DEVELOPMENT OF SINGLE CYLINDER ENGINE TEST RIG FOR SMALL ENGINE DYNO

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DEVELOPMENT OF SINGLE CYLINDER ENGINE TEST RIG FOR SMALL ENGINE DYNO

NAZIRUL IZZAT BIN IBRAHIM

Report submitted in partial fulfillment of the requirements

For the award of Diploma in Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2010

SUPERVISOR'S DECLARATION

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

Signature :

Name of Supervisor : MOHD RAZALI BIN HANIPAH

Position : LECTURER

Date :

STUDENT'S DECLARATION

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

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Date :

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ABSTRACT

This work is on the design and fabrication of a test rig structure that suite to the engine MODENAS Kriss 110cc. The objective of the report is to design and fabricate a test rig structure that suite to the engine MODENAS Kriss 110cc. This project also describes the review of products which are available around the world following to the title of the project. Design generation is showed and solid three dimensional structures modelling of the test rig structure that suite to the engine MODENAS Kriss 110cc was developed with computer aided design software. This report also explain the fabrication process that be needed for this project. Descriptions of material also show on this report. The problems encountered during completion of this project are also show in the report. An Improvement of the test rig structures that suite to the engine MODENAS Kriss 110cc needs for further application.

ABSTRAK

Laporan ini menunjukkan lukisan dan pembuatan struktur rangka ujian yang memuatkan enjin jenis MODENAS kriss 110cc. Objektif laporan ini adalah untuk lukisan dan pembuatan struktur rangka ujian yang memuatkan enjin jenis MODENAS kriss 110cc. Laporan ini juga menerangkan tentang produk-produk yang terdapat di serata dunia berdasarkan tajuk projek yang diberi. Konsep lukisan telah ditunjukkan dan permodelan struktur-struktur bongkah tiga dimensi untuk rangka ujian yang memuatkan enjin jenis MODENAS kriss 110cc yang telah dihasilkan menggunakan perisian lukisan bantuan komputer. Laporan ini juga menerangkan proses pembuatan yang diperlukan untuk projek ini. Penerangan mengenai bahan yang akan digunakan dalam projek juga diterapkan didalam laporan ini. Masalah yang dihadapi semasa menyiapkan projek ini juga terdapat di dalam laporan ini. Idea penambahbaikan untuk rangka ujian yang memuatkan enjin jenis MODENAS kriss 110cc juga disediakan untuk pembaharuan masa akan datang.

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LIST OF ABBREVIATIONS

Kg	Kilogram
Kgf.m	kilogram-force meter
Km/h	Kilometer per Hour
kW	kilo Watt
L	Liters
mm	millimeters
N.m	Newton meters
PS	Pound per Second
rpm	Revolution per minutes
SOCH	Single overhead camshaft

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

This project work on to design and fabricate a test rig structure for engine single cylinder that will test to the dyno engine. Engine single cylinder that been use for dyno test type MODENAS 110cc. The dynamometer engine is needed to calculate the torques in real time that delivered from the crankshaft single cylinder engine. So, the test rig for engine single cylinder must be rigidly and high stability when running. Overall, the project will meet acquire skills of design and fabrication.

1.2 PROBLEM STATEMENT

Engine MODENAS 110cc does not have any test rig to be mounted on the dyno engine. Therefore, a test rig must be designed and fabricated to sure that engine can run on the dyno. Furthermore, the test rig must be following the existing engine dyno dimension which is available in the Engine Performance Laboratory, University Malaysia Pahang.

1.3 OBJECTIVE

Objective for this project is to development of single cylinder engine test rig that suite to the 4 stroke engine model MODENAS 110cc for small engine dyno testing. Furthermore, this test rig stricture must be rigid and stable.

1.4 SCOPE

In project, scope project needed to specific range in the completion of a project. So, scope of this project is the test rig is suitable for engine model MODENAS Kriss 110cc only, it because every engine they had their specific dimension. Then, the design must fitting to the rail that existing on the Engine Performance Laboratory and the design that had fabricate were tested for fitting and static stability only to ensure the test rig do not break.

1.5 FLOW CHART

A flow chart, or flow diagram, is a graphical representation of a process or system that details the sequencing of steps required to create output. This flow chart was present steps or process of final year project that I will present in this semester. Figure 1.1 shows that process to complete my final year project.

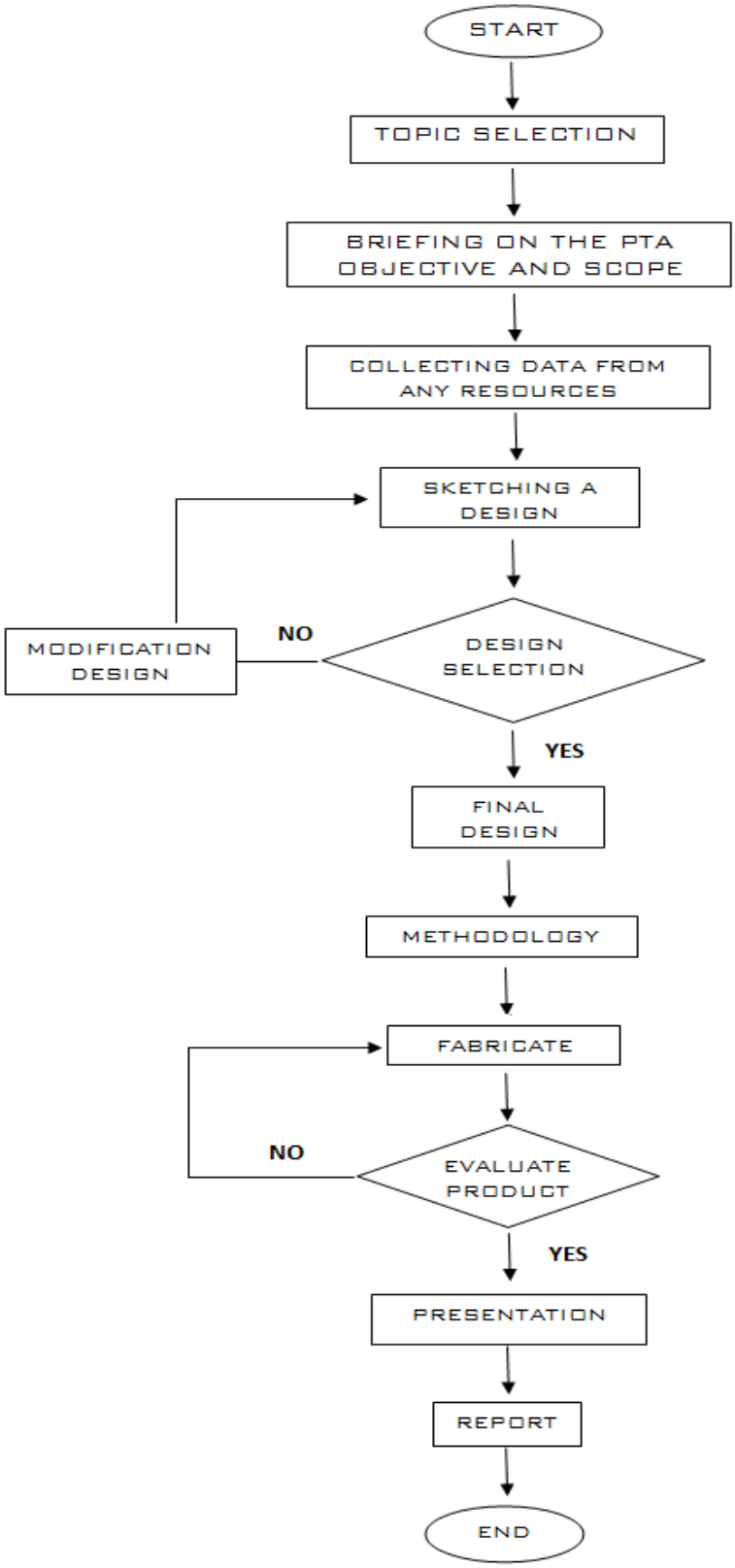

Figure 1.1: Flow Chart

The final year project starts with the title selection that been given. They had 31 title of project that had been state by coordinator final year project. Then, the topic that had selected will be brief about the problem, objective and scope by supervisor. From that data of literature review is need to make the objective are achieve. Data were collected from any research such as book, magazine, web site, or video. This step helps to create a design that suite to the product.

Regarding to the data that had collected, a design is needed for the fabricate process. The designs were crate by following the scope of project. It is to make sure the designs are following to the specification. After that, the designs that had created will continue to the selection design and the best design will be a final design and improvement to the design if needed. Then, it is ready to the fabricate session.

A final design is must complete with the dimensions to proceed to the fabrication. The fabrication process that involved is cutting, welding, bending, grinding, milling, and drilling.

Here come the testing and evaluation process. A product will be test to see if it full fills the requirement such as safety, ability and strength. During the testing, if a problem occurs, the process of fabrication a test rig structure will step back to the previous process. The reason to step back is to fix the error.

After all the parts had been joined together and no error, here comes the phase of result and discussion. In this part, how the multifunction will be inform. Beside, how to achieve objective and solve problem statement of the project will be discuss in this phase.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A literature review is a body of text that aims to review the critical points of current knowledge and or methodological approaches on a particular topic. Literature reviews are needed be get the information about the project that will operate. This review will give information about my project especially the product that had existed in the market and materials used on the fabrication. It is important to make sure my project become productive. Then, a design will create base on data that had been collected in literature review.

2.2 DYNAMOMETER

A dynamometer or "dyno" for short is a device for measuring force, moment of force (torque), or power. For example, the power produced by an engine or motor can be calculated by simultaneously measuring torque and rotational speed (RPM). For calculate the force and torque motoring or driving dynamometer is used. In my project, dynamometer is used to get the power and torque of engine model MODENAS Kriss 110 cc. Figure 2.1 shown how the engine and dynamometer are attached each other by coupling the crankshaft of engine and shaft on the dynamometer to measure the torque and velocity of engine.

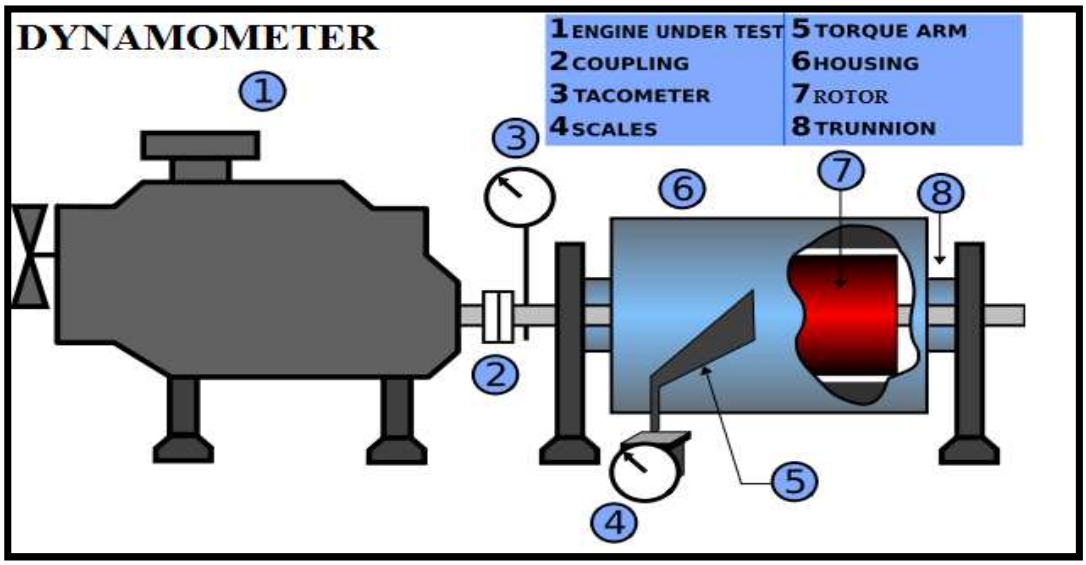

Figure 2.1: Dynamometer

Source: http://en.wikipedia.org

In semester 3 I have learn how to calculate velocity, torque, and power that lecture by (En. Azrul, 2009) in subject solid mechanic. To determined the engine speed and torque using the following equation:

$$P = \tau \cdot \omega$$

Or

$$P = F \cdot v$$

Where

P is the power in watts

τ is the torque in Newton meters

ω is the angular velocity in rotations per minutes

F is the force in Newton

v is the linear velocity in meters per minutes

Dynamometer that had in automotive laboratory is type Eddy Current. This dynamometer can detect power over 150 kW. Eddy-Current Dynamometer's theory is based on Eddy-Current (Fleming's law of right hand). The construction of eddy-current electro brake as shown in Figure 2.3 has a notched disc (rotor) which is driven by a prime mover (such as engine, etc.) and magnetic poles (stators) are located outside of it with a gap. The coil which excites the magnetic pole is wound in circumference direction. When a current runs through exciting coil, a magnetic flux loop is formed around the exciting coil through stators and a rotor. The rotation of rotor produces density difference, then eddy-current goes to stator. The electromagnetic force applies in opposite of the rotational direction by the product of this eddy-current and Vector of magnetic flux and it becomes brake (TOKYO METER CO., LTD, 2000).

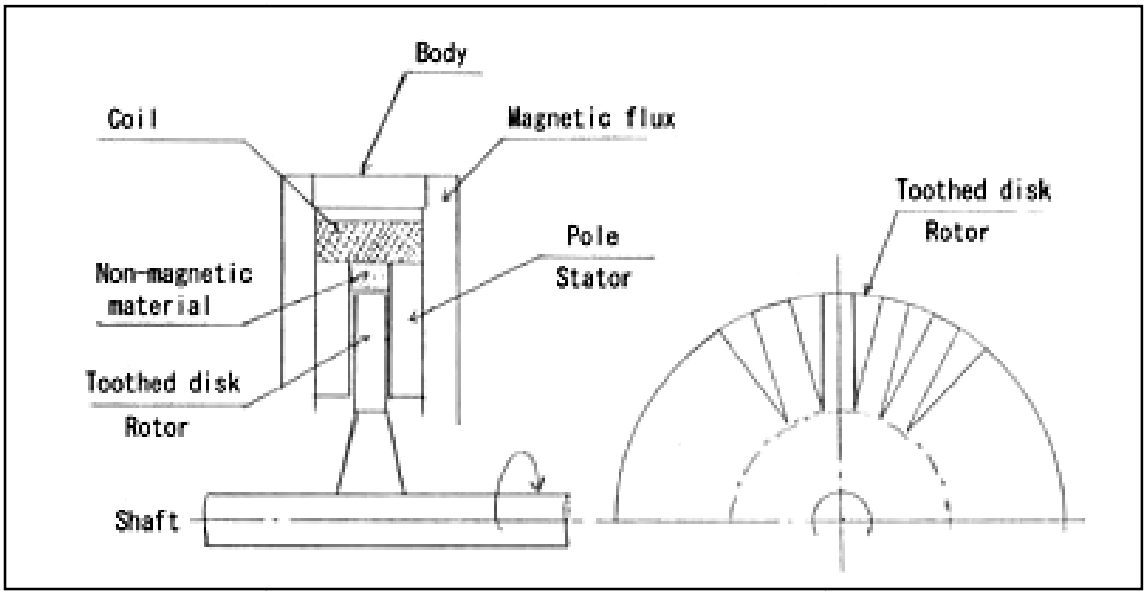

Figure 2.3: Contraction of Eddy Current Electro Brake

Source: http://www.tokyometer.co.jp

2.3 ENGINE

The engine that will operate on the dynamometer is model MODENAS Kriss 110cc. Table 2.1 shown the characteristics of the engine:

Table 2.1: Characteristic MODENAS Kriss 110 cc

KRISS 110 CC
Max power: 9.0 PS (6.6 kW) @ 8,500 rpm
Max torque: 9.3 N·m (0.95 kgf·m) @ 4,000 rpm
Engine type: SOHC 2-valve 4-stroke single-cylinder, air-cooled
Displacement: 111 cc
Bore x stroke: 53 x 50.6 mm
Compression ratio: 9.0:1
Fuel tank capacity: 4.3 L
Dry weight: About 100 kg
Transmission: 4 speed with automatic centrifugal clutch
Max speed: about 140 km/h

Figure 2.3 show the engine that existing at the laboratory. I had measure the dimension of the engine and get the area of engine are arrange 300mm x 440mm x 200mm.

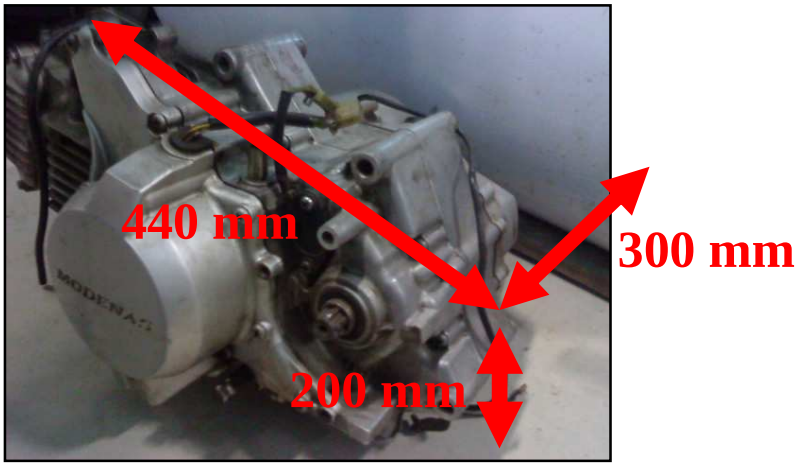

Figure 2.2: Engine Kriss 110 cc

2.4 TEST RIG

The test rig structure is the main structure for hang up the engine that will test on the dyno engine. The test rig structure was design base on the dimension dynamometer used such as height, and length. There are many of test structure can be design, because it base on the type of engine that used. A test rig that will fabricate must be static and rigidly for static stability of engine maintain when running.

2.4.1 Motorcycle Engine Test Rig

Figure 2.4 shown that test rig was made by Dr. Gitano Horizon (University Science Malaysia). This design was aim to testing at small engine dynamometer.

The material that been use to fabricate this test rig by using mild steel angle, mild steel hollow, nat and bold.

Figure 2.4: Motorcycle Engine Test Rig

Resource: www.skyshorz.com

2.4.2 Four Stroke Single Cylinder

Figure 2.5 shown that test rig single cylinder, 4 stroke diesel engine was fabricate by Techno Lab Equipments Company. This company had made many products on the engine including this one. The material that been use to fabricate this test rig by using mild steel angle and it is joining by welding method. The design was fixing and there are no adjustments.

Figure 2.5: Vcr Diesel Engine Test Rig

Resource: www.technolab.co.in

2.4.3 Fz Motorcycle Test Rig

This product was design and fabricate by engineer in Figure 2.6, this product had been test at Universiti Malaysia Pahang (UMP) for dynamometer test and it is located in Engine Performance Laboratory, UMP. There are so many materials used on fabricating this design but it is effective design and looks stable.

Figure 2.6: Fz Engine Test Rig With Dyno Engine

This design was completely with the height adjustable shown in Figure 2.7 to locate the drive shaft of dyno engine. This adjustable height can be adjusted by using spanner and allen key to unlock the clamp that grip the shaft.

Figure 2.7: Adjustable High

2.5 MATERIALS

Materials are needed to make a test rig structure. A good characteristic of materials are need to make the high quality of test rig structure. Regarding to the test rig structure that had review, most of the test rig structure are made by mild steel.

Why mild steel is use for test rig structure? The American Iron and Steel Institute defines a carbon steel or mild steel as having no more than 2 % carbon and no other appreciable alloying element. Carbon steel makes up the largest part of steel production and is used in a vast range of applications.

Typically carbon steels are stiff and strong. They also exhibit ferromagnetism (i.e. they are magnetic). This means they are extensively used in motors and electrical appliances. Welding carbon steels with carbon content greater than 0.3 % requires that special precautions be taken. However, welding carbon steel presents far fewer problems than welding stainless steels. The corrosion resistance of carbon steels is poor (i.e. they rust) and so they should not be used in a corrosive environment unless some form of protective coating is used (Paul Hudson, 2006). Tables 2.2 show the advantages and the disadvantages of mild steel.

Table 2.2: Advantage and Disadvantage of Mild Steel

Advantages	Disadvantages
• Cheap • Wide variety available with different properties • High stiffness • Magnetic • Most carbon steels are easy machine and weld	• Poor corrosion resistance

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology is the set of method and principles that you use when studying a particular subject or doing a particular kind of work state in (Edinburgh Gate. 2006). The data that had review is used to get the design and identify method of fabrication of this product. In this session the methodology will describe about the design, final design, selection materials, and fabrication method.

3.2 DESIGN CONCEPT

The data that get from the review give me some idea to make a design of the project. The design must be appropriate with the scope of project.

Before I start to design the concept of project, I have 2 choices to make the design.

i) First design is use the existing body frame of motorcycle MODENAS 110cc, which is a modification of body frame are need to following the scope of project.

ii) Second design is does no use the body frame of motorcycle MODENAS 110cc, which is a new design is need regarding to the review data.

So, I had to choice the second design because if I use the body frame, I must cut only on the engine holder and it might hard to get the correct axis when want to fabricate. Then, the new design is easier to design, it will give me to involve more method on the fabrication and I will use all knowledge and skills of mechanical to fabricate it.

2.2.1 DESIGN 1

First design was create simply, where the frame body of structure were made fix and rigidly shown in Figure 3.1. It is included the engine holder adjustable for holder the engine correctly. It is looks easy and do not use many method to fabricate.

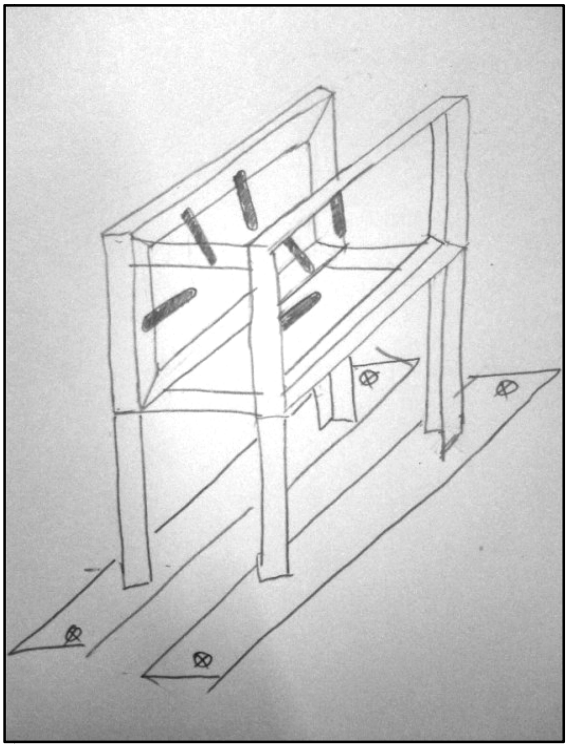

Figure 3.1: Design 1

3.2.2 DESIGN 2

The second design is idea from the engine hoist that shown in Figure 3.2. This engine hoist usually used to remove the engine from the car. It can withstand over 3 tone of weight.

Figure 3.2: Engine Hoist

Source: http://www.northerntool.com

From there I can design the engine holder is likely same design with the engine hoist. This design is complete with the engine holder shown in Figure 3.3and I minimize the stand become 3.

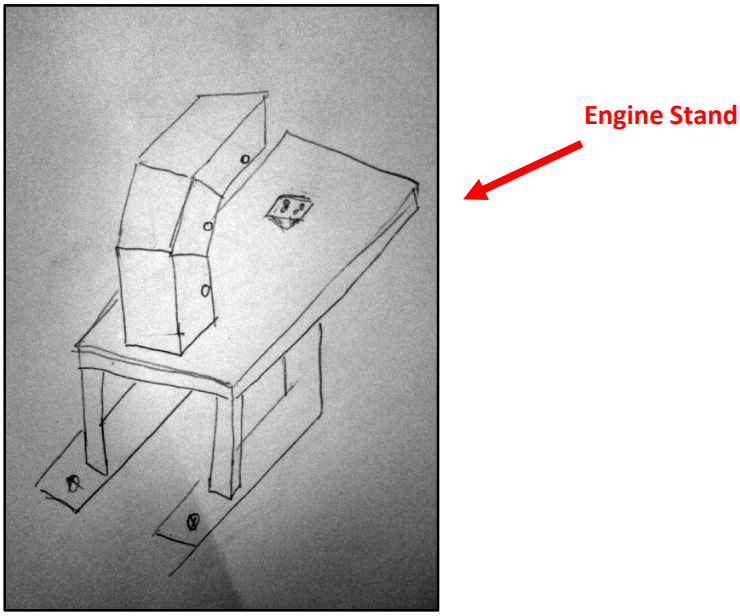

Figure 3.3: Design 2 with Engine Stand

3.2.3 DESIGN 3

Design third is the same concept with the second design shown in Figure 3.4. The different between these designs is the engine stand that I spread it from the body because to minimize the engine area when joining the engine with the test rigs. These designs also contain the height adjustable for mount accurately to the height of dyno engine shaft.

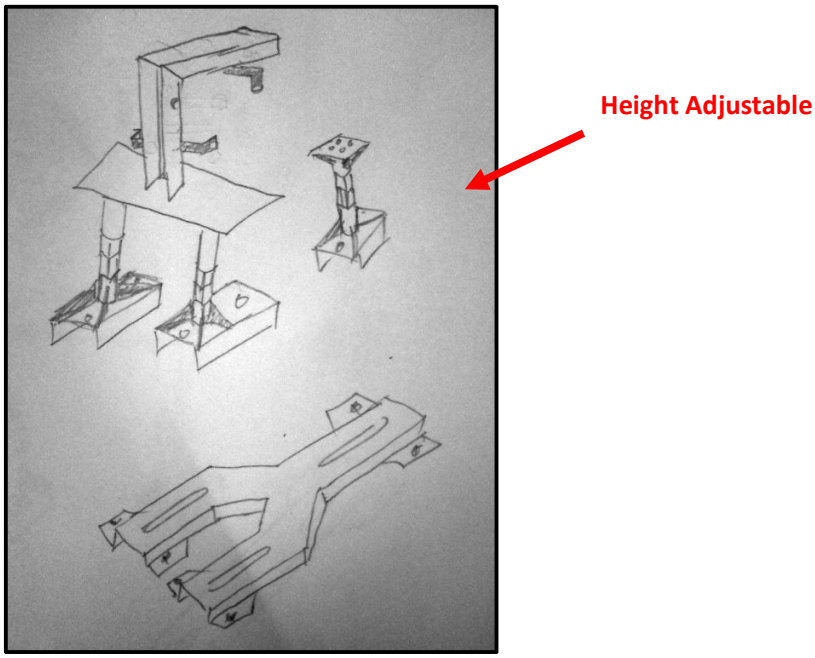

Figure 3.4: Design 3

3.2.4 DESIGN 4

For design fourth I try to simplify from all the design to make it easy to fabricate it shown in figure 3.5.

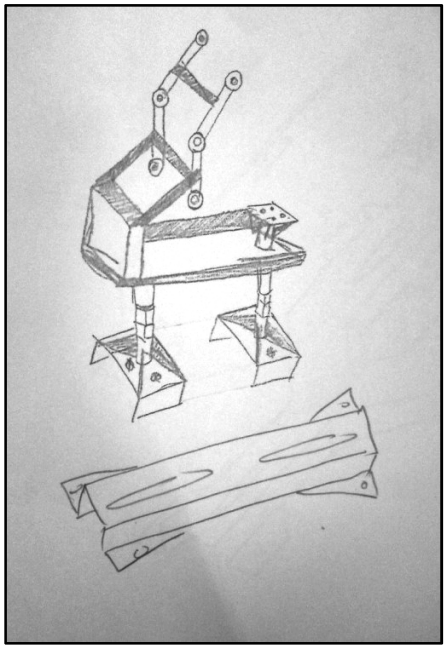

Figure 3.5: Design 4

3.3 DESIGN SELECTION

After design the concept, comparison from all the design and study the best design that relate with criteria selection. Then make decision which design is the best.

Below shown the table 3.1 which uses to select which criteria is the best from screening concept. Design 1 will be the datum because it is the quite simple design with the existing test rig structure.

Table 3.1: Screening Concept

CHARACTERISTIC	DESIGN			
	1 (DATUM)	2	3	4
Rigidly	0	0	-	-
Adjustable High	0	0	+	+
Adjustable Engine Holder	0	-	-	-
Adjustable Stand	0	-	+	+
Manufacture	0	0	-	+
Material Usage	0	-	+	+
Easy To Handling	0	+	+	+
Sum of (+)	-	1	4	5
Sum of (0)	7	3	-	-
Sum of (-)	-	3	3	2
Net Score	0	-2	1	3
Rank	3	4	2	1

Note:
0 is same as
+ is better than
- is less than

As you can see the concept design had been rank. So, I expect that design 4 and design 3 will continue to the next step which is the improvement are need to get the best design from this two design.

3.4 FINAL DESIGN

Final design is totally the last of design that had chosen from the concept design. Review the data that I get from the screening concept, I have design one more design that improvement and combination from the design 3 and design 4. Figure 3.6 shown the design that I had give improvement and combination. I mention it as design 5.

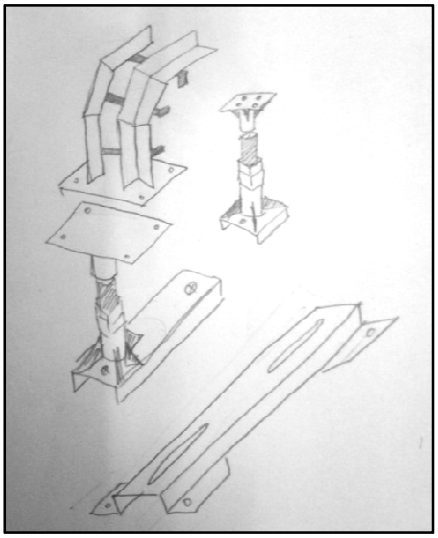

Figure 3.6: Design 5

After I get the improvement design, I was forwarding it to my supervisor En. Razali. Then, this design gets recommendation from him and I accept the recommendation. He suggests this design must have four stands to get the stability when engine running and the body must join with the body. Then, I modeling the design that he recommended. Figure 3.7 shown my 3D modeling final design and it is ready to the next step which is fabrication.

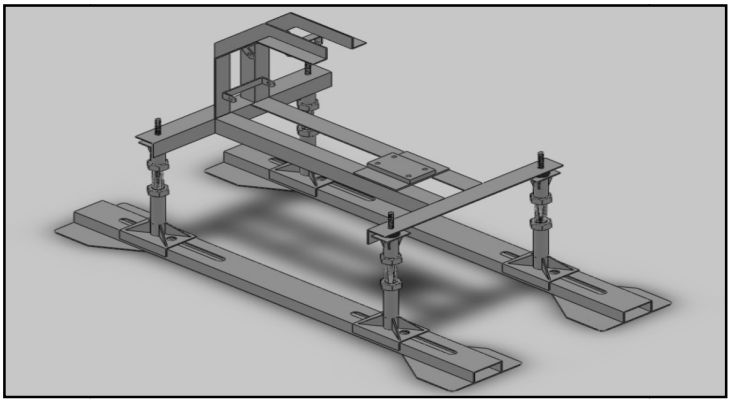

Figure 3.7: 3D Modeling Final Design

Before the fabrication process run, the final design must have a dimension for the size of part that will be fabricate. A drawing will show the dimension of the part, I used Solid Work software to get the dimension of part and 3D modeling of project shown in Figure 3.7. All drawing part will show at Appendix A2.

3.6 MATERIAL SELECTION

Design that had modeling form Solid Work software will be define the material usage before go to the fabrication session. This model I choose mild steel because of the material characteristic that I review. Below show the list of materials that use on test rig in Table 3.2.

Table 3.2: List of Materials

BIL.	MATERIAL	SIZE	LENGTH	QUANTITY
1.	Angle bar	50mm x 50mm	4m	1
2.	Hollow pipe	1 inc. dia.	1m	1
3.	Plate	30mm x 3mm(thick)	0.3m	3
4.	Hollow square	50mm x 100mm	1.2m	2
5.	Flat bar	50mm x 5mm (thick)	1m	1
6.	Flat bar	100mm x 5mm (thick)	1.5m	1

3.6 FABRICATION METHOD

Fabrication, when used as an industrial term, applies to the building of machines, structures and other equipment, by cutting, shaping and assembling components made from raw materials. This fabrication session were describing from the select material until the end of project which is finishing. Figure 3.8 shown fabrication method that will operate on this project by following the part.

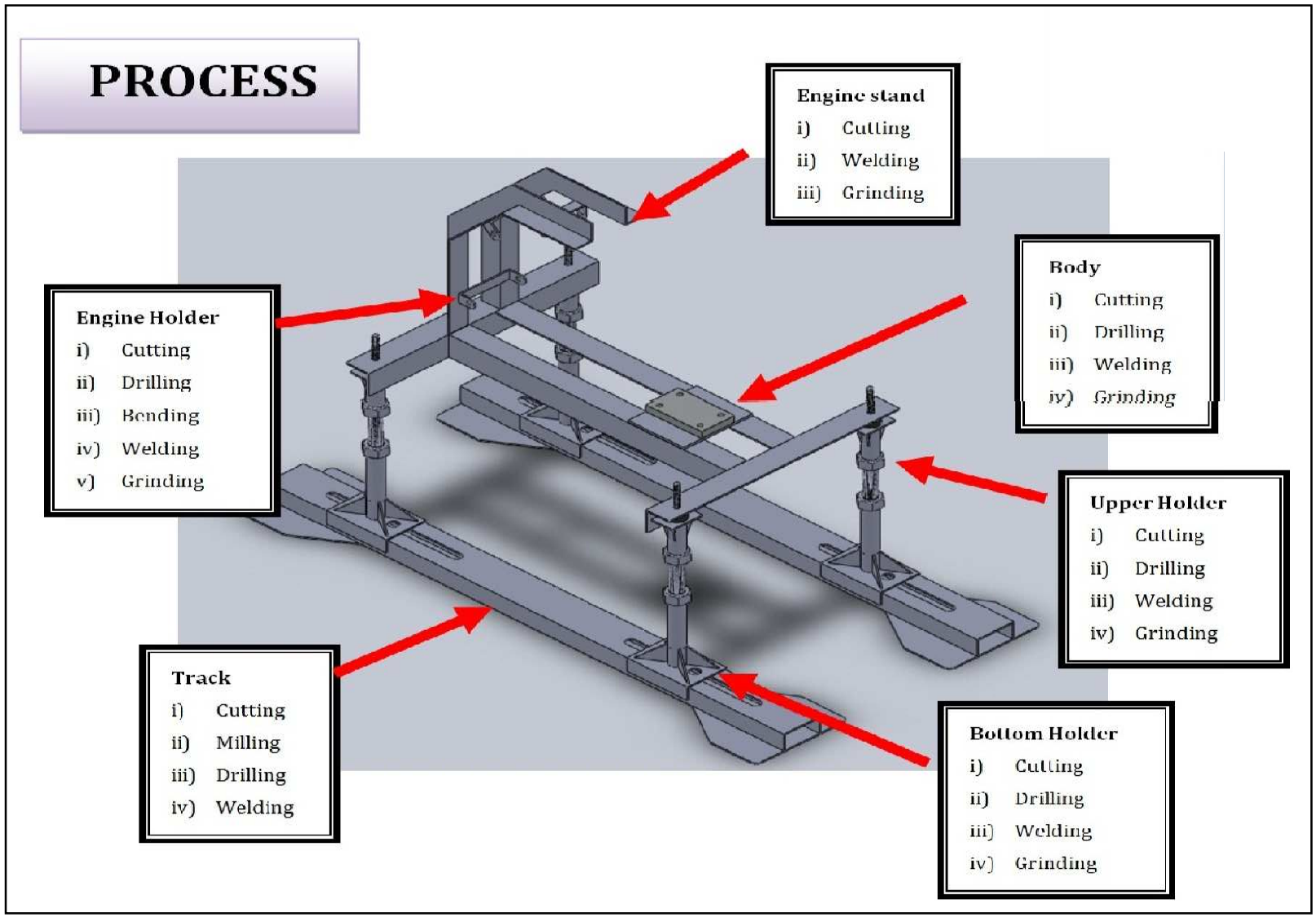

Figure 3.8: Process of Project

3.6.1 Measuring

In science, measurement is the process of obtaining the magnitude of a quantity, such as length or mass, relative to a unit of measurement, such as a meter or a kilogram. The term can also be used to refer to the result obtained after performing the process. A device is needed to measure the material and get the accurate dimension before to the other process.

For my project I use measuring tape to mansion the length of material shown in Figure 3.9 and a vernier caliper to check the thickness of materials that will use on this project.

Figure 3.9: Measuring

3.6.2 Cutting

Cutting is the separation of a physical object, or a portion of a physical object, into two portions, through the application of an acutely directed force. Cutting also describes the action of a saw which removes material in the process of cutting.

After I measure the material, cutting process is needed to separate the material by part. Before using the cutting machine, a safety precaution is needed to protect worker from the hazard. Figure 3.10 show personal protective equipment before running the cutting machine.

Figure 3.10: Personal Protective Equipment

A saw machine used to cut the materials that took from the store. All materials in the store are length more than 3 meter. So, I need to cut it to a small part. Figure 3.11 show the machine band saw that I use to cut the materials.

Figure 3.11: Band Saw Machine

Some part of my project had an angle to joint. So, a disc cutter is needed to make an angle cut shown in figure 3.12.

Figure 3.12: Disc Cutter

A shearing machine is used to cut a metal sheet. Figure 3.13 Shown the Shearing machine that used on this fabrication. This sheet metal use to make a part of project known as engine holder.

Figure 3.13: Shearing machine

3.6.3 Drilling

Drilling is the cutting process of using a drill bit in a drill to cut or enlarge holes in solid materials, such as wood or metal. Different tools and methods are used for drilling depending on the type of material, the size of the hole, the number of holes, and the time to complete the operation. Figure 3.14 shows the machine drilling that I used to make a hole to the part of my project. Protective equipment must be wear to avoid from the hazard.

Figure 3.14: Drilling Process

3.6.4 Joining (Welding)

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the *weld pool*) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld.

To join all the material into the part of test rig structure, welding process will be the selected process. A Shield Metal Arc Welding (SMAW) will be used for joining process shown in Figure 3.16. Figure 3.15 show the protective equipment to do a welding process.

Figure 3.15: Protective equipment for welding

As you can see, the glove on the Figure 3.14 is to protect hands from the heat that comes out from the welding process. Then, the face shield is to protect your face from burn.

Figure 3.16: Welding process

3.6.5 Bending

Bending is a process to make a part material to be curve or bend. To make a part of my project become bend a pneumatic bending machine is used to make it bend 90^{o} angle. Figure 3.17 shown the bending machine that I used and Figure 3.18 shown the part that I have bend.

Figure 3.17: Bending Machine

This part is to hold the engine to hang up on the test rig. There have three of part to hang up the engine on the test rig structure with different dimension following to the engine dimension.

Figure 3.18: Part That I Have Bend

3.6.6 Milling

Milling process is needed to make a hole or slot. Milling process is needed to make the track that hold on the rail that had in the Engine Performance Laboratory. A milling machine is use to make the hole. Protective equipment is

needed to make sure it safe when you do the process. Figure 3.19 show a part that I fabricated use milling machine.

Figure 3.19: Rail Stand

3.6.7 Finishing

Finishing processes may be employed to improve appearance, adhesion or wet ability, solder ability, corrosion resistance, tarnish resistance, chemical resistance, wear resistance, hardness, modify electrical conductivity, remove burrs and other surface flaws, and control the surface friction. In limited cases some of these techniques can be used to restore original dimensions to salvage or repair an item.

For finishing process in my project I use the surface become smooth and edge of angle of the project. A grinding machine is needed to make the surface and edges become smooth shown in Figure 3.20.

Figure 3.20: Finishing On Grinding Machine

Then, finishing process appearance has done by paint the surface of product using spray. Figure 3.21 shown final products after finishing process.

Figure 3.21: Final Finishing

CHAPTER 4

RESULTS & DISCUSSION

4.1 INTRODUCTION

CHAPTER 4 is the discussion on the results for modification of this project and several problems occur to the project. This chapter also will discuss mainly about the problems encountered during the whole project was been carried out.

4.2 PROJECT PROBLEMS

During the project on going, many problems occur from the beginning of the project until the finishing producing of product.

The concept and ideas review for this project are not very wide because it is not widely modified by the manufacturer. Therefore, the concept should come with own ideas on this project. Besides that, test rig that specific to the engine MODENAS Kriss 110cc currently does not had in the market. So, the drawing and dimension need to generate and mention for design the concept of project by referring the engine model MODENAS Kriss 110cc design.

In faculty central store there are limited resources on type of material. Therefore, the design had to change following to the materials that using the dimension of material

that using conversion unit which is inch. So, the dimension of the final product is not accurate recording to the final design use metric unit which is millimeter.

Furthermore, Welding process is harder process of fabrication on assembly the part. It needs a high skill to do this process. Besides that, to get accurate joining recording to the drawing is hard because this is manual process. Figure 4.1 show a part that joining using welding process.

Figure 4.1: Welding Part

4.3 PROJECT DESCRIPTION

The problem statement for this project is no a test rig structure to engine MODENAS Kriss 110cc that will run to the dynamometer. To solve the problem, idea to produce test rig structure with efficient look had come. A several new concept designs were come out to solve the problem. Those new concept designs are create by depending on the objective. Then, they were comparing to look, which of them could be the final design and will be fabricate. The engine had been suite to the test rig structure shown in Figure 4.2. That means the objective of the product had been achieved. However, there had something problem happened on this test rig which is the body is bend when the engine hang up on the test rig. So, it is need some modification on this test rig for future used.

Figure 4.2: Test Rig Testing

4.4 FUNCTION OF TEST RIG

Figure 4.3 show the modelling product and labelled with the function of the part.

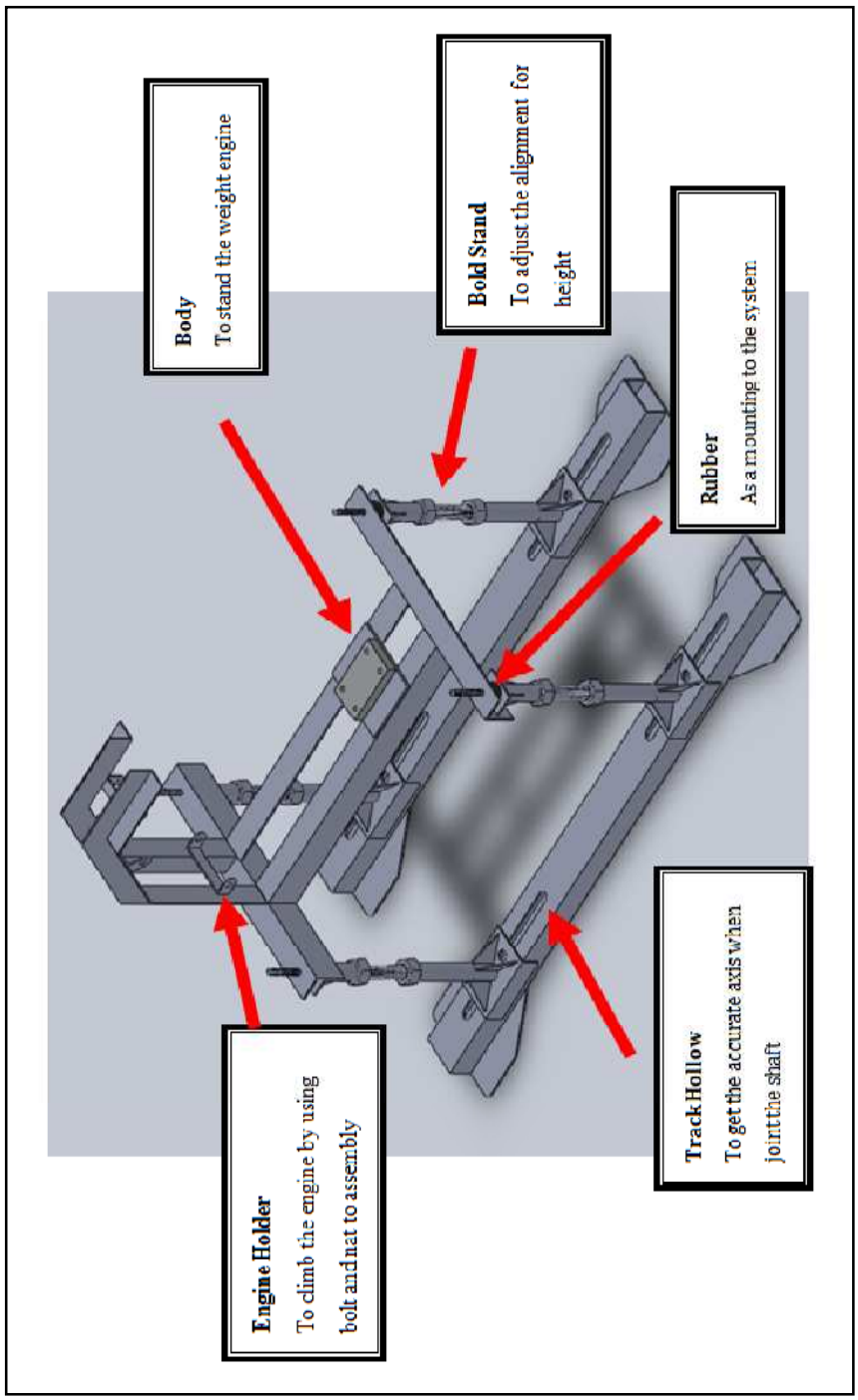

Figure 4.3: Function of Part

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

CHAPTER 5 is the conclusion and recommendation of this project. In this chapter, it will include the objective of this project is fulfilled and some weakness that need to be improve.

5.2 CONCLUSION

The project is finish and the test rig structure is able to hold the engine MODENAS Kriss 110cc. The objective of the project is achieved at the end of design and fabrication but there had a problem in the product which is the material that used is not very enough tough to hold the engine on the test rig and it is easily to bend when some massive vibration appear from the engine. So, this product needs some modification in term of material used, fabrication skill, and the most important is the analysis of the product to make sure the test rig structure that had fabricate not fail.

5.3 RECOMMENDATION

The test rig structure has its weaknesses which will need to be improved to get a better result.

The test rig structure is made in angle bar 3mm thickness. However, it is better to use an angle bar with 5mm thickness. It is because 3mm thickness is easily to bend when the engine put on it, so I prefer to 5mm thickness to make sure the body of structure is more toughness. However, the analysis on the product is needed to ensure the test rig can function properly when the engine running on it.

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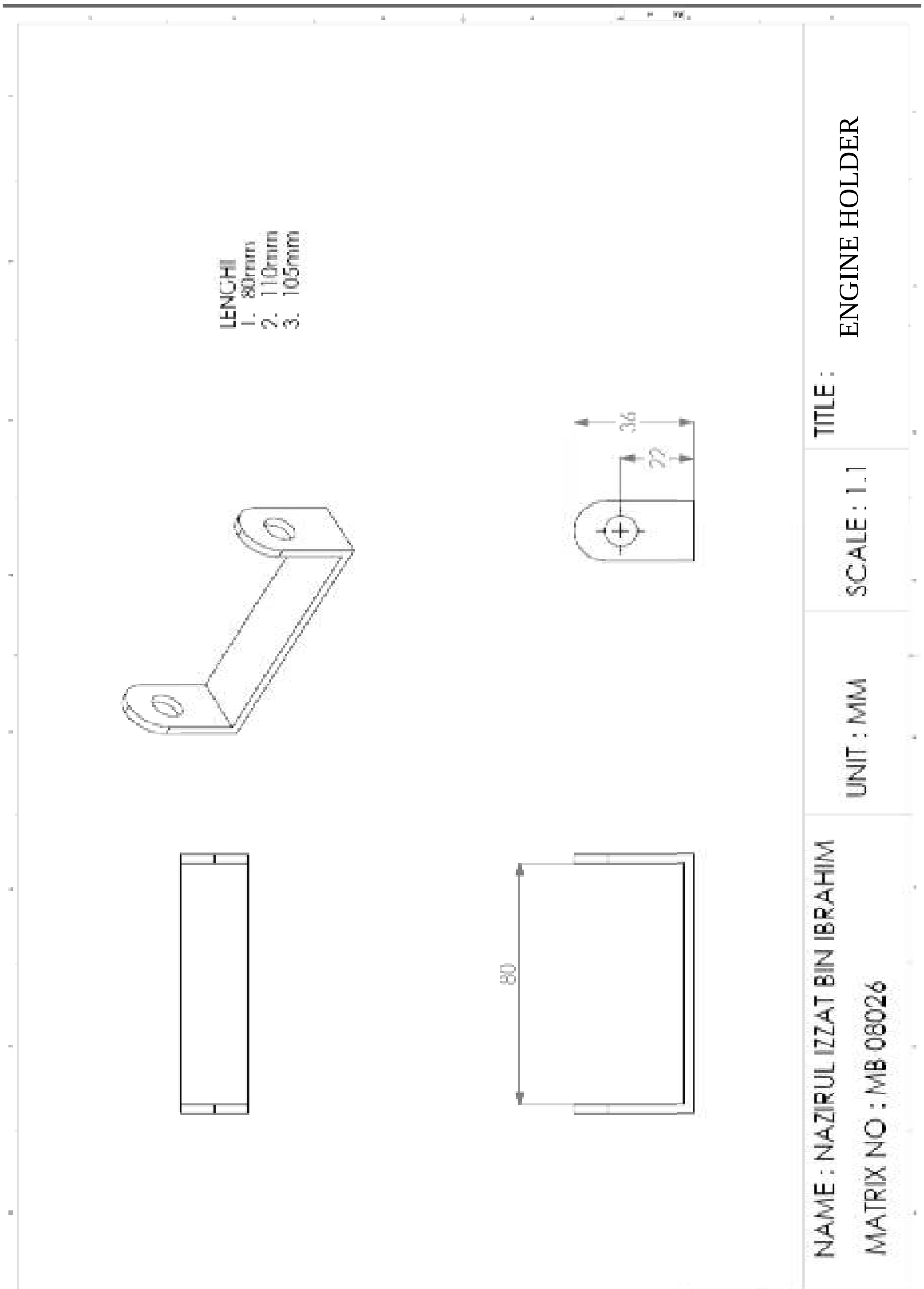
ACTIVITIES	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Topic Selection And Registration																
Literature Review																
Sketching Design And Collecting Data Or Dimension																
3d Design And Modeling																
List Of Material Used																
fabricate																
Evaluate product																
presentation																
Final report																

Gantt chart

Actual

Plan

APPENDIX A2



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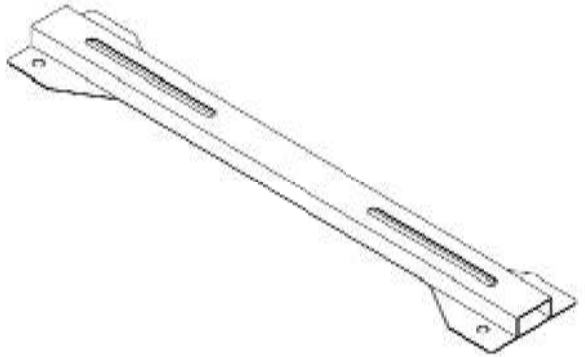

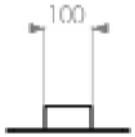

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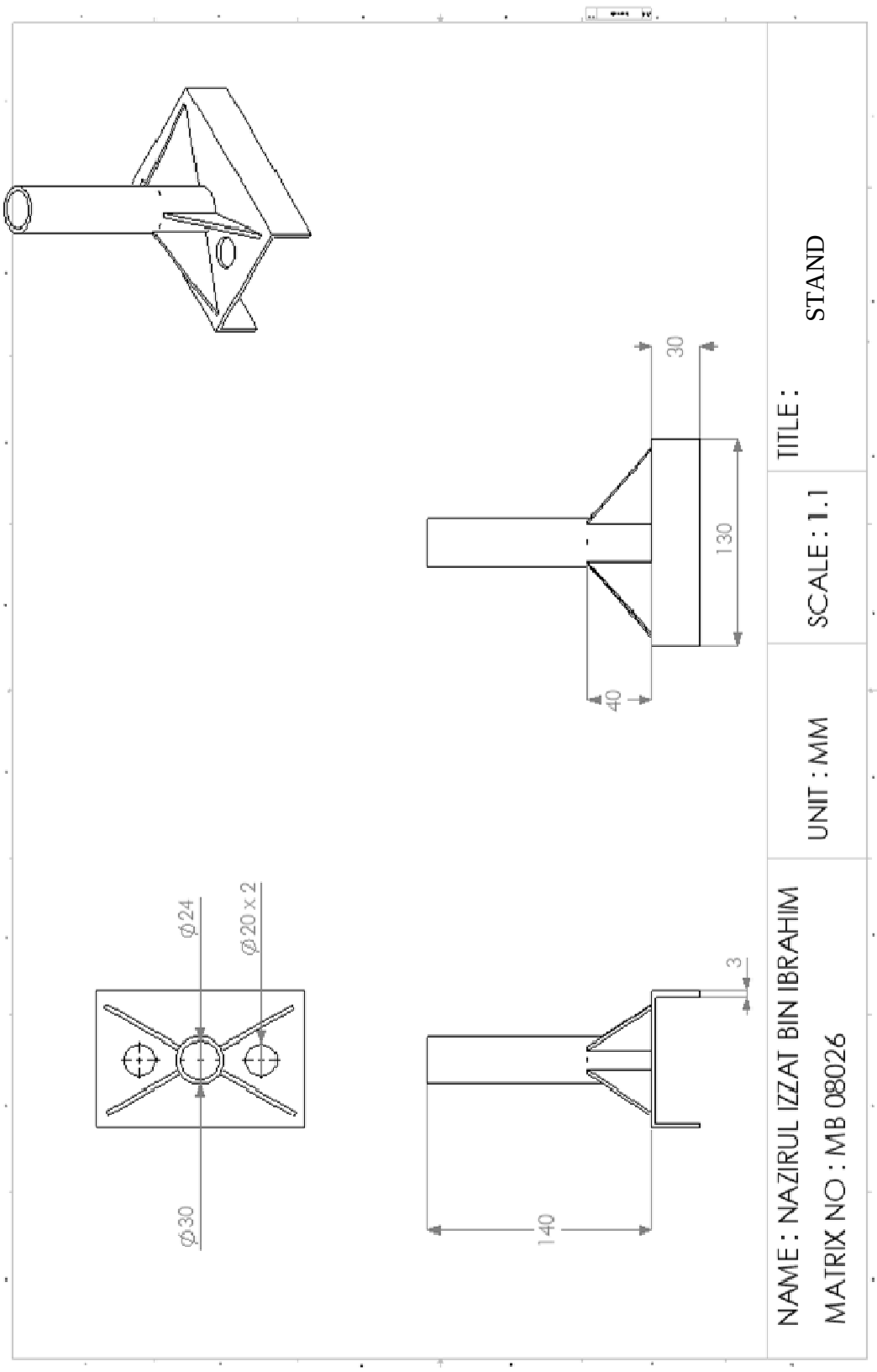
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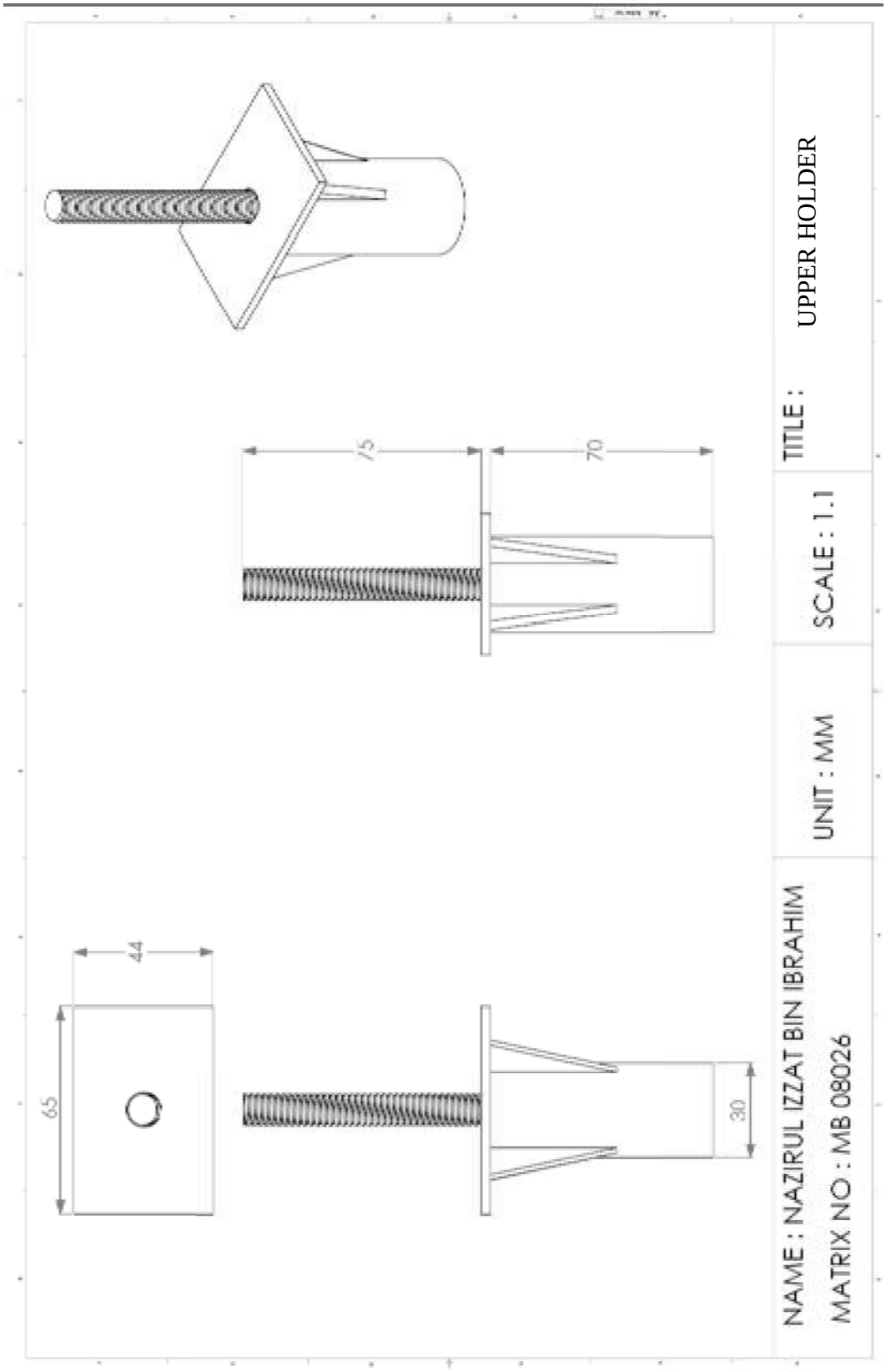
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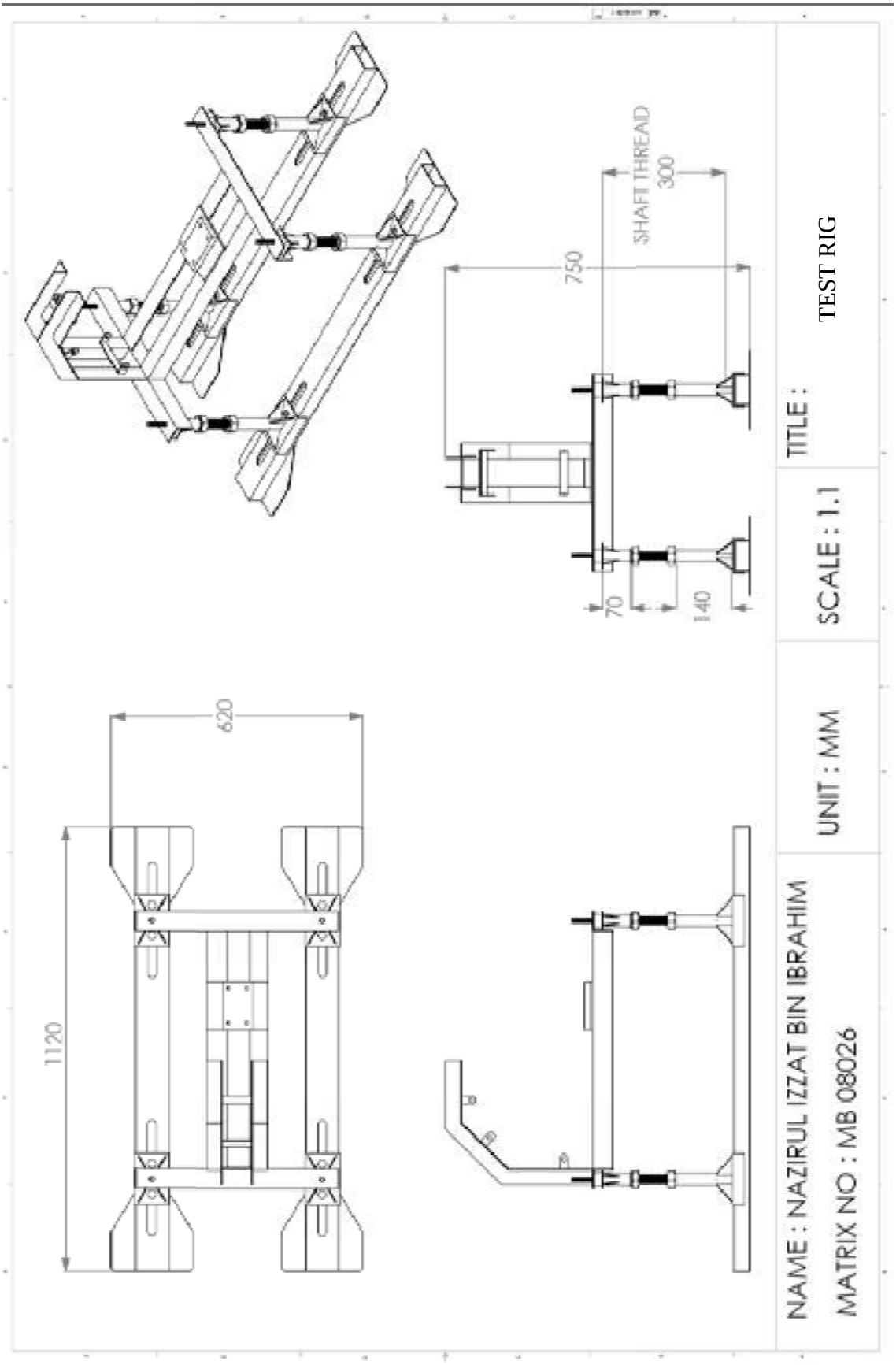
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MATRIX NO : MB 08026
UNIT : MM
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TITLE :
TEST RIG