

Development in automotive technology sector creates a new idea in turbocharger system. The tasks given for the final year project is to the design and builds a turbocharger stand and airflow circuit piping for an automotive turbocharger testing apparatus. The airflow piping was made using PVC pipe. The piping made from the blower to the compressor inlet. Compressor outlet piping was branched into two; flow through an intercooler and flow bypass the intercooler. Meanwhile, the flow into and out from the turbine was also installed in the apparatus. Variable speed blower is used to supply incoming air to the turbo compressor. This test apparatus was far from complete as this is the first step to a complete instrumented turbocharger test apparatus that capable of measuring input and output pressure and temperature.

ABSTRAK

Kemajuan dalam sektor automotif telah mengilhamkan satu idea baru untuk sistem turbo. Tugasan yang diberi untuk projek tahun akhir bertajuk mereka dan membina penyangga turbo serta litar perpaipan aliran udara sebagai alatan pengujian turbocharger automotif. Sistem aliran paip diperbuat daripada poly vinyl chloride.Pemampat luar paip terbahagi kepada dua bahagian iaitu udara keluar akan melalui sistem penyejuk (intercooler) dan melalui laluan pintasan. Sementara itu, aliran keluar dan ,masuk dari sistem turbine turut dipasang pada kelengkapan peralatan pengujian.Penghembus udara yang dapat mengawal kadar kelajuan udara yang membekalkan udara masuk ke sistem pemampat turbo. Peralatan ini merupakan langkah pertama untuk menghasilkan sebuah peralatan pengujian turbo yang dapat digunakan untuk mengira kadar kemasukan dan tekanan mampatan serta mengira suhu udara pada aliran sistem turbo.

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The project involves designing and fabricates a turbocharger stand and air flow circuit piping for an automotive turbocharger testing apparatus. Fundamentals, the turbocharger use widely in automotive sector that functionally use to increase the mass of air entering the engine to create more power .Since now, University Malaysia Pahang especially Faculty of Mechanical Engineering didn't have the apparatus to testing the performance of turbocharger.

The turbocharger test rig is a facility dedicated to the experimental study of compressors and turbines which are used for turbo-charging the reciprocating internal combustion engines. The apparatus developed makes it possible to carry out basic studies on the energy and fluid-dynamic behavior.

The design of the project is based on the concept that created by student and approved by the supervisor. All the material that use for the project is prepared and funding by faculty of mechanical engineering.

At University Malaysia Pahang (UMP) especially in Faculty Mechanical Engineering didn't have the special apparatus to test the turbocharger performance .So from this problem, the idea come out to create the design apparatus for turbocharger.

1.2 PROJECT OBJECTIVE

There objective of the project that needs to achieve are:

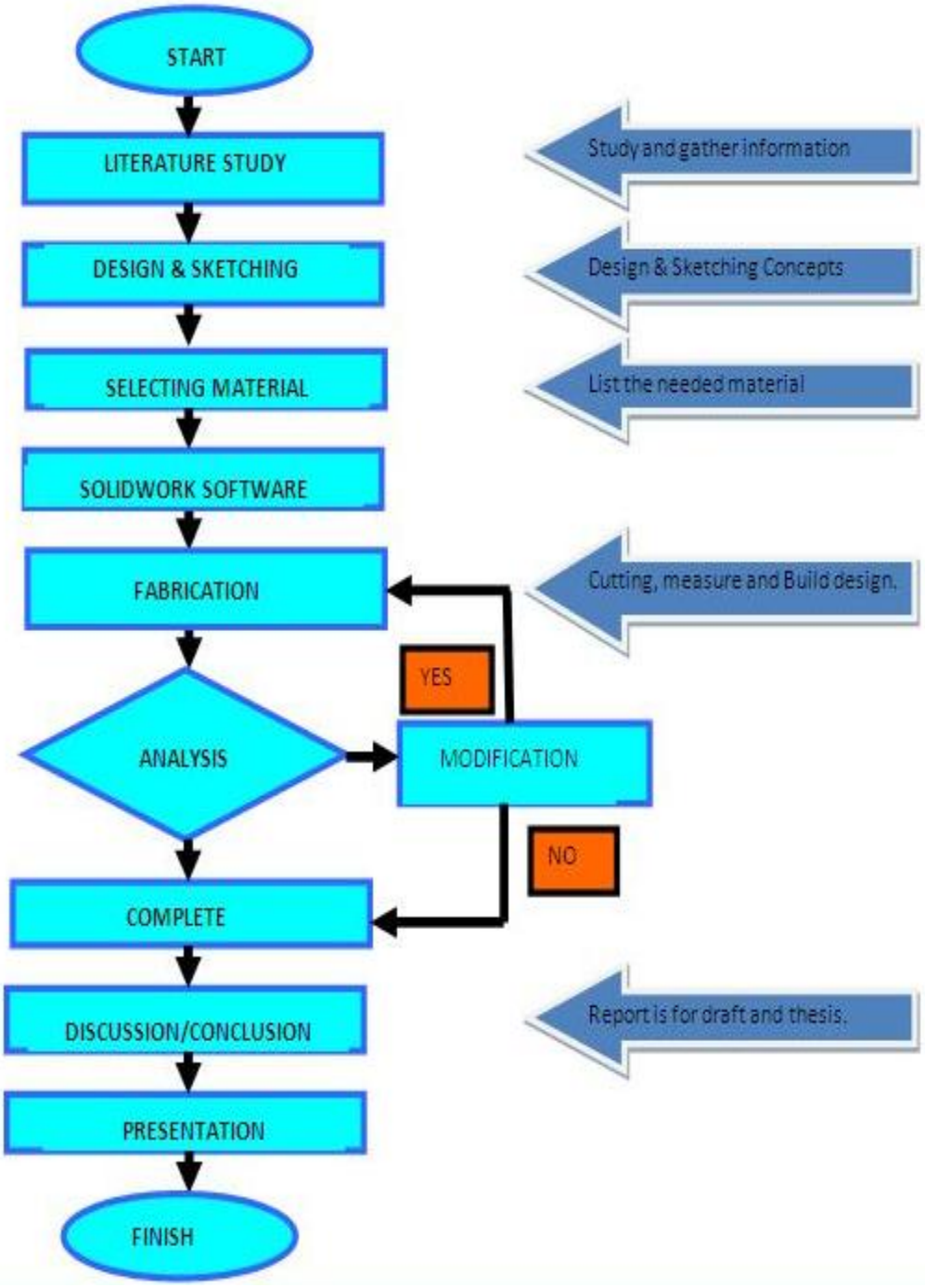
- Design and build the air flow circuit for the an automotive turbocharger testing apparatus.

1.3PROJECT SCOPES

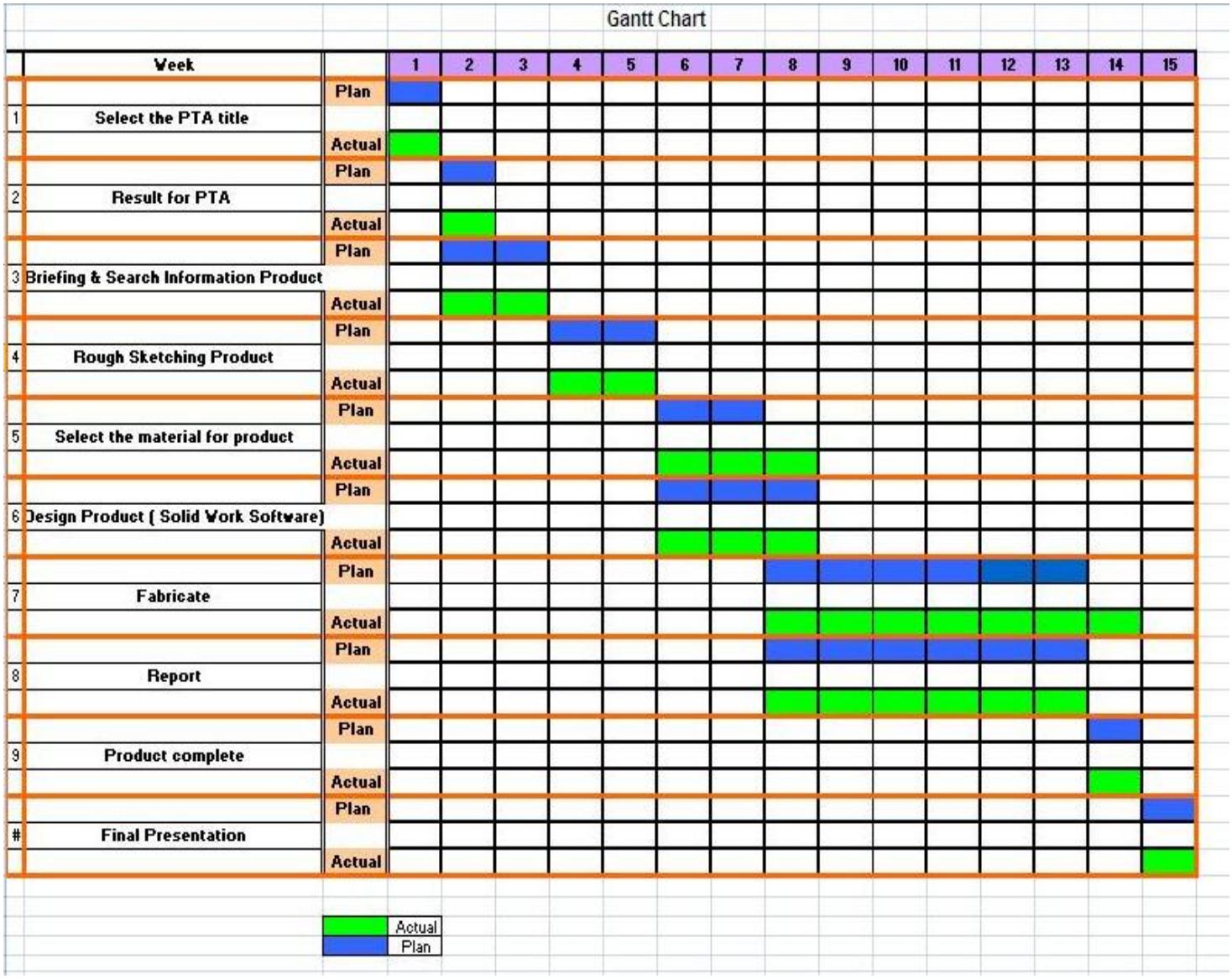
There are several scopes for my projects:

a) Design piping from blower to turbocharger and discharge pipe to atmosphere.
b) Build and install piping to the rig stand.
c) Installation of variable speed blower.

1.4 FLOW CHART



1.5 GANTT CHART



CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

2.1.1 Turbocharger Test Stand Apparatus

The test requires flow to be passed through the turbocharger variable nozzle / turbine assembly under controlled pressure condition to allow an operator to set the turbocharger. One of the major challenges of today's engine developments is the reduction of climate-relevant CO2 emissions. Downsizing in combination with charging systems is seen as one key technology to utilize the fuel consumption potentials of diesel and gasoline engines. In order to maintain engine power and fun-to-drive with downsizing concepts, or even improve them, the turbocharger design and optimization has to be even more integrated into the engine developments process. Machines supplied have been both manually loaded and unloaded and integrated into a pallet transfer system (refer to **Figure 2.0**). The testing includes semi-automatic setting with manual tightening with a torque spanner to a known torque carried out to lock the parameters in place.

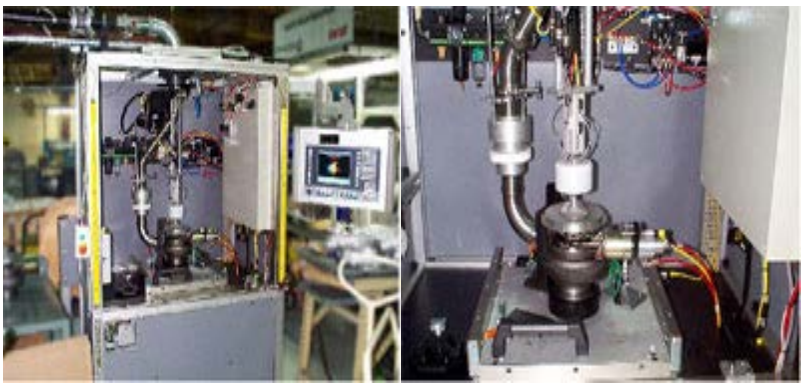


Figure 2.0: Turbocharger Test Rig

Main elements consist on this system are flow circuit will closed loop pressure control and measurement of a pressure, flow rate and temperature. The turbocharger also has mounting fixture on transfer slide with inlet connectors, seals, clamps and anti-rotate device. Next elements that have are the exhaust connection system and silencer. Actuator connector and closed loop pressure or vacuum control system and have torque wrenches. This system also can control system and operator interface (refer to **Figure 2.1**).

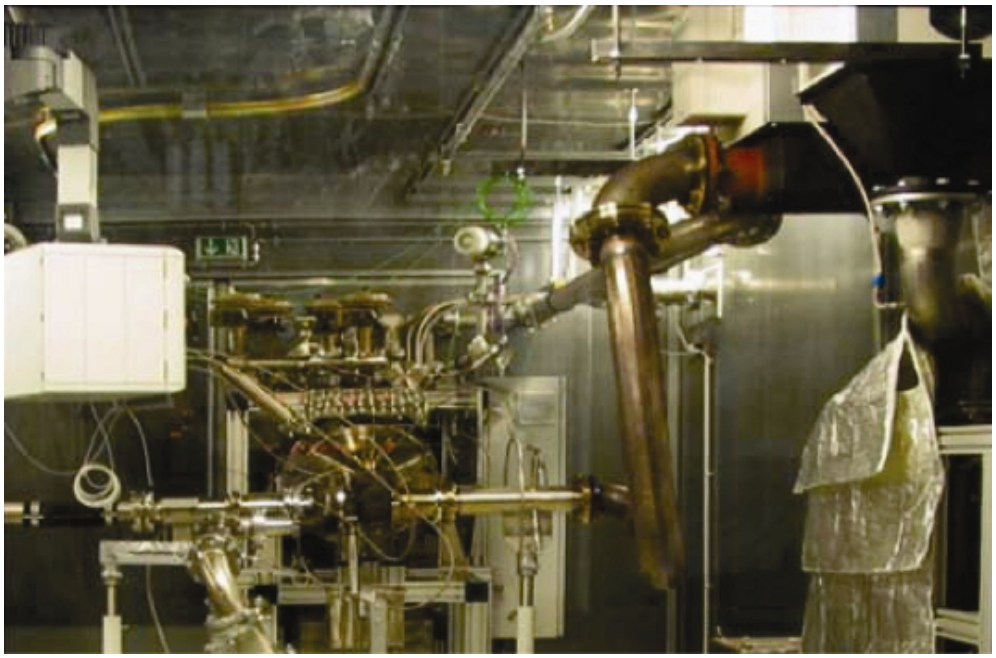


Figure 2.1: Turbocharger stand apparatus

The high degree of flexibility of this test rig allows turbocharger mapping measurements of single and two-stage charging systems under state-of-the-art boundary conditions. The direct connection to engine process simulation, engine test benches and CFD analysis guarantees an in-depth understanding of the interaction between turbo machinery and combustion engine.

2.1.2 Turbocharger

The turbocharger function is to increase the mass of air entering the engine to create more power. A Turbocharger, often called a turbo, is a small radial fan pump driven by the energy of the exhaust flow of an engine (**refer to Figure 2.2).** A turbocharger consists of a turbine and a compressor linked by a shared axle. Turbochargers and superchargers are engineered to force more air mass into an engine's intake manifold and combustion chamber. Intercooler is a method used to compensate for heating caused by supercharging.

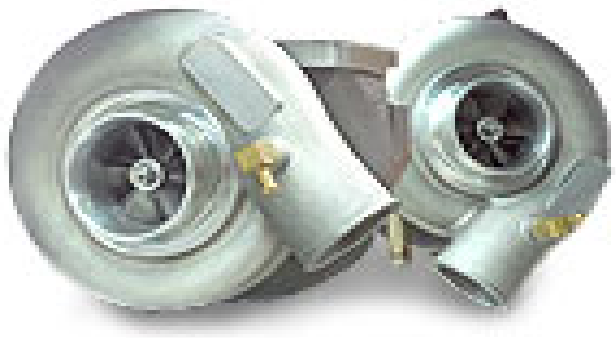


Figure 2.2: Turbocharger

Turbochargers are well known in the prior art, and typically comprise a turbine for driving a compressor to supply relatively high pressure charge air to a combustion engine. The turbine is rotatable driven by exhaust gases from the engine and in turn rotatable drives a compressor for compressing charge air supplied to the engine. An inherent design problem

with turbochargers, however, is that the rotational speed of the turbine and compressor increases as the speed and/or load of the engine increases.

At relatively high operating engine speeds or loads, it is possible for the turbine and compressor to be driven at speeds above critical design limits, or for the compressor to supply charge air to the engine at boost pressures higher than the engine can withstand.

A wide variety of control devices for turbochargers have been developed to limit the rotational speed of the turbocharger compressor, and thereby to control the boost pressure level of the charge air supplied by the compressor.

Such devices may be mounted either on the compressor or the turbine, and commonly includes blow-off or pop-off valves, turbine bypass or waste gate valves, compressor inlet control valves, and the like.

These valve devices are generally similar to each other in principle in that each comprises a valve responsive to a predetermined pressure level or pressure differential to restrict the availability of gases for driving the turbine, or for supply to the engine by the compressor. For example, a turbine waste gate valve operates to close a flow path bypassing the turbine, and may be opened by a pressure-responsive valve actuator to allow a portion of the engine exhaust gases to bypass the turbine to atmosphere(refer to **Figure 2.3**).

In this manner, the turbine is rotatable driven by a relatively reduced mass flow of exhaust gases to limit the rotational speed of the turbine, and thereby also to limit and control the rotational speed and resultant boost pressure of charge air supplied by the compressor .

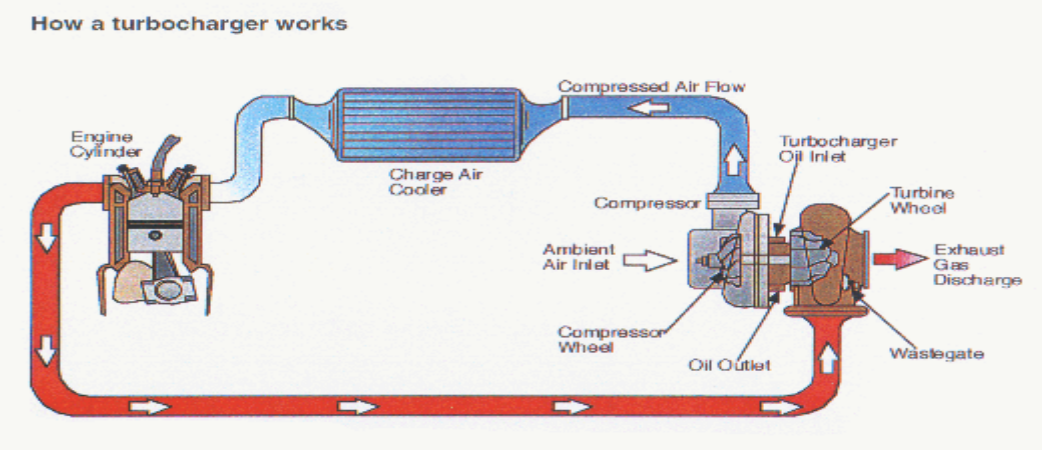


Figure 2.3: How the turbocharger work

Now the turbocharger applications apply widely in automotive sector such as sporty car, racing car contest, and use for individually person that interesting to the high performance car.

The turbocharger has four main components. The turbine (almost always a radial turbine) and impeller/compressor wheels are each contained within their own folded conical housing on opposite sides of the third component, the center housing/hub rotating assembly.

2.1.3 Intercooler

The function of intercooler is intercooler system ensures much lower engine operating temperatures (refer to **Figure 2.4).** The turbo charger function is to compress and force a greater volume of air into the engine, producing more power. It is a basic law of physics, the temperature will increase when the air compress.

Figure 2.4: Intercooler

Passing a compressed and heated intake charge through an intercooler reduces its temperature (due to heat rejection) and pressure (due to flow restriction of fins). If properly engineered, the net result is an increase in density. This increases system performance by recovering some losses of the inefficient compression process by rejecting heat to the atmosphere.

An intercooler cools the air sufficiently in order to improve engine performance as well as prolong the working life of the engine.

By cooling the air that flows into the engine, increases the mass of air flowing into the engine. A higher mass of air means more fuel can be burnt in a single combustion stroke and more power is produced per stroke. Obviously, the downside to this is that any object placed in the stream disturbs the airflow pattern and hence reduces the amount of air that can be passed. Although this is true for older intercooler designs, the newer intercoolers have been designed with flow efficiency in mind, and as such flow restrictions are minimized. Hence, in modern day terms, the gains to be had using an intercooler far outstrips any disadvantages.

Intercoolers are usually placed between the turbo and the engine air inlet. Compressing the air adds a lot of energy to it which makes it fairly hot, by cooling it this increases the density of the air cramming more air per volume. This increases the performance and efficiency of the engine.

CHAPTER 3

PROJECT METHODOLOGY

3.1 DESIGN TARGET

The design specifications for this project are its have cap for outlet and inlet compressor. Other than that the piping flow has two ways, whereas the air flow will throughout from system through the intercooler or not.

Design concept created follow by the several criteria such as the suitability design of rig and turbocharger stand. It also must to have the bypass to control the air flow in the system which it will through the intercooler or release direct to the ambient.

The several propose concept design create for this project. At the end of this step, just one design that will be chooses for the final design project. The propose design have the advantages and disadvantages for guiding to select the final design.

3.2 CONCEPT

3.2.1Concept 1

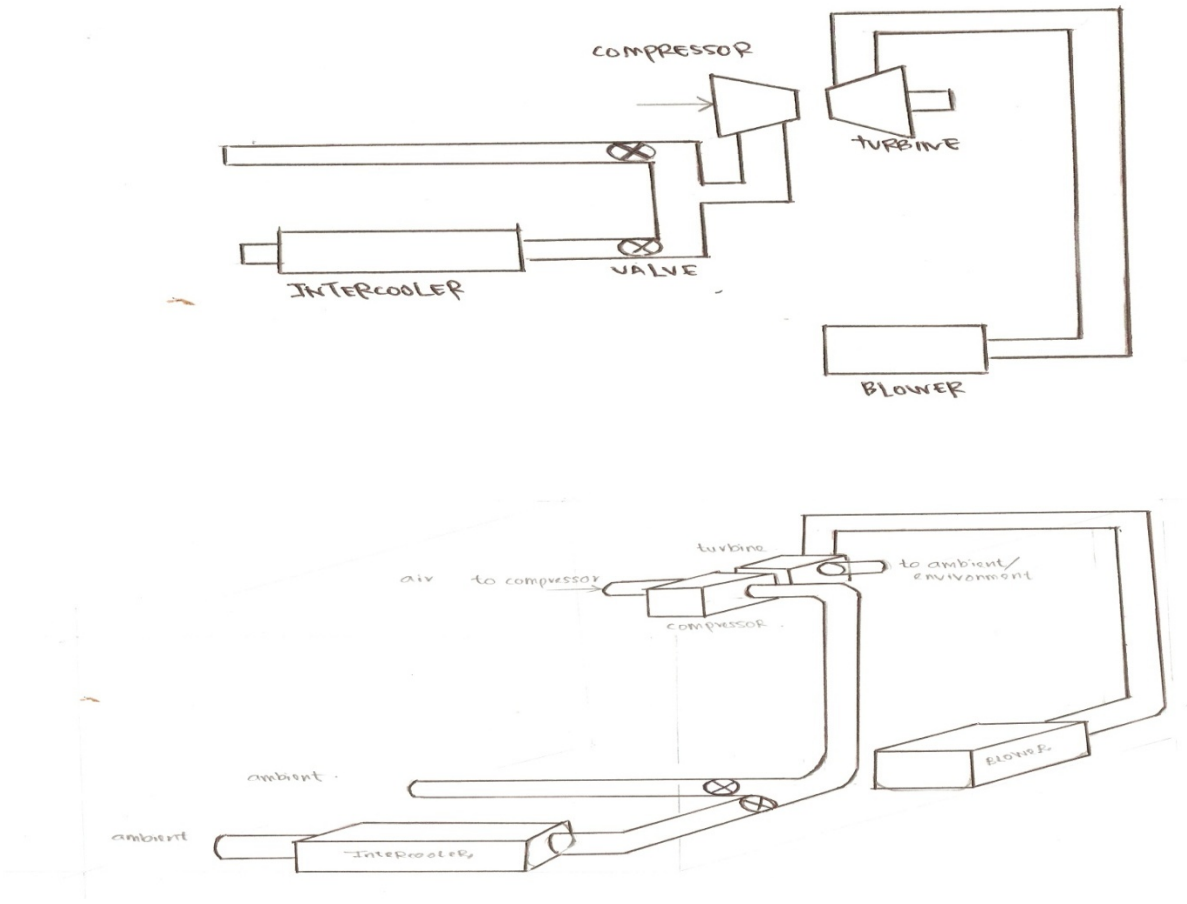


Figure 3.1: Schematic View And Oblique View

Advantages:

1. The placement of intercooler is at the base of rig, so it suitable to support the weight of intercooler.
2. Have two valves at junction pipe to control the air flow.
3. Just a small space that needed for this design

3.2.2 Concept 2

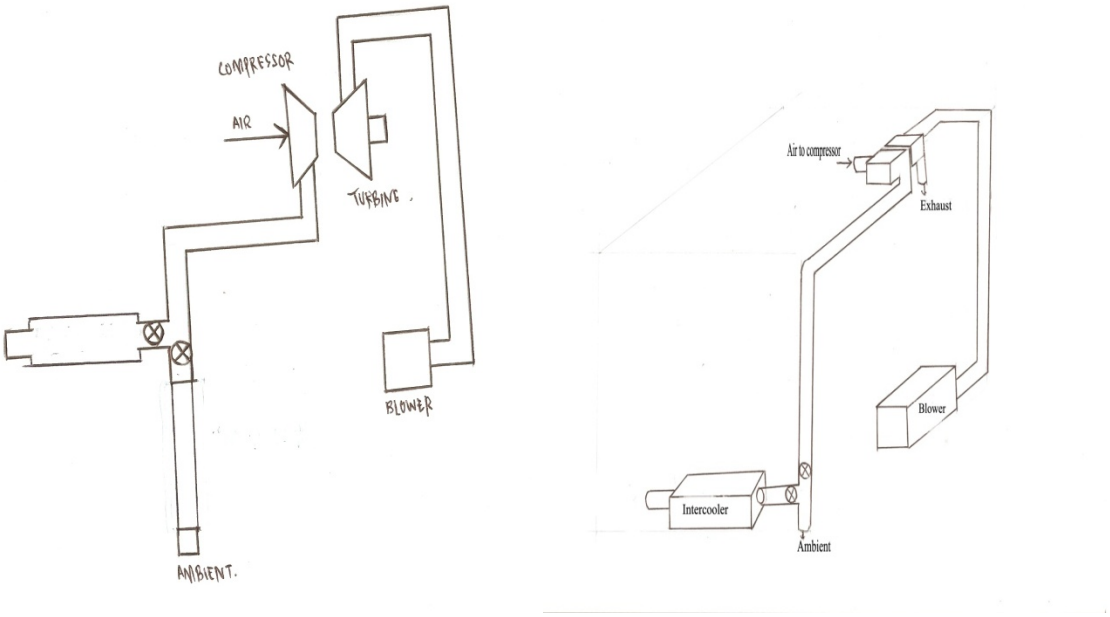


Figure 3.2: Schematic View

Advantages

i. Air flow that produce from outlet compressor throughout directly.
ii. Simple design and easy to fabricate.

Disadvantages

i. The placement of valve is not suitable for the system cause it will influence the air flow result.

3.2.3 Concept 3

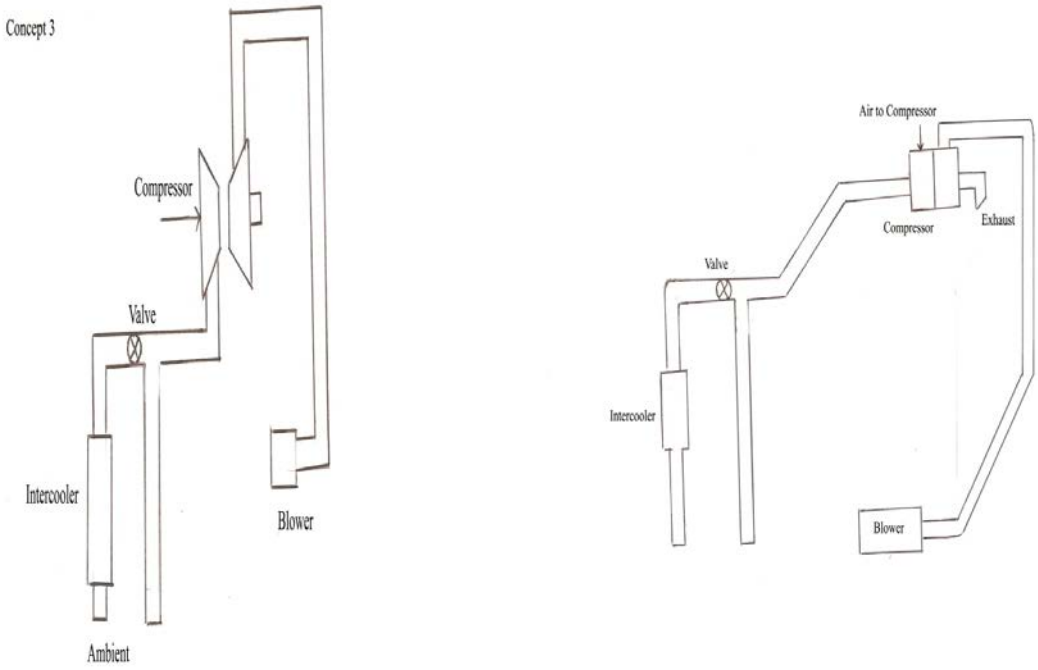


Figure 3.3: Schematic View

Advantages

i. Simple design and just using single valve for the system.

Disadvantages

i. The placement of intercooler is not suitable for the design. (weight factor)

ii. The air flow that will through the intercooler will influences the result of output air flow.

3.3 DESIGN SELECTION

The design concepts choose followed by the best concept among the best concept design that created. The final concepts (refer figure 3.10) choose by the some criteria such as the suitable design, the advantages that have on the design, and the design is easy to use when it completed.

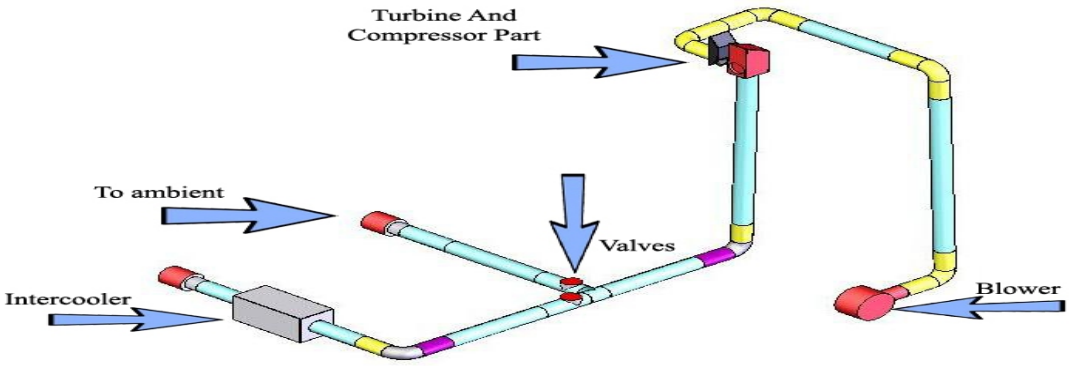


Figure 3.4: Final Concept Design

3.4 LIST OF MATERIAL

Figure 3.5: Turbocharger

Specification of Turbocharger

Type: *Ishikawajima Harima Heavy Industries*)

Bearing System: 2 Floating

Cooled by: Water and Oil

Figure 3.6: Variable Speed Blower

Specifications

Model: Makita Blower UB1100		**No load speed**	16,000
Air Pressure	5.5kpa	**Overall Length**	480mm
Max. air volume	2.8m3/min	**Net weight**	1.7kg

Figure 3.7: Plat Metal (Mild Steel)

Figure 3.8: PVC (Poly Vinyl Chloride)

Figure 3.9: Elbow Pipe

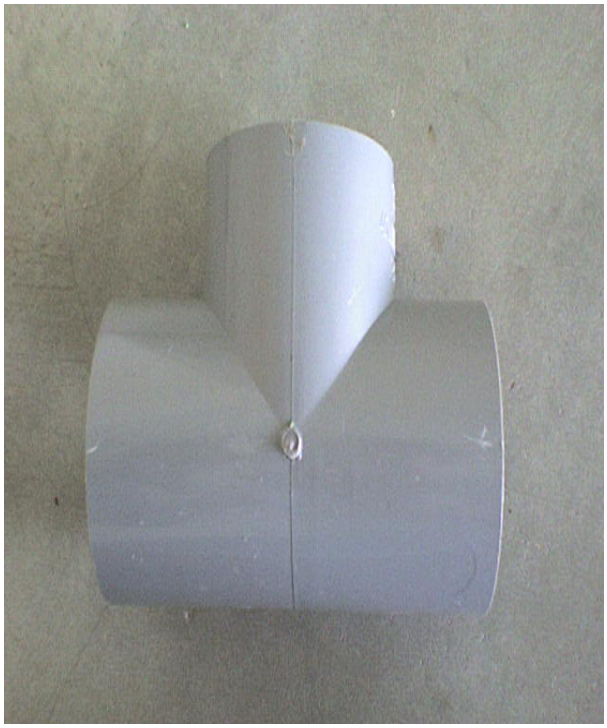


Figure 3.10: T- Pipe

Figure 3.11: Ball Pipe Valve

3.5 COMPRESSOR INLETFLANGE DESIGN

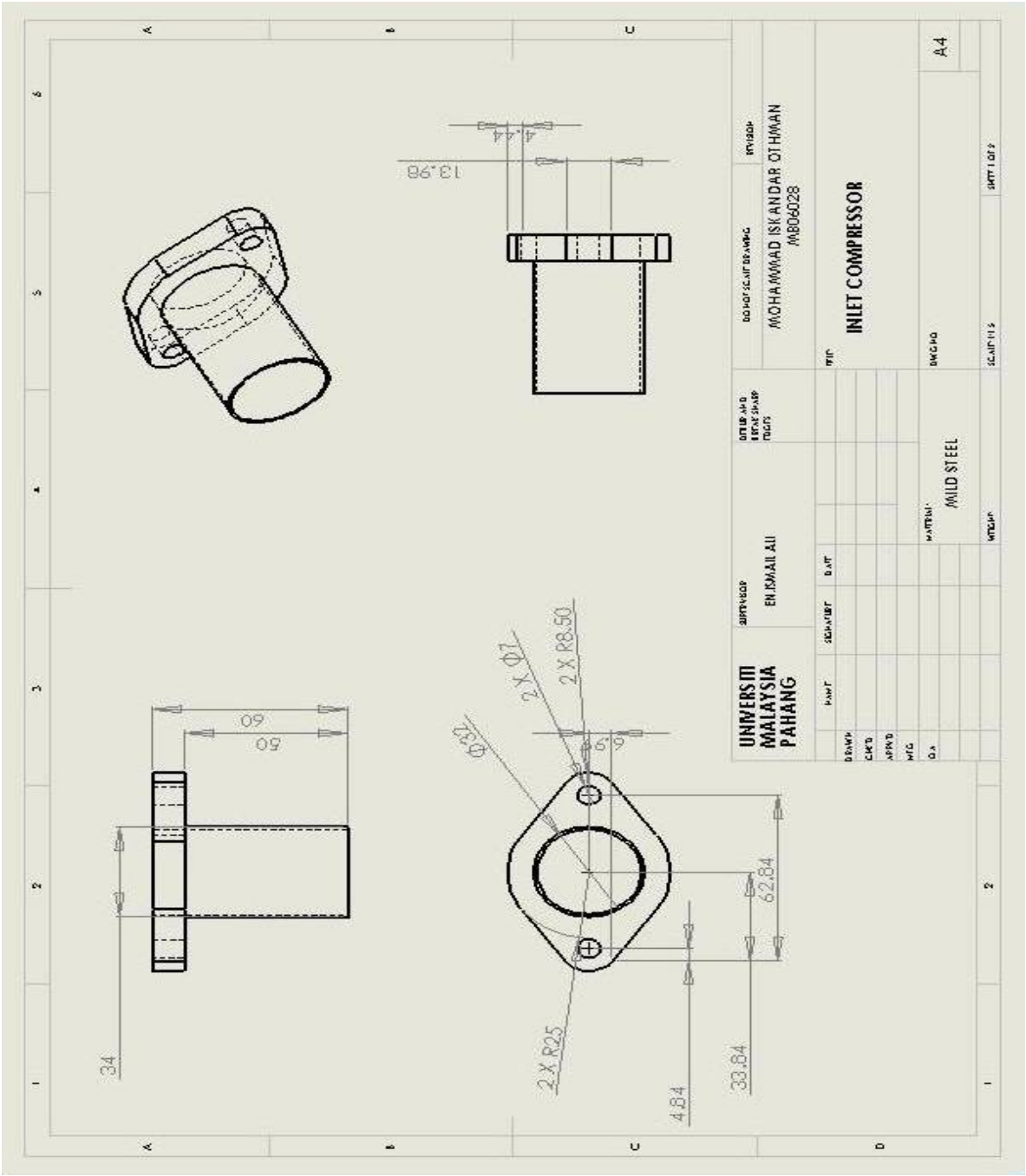


Figure 3.13: Orthographic View Inlet Flange Compressor

3.6 COMPRESSOR OUTLETFLANGE DESIGN

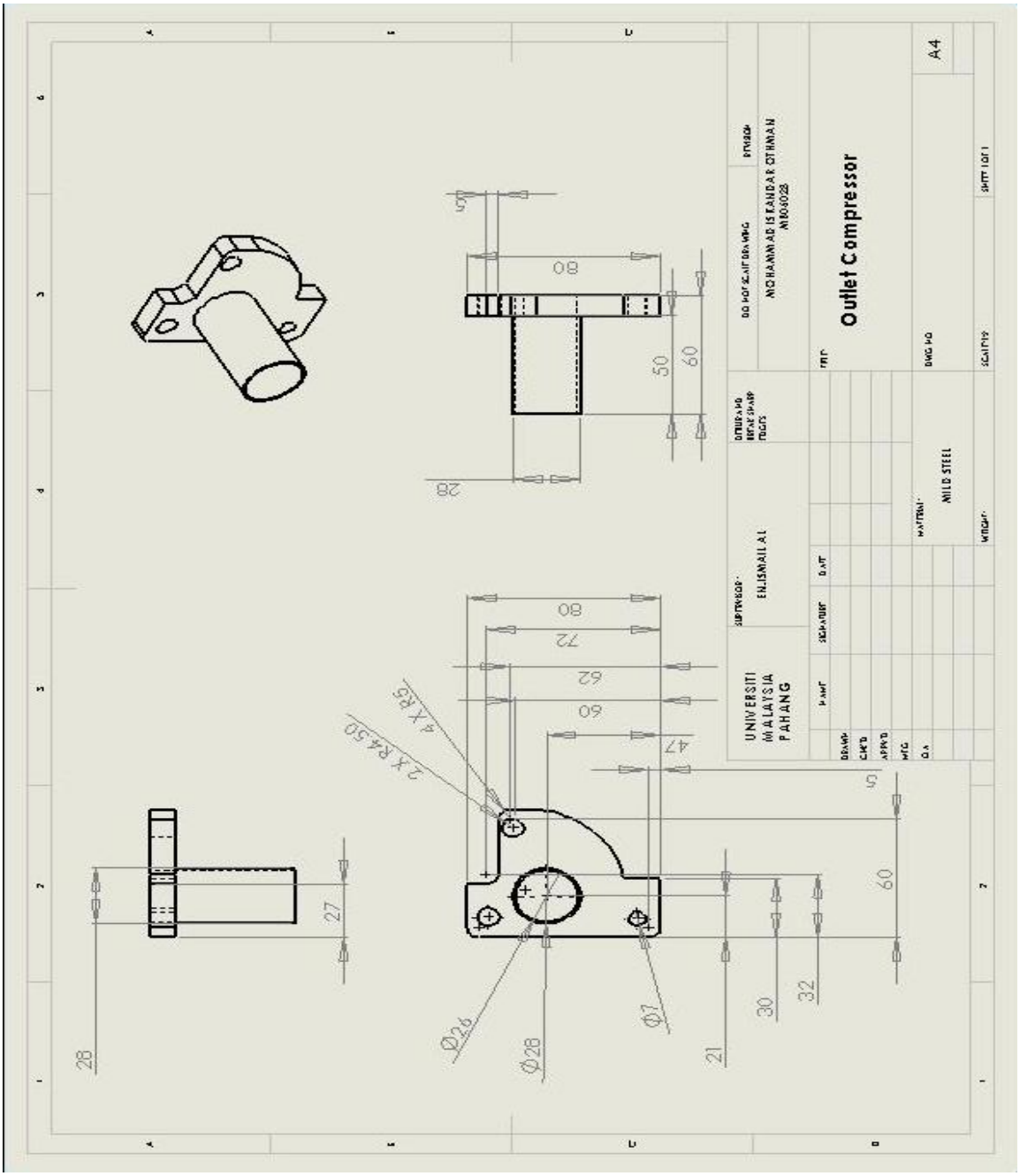


Figure 3.15: Orthographic View Outlet Flange Compressor

3.7 FABRICATION PROCESS

3.7.1 Introduction

After all the designing process and choose the best concept design complete, the fabrication process start by using the selecting raw material followed by the product dimension. Various type of method can be used to fabricate this project. Manufacturing Process is a collection of technology and methods used in the manufacturing defines when and how it is to be made. Fabrication process is a process to make only one product rather than manufacturing process that focus on the large scale production .The manufacturing and fabricating process differentially by quantity of product producing. In this project, the design is to make a real apparatus and can be used fully at the end. For this project, overall part that need to fabricate use the machine and accommodation that have at the UMP laboratory such as welding machine.

3.7.2 Process Involved:

This project consist the several process such as:

Measuring process – Measure the part / material based on the specification design

Cutting process – Cut the raw material followed the dimension

Welding process – weld the sheet metal part to the hollow bar.

Drilling process – Make holes on the work piece.

Assembly process – Assemble all the part/ component

Marking process – This process do before the cutting process do on it.

Grinding/Filing process – Removed the sharp edge at the work piece.

Plasma Cutting Process – Cutting the work piece follow the desired shape.

3.7.3 Process Step

The fabrication process is start with selecting the suitable materials for design .(**Figure 3.14)**.Next the measuring process to the all part that need to cut according the drawing dimension concept design. **(Figure 3.15)**The marker pen or scriber and tape scale use for marking the desire dimension.(**Figure 3.16**) After that, the PVC (poly vinyl chloride) that main material that used for this design cut by using hand saw. For cutting plat metal, the bend saw use for cutting the metal with specification 100mmx100mmx5mm. **(Figure 3.17)**

Before the outside shape cut to the desire design, all the holes for screw must to drill first to both of work piece (outlet and inlet compressor). **(Figure 3.18)**

To making the big hole at the centre of plat metal diameter 32 mm, it is have 2 methods to fabricate this part. They are by using the drilling machine to make hole around the marking part at the centre part **(Figure 3.19)** and the second method is by using the machine plasma cutting.

Next step is continued with cutting process for the outside shape design by using the plasma cutting that applied the high compress air. The high focus is needed when handle this machine to make sure the work piece become failed**.** (**Figure 3.20**& **Figure 3.21).**

After all the work piece cut into desire design, the machine grind use to remove the sharp edge at the corner of work piece and at the hole center of both work piece by using grind machine. **(Figure 3.22)**

To assemble the hollow rod and plat metal, they are using the MIG (metal inert gas) process. To makes the welding part is more greats, the grind process need to do on the weld part. The MIG method chosen caused this method is easy to use and makes more great looking welds. **(Figure 3.23)**

Use the hose clip to tight the connection between hose piping and PVC**.(Figure 3.24).**After the process done, the inlet and outlet that already complete ready to install at the turbocharger. The process complete when all the part already to assemble.

Figure 3.14: Selecting material

Figure 3.15: Marking raw material

Figure 3.16: Marking Hole at the centre work piece

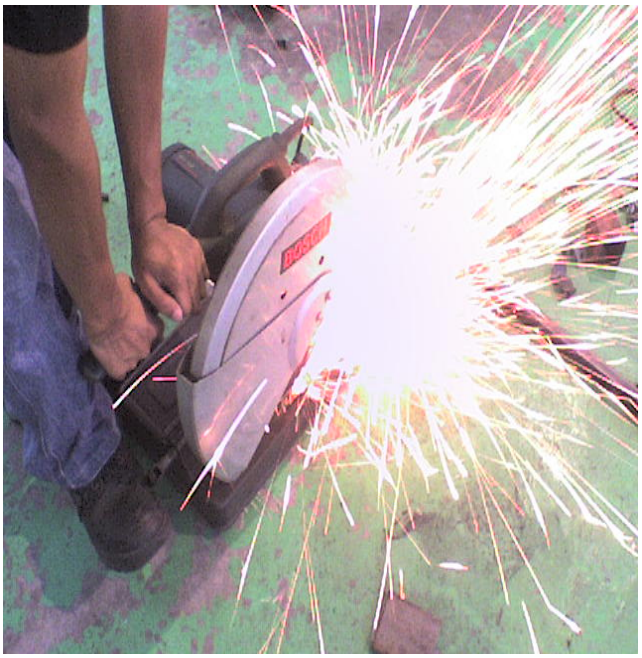


Figure 3.17: Cutting Process

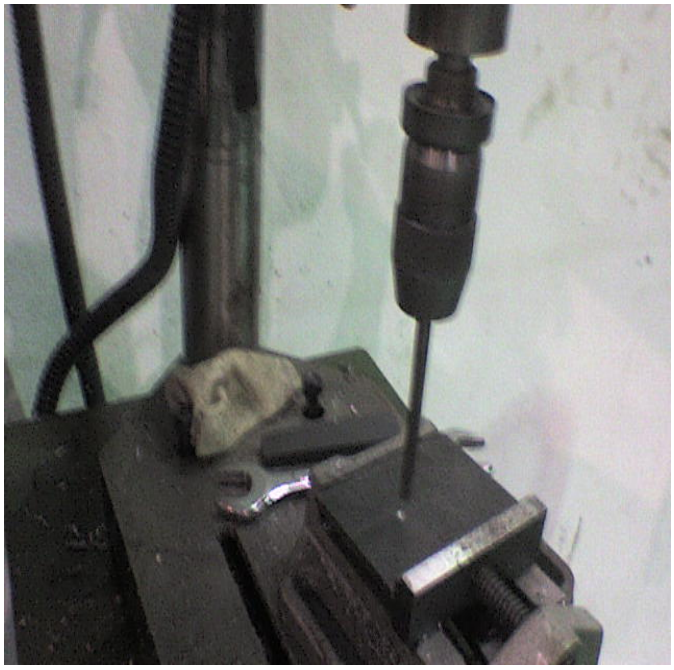


Figure 3.18: Drilling process to make hole for screw

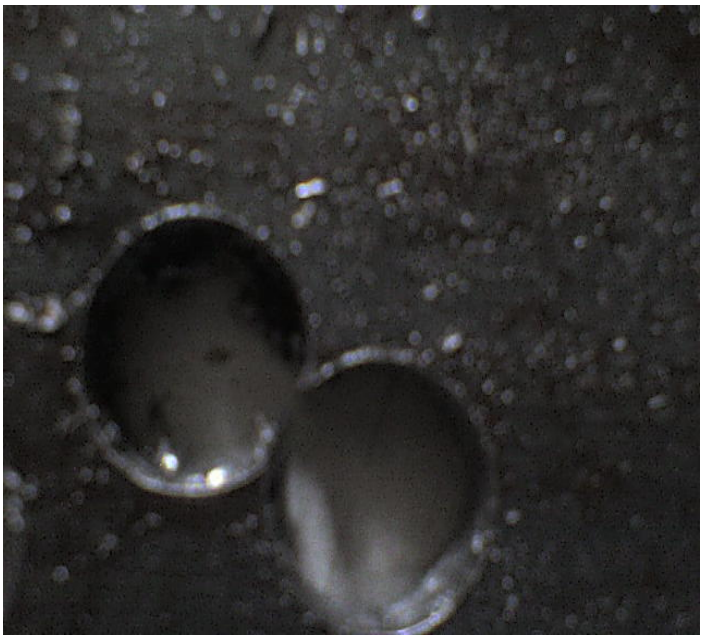


Figure 3.19: Drill the hole around the marking

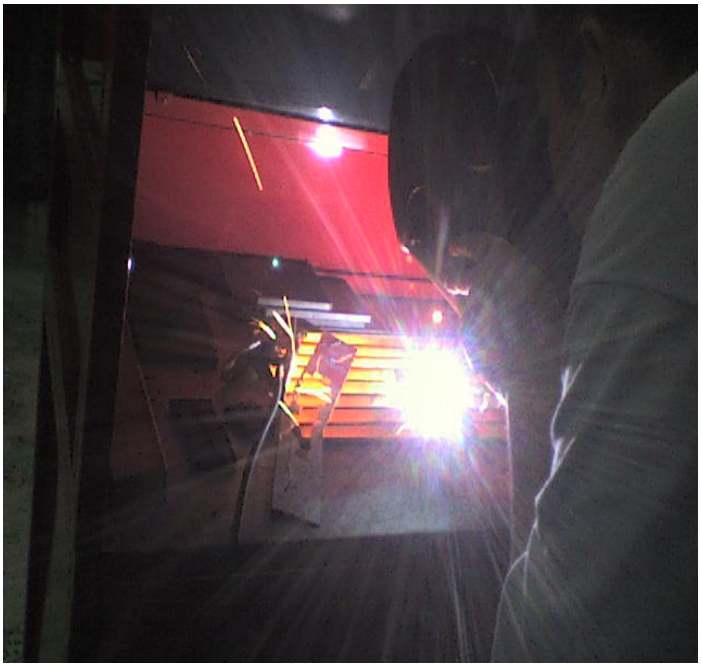


Figure 3.20: Cutting Material by using the plasma machine cutting

Figure 3.21: Results Cutting hole by using plasma machine cutting

Figure 3.22: Grind process

Figure 3.23: Welding process

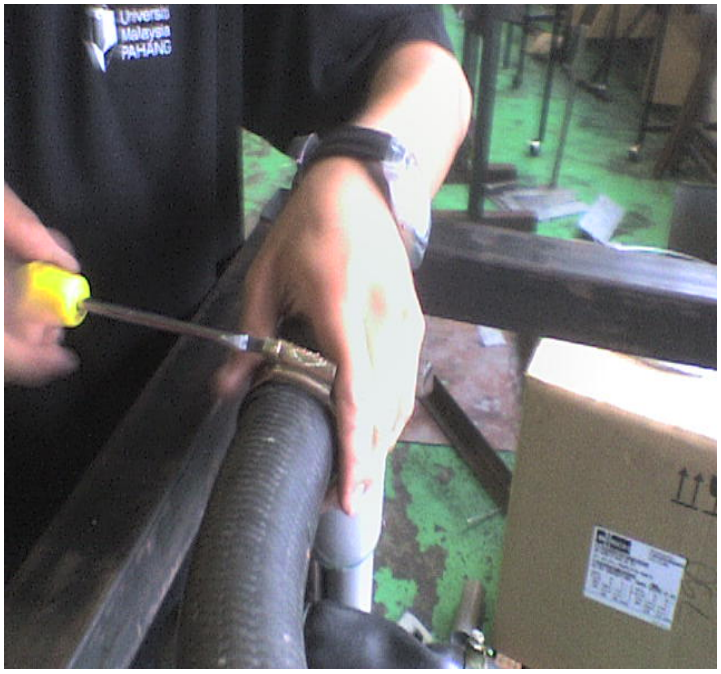


Figure 3.24: Use hose clip

CHAPTER 4

RESULTS AND DISCUSSION

4.1 PROJECT RESULTS

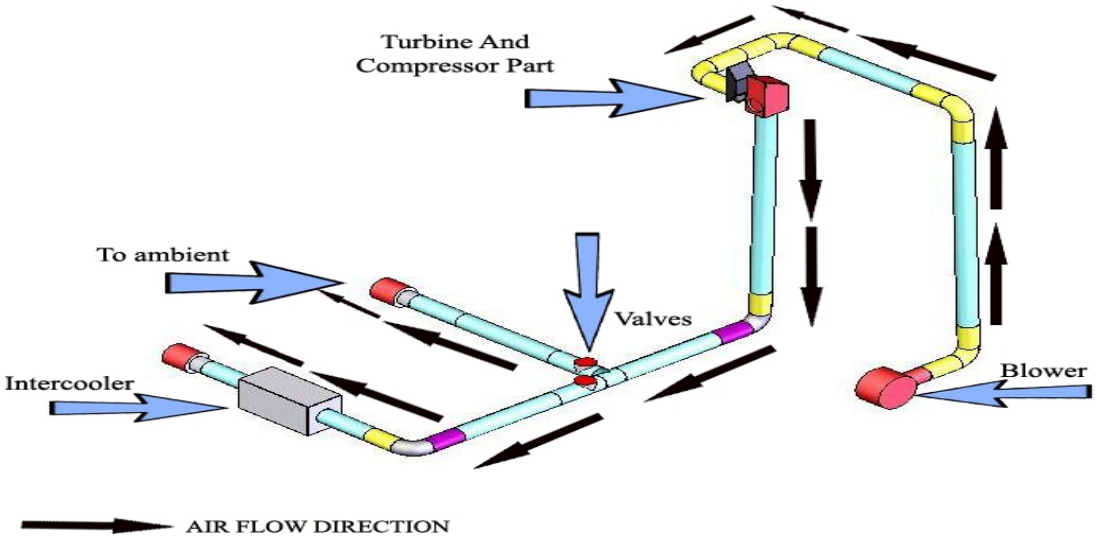


Figure 4.1: Air Flow Direction

According to the **Figure 4.2** , the energy that generate from blower produce the temperature, and velocity that will influenced the rate of flow system .This system have two way to rejected the waste heat that provide from blower. It is from through intercooler and the next way is the flow release to the ambient freely out from system.

From this situation we can calculate the Q_{in} (flow enter) and Q_{out} (flow out) for this system.

Figure 4.2: Final assemble

The system apparatus can use fully when the intercooler system attached on it and all the measurement apparatus for measure pressure, temperature, and thermal efficiency put on the final design.

Figure 4.3: Inlet Compressor Flange

Based on the Figure 4.3, the process that involved to making this part are drilling process for screw holes, plasma cutting, welding and grinding process.

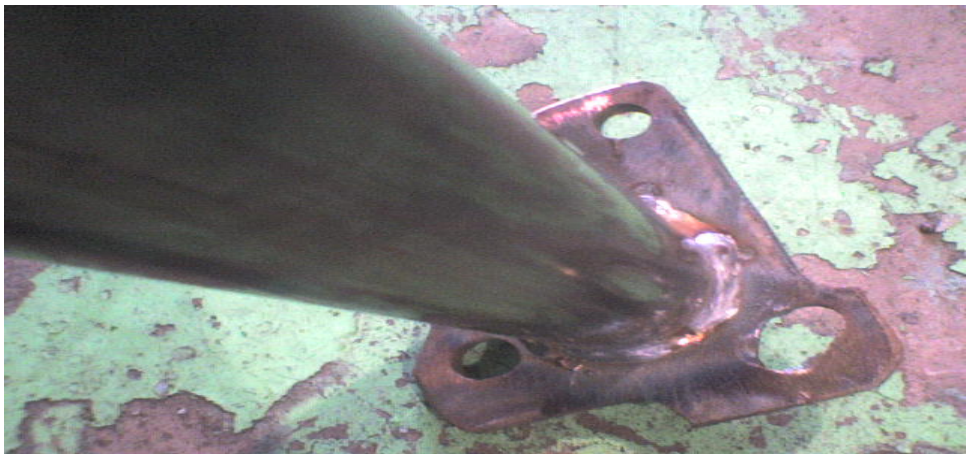


Figure 4.4: Outlet Compressor Flange

To making the centre hole for this part, the drilling process around the marking hole been selected. After that, the process grind do on it to remove sharp edge.

Figure 4.5: Complete Assemble for Inlet Compressor

Figure 4.3 and figure 4.4 showed the inlet and outlet compressor complete to assemble to piping connection. The hose radiator use to connect the rod for inlet and outlet to the PVC pipe.

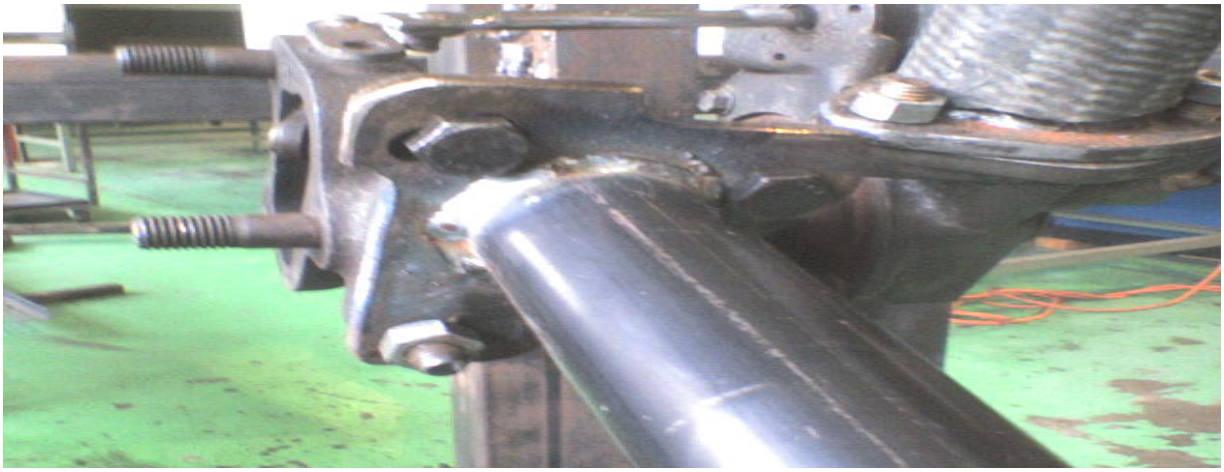


Figure 4.6: Complete Assemble for Outlet Compressor

Figure 4.7: The complete connection

Figure 4.8: The piping air flow piping with rig and stand of turbocharger.

According to the Figure4.5 and Figure 4.6 showed the complete connection for inlet and outlet. Each connection used the hose clip for the connection between the PVC pipe and inlet/outlet hose piping. Based on the planning the intercooler hose use to connect the pipe but it replace by using the motorcycle tube cause the intercooler hose difficult to found.

For figure 4.7 the air flow piping already installs at the rig and stand turbocharger ready to use .

4.2 PROJECT DISCUSSION

Materials	Units
PVC (Poly Vinyl Chloride)	5 Meter Length(Ø40 mm)
Turbocharger (IHI Type)	1
Variable Speed Blower	1
Elbow Pipe	6
T- Pipe	1
Ball Valve	2
Hose Piping	3
Sheet Metal	2
Hollow Pipe	2
Hose Clip	10

Table 4.0: There are list of materials used in this design

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 INTRODUCTION

This chapter concludes all the things work that already done and expressed the recommendation on the design at the future time.

5.2CONCLUSION

The conclusions for this project are the objective for this project is successfully to achieve completely and ready to use if the intercooler install on it. So the apparatus stand

The apparatus can use for thermodynamics process, such to measure the inlet and outlet flow if the intercooler install and all the measurement tools to measure the pressure, temperature and speed flow install on it. The apparatus have two valves that control the flow to enter through intercooler or not.

5.3 RECOMMENDATION

Several recommendations that I would like to express for the more improvement to the future are use the steel hollow material as the main raw material replace the poly vinyl chloride (PVC) for the piping circuit. Continue the project with the designation complete with the measurement tools such to measure the pressure, temperature or speed flow that use to the system. Next that I want to recommend is the system complete with the computer analysis that can calculate the pressure, temperature and flow rate for the system.

REFERENCE

1. ALAN ALLARD (1982,1986), “Turbocharging and Supercharging.”Wellingborough: Patrick Stephens.

2. YUNUS A.CENGEL.MICHAEL A.BOLES “Thermodynamics An Engineering Approach”

3. KIRBY S.CHAPMAN, JACQUE SHULTZ “Guidelines for Engine Turbochargers”

4. http://www.turbolader.net/en/content/performance_turbocharger.htm

5. http://www.turbochargedpower.com/History.htm

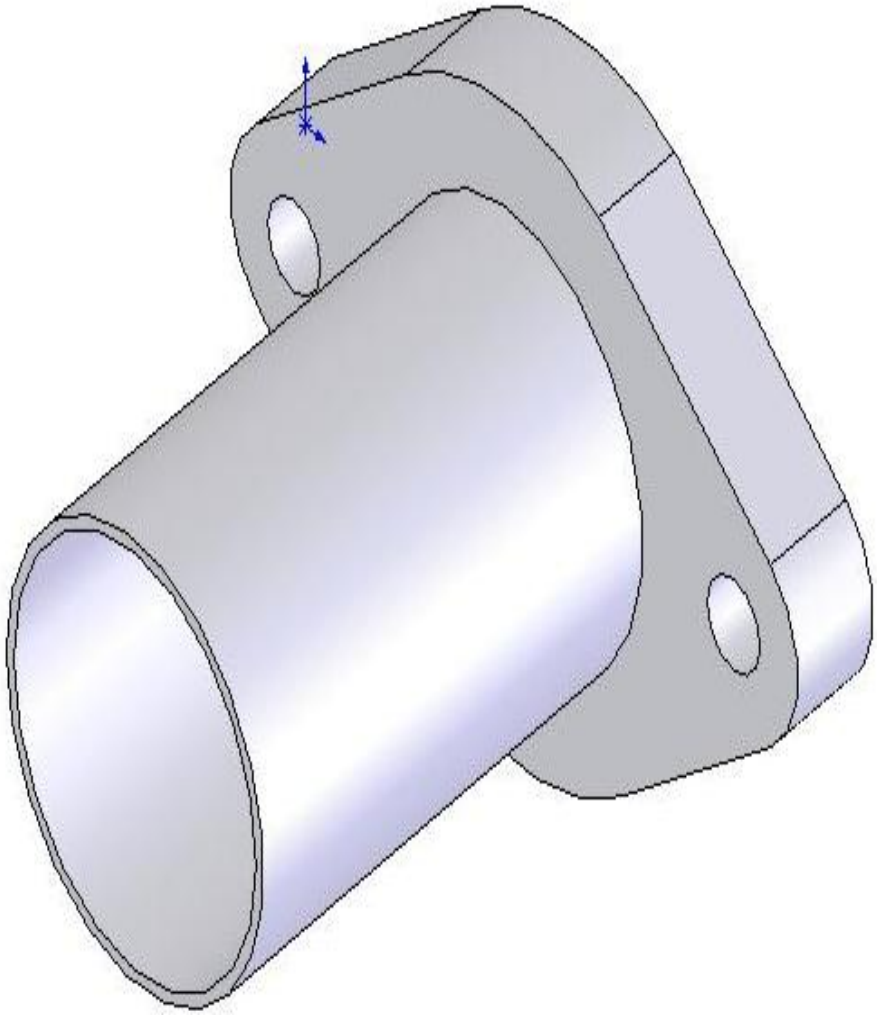
6. http://www.devileye.net/catalog/turbocharger_control_actuator/

7. http://www.tqc.co.uk/testmachines/turbocharger_testing.htm

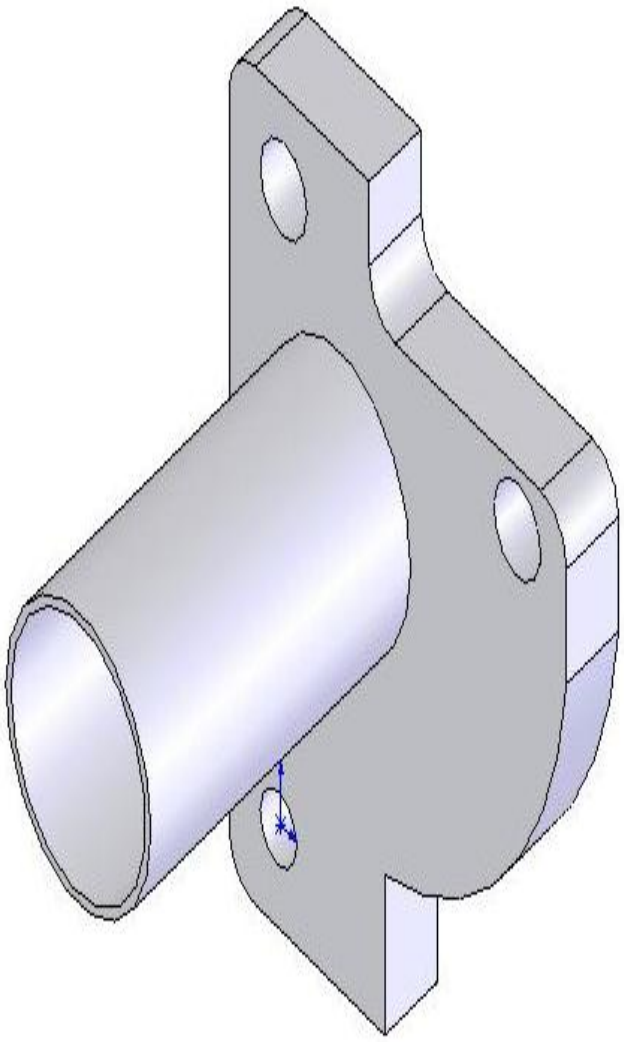
8. http://www.turboprecleaner.com/comparison_charts.aspx

9. http://www.quickhonda.net/exhaust.htm

APPENDIX A (ISOMETRIC VIEW)



COMPRESSOR INLET FLANGE DESIGN



COMPRESSOR OUTLET FLANGE DESIGN