UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: **DESIGN AND FABRICATION OF A SINGLE CYLINDER ENGINE TEST PLATFORM WITH ITS EXPERIMENTAL EQUIPMENT**

SESI PENGAJIAN: 2011/2012

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DESIGN AND FABRICATION OF A SINGLE CYLINDER DIESEL ENGINE TEST PLATFORM AND IT'S EXPERIMENTAL EQUIPMENT

AUJI BINTI SAMSUDIN

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

Faculty of Mechanical Engineering
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JANUARY 2012

SUPPERVISOR’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: Ahmad Basirul Subha bin Alias
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Date: 10th January 2012

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.

Signature:
Name: Auji binti Samsudin
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Date: 10th January 2012

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ABSTRACT

This project focuses on the design and fabrication the main structure for diesel engine testing platform. It is a part of an engine performance testing of a single cylinder diesel engine. Diesel engine performance testing for the study of future biodiesel fuel would require a stand for engine mounting. To achieve the objective, the testing platform must be designed and analyzed the designed platform and its coupling plate. The Computer Aided Design (CAD) is use to design the platform using the dimension that have been measured earlier. For the analysis of the design, the SolidWork software is used to analyze it. The proposed design is prove to be reliable based on the analysis result. Finally, the engine platform for diesel engine testing has been developed.

ABSTRAK

Projek ini memfokuskan kearah mereka bentuk struktur platform enjin diesel dan peralatan uji kajinya. Ia adalah sebahagian daripada projek penyelidikan prestasi enjin diesel. Ujian prestasi enjin ini adalah untuk pengajian minyak biodiesel yang memerlukan kaki enjin untuk meletakkan enjin tersebut. Untuk mencapai objektifnya, platform uji kaji mesti direka bentuk dan menganalisis reka bentuk platform dan plate berpasangan itu. *Computer Aided Design (CAD)* digunakan untuk mereka bentuk menggunakan dimensi yang telah diukur sebelum ini. Untuk analisis reka bentuk itu, perisian *SolidWork* digunakan untuk menganalisa platform itu. Reka bentuk yang dianalisi itu didapati sesuai untuk digunakan berdasarkan analisi yang dijalankan. Akhirnya, platform enjin untuk uji kaji minyak biodiesel dapat disempurnakan.

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INTRODUCTION

1.1 Project Background

Development of a single cylinder diesel engine platform is part of the biodiesel fuel testing research activities under the RDU090373 grant. The engine used is 4 stroke agricultural diesel engines. Engine has to be mounted on a test platform in order for it to be connected to the dynamometer's shaft for performance testing.

This project focuses on the design and fabrication of a single cylinder diesel engine test platform and its experimental equipment setup in order to be used in engine performance testing.

1.2 Project Scope

Scope that is planned for this project is listed as followed;

- Design the platform based on the measured dimension.
- Fabrication of the platform based on the design.
- Design the coupling plate based on the measured dimension.
- Fabrication of the coupling plate based on the design.

1.3 Project Objective

Objectives of this project are:

a) To design and fabricate of a single cylinder engine testing platform.
b) To design and fabricate of a coupling shaft for the engine dynamometer.

1.4 Gantt Chart

Table 1.1 below shows the planning and the actual work of the project.

Table 1.1 Gantt Chart Planning for the Project

Project Activities / Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Briefing about FYP by the lecturer	Plan														
	Actual														
Choose the project that listed	Plan														
	Actual														
Project been given and start meet the supervisor	Plan														
	Actual														
Do some literature review and gather information	Plan														
	Actual														
Do the sketching, gantt chart and flow chart	Plan														
	Actual														
Do the Solidworks and present to supervisor	Plan														
	Actual														
Progress report and progress presentation	Plan														
	Actual														

Present the structure progress to supervisor	Plan														
	Actual														
Fabricate the structure	Plan														
	Actual														
Final report preparation	Plan														
	Actual														
Completing the final presentation slide	Plan														
	Actual														
Present the FYP to panel	Plan														
	Actual														

1.5 Process Flow

The flow of works execution for this project is indicated as in Figure 1.1 below.

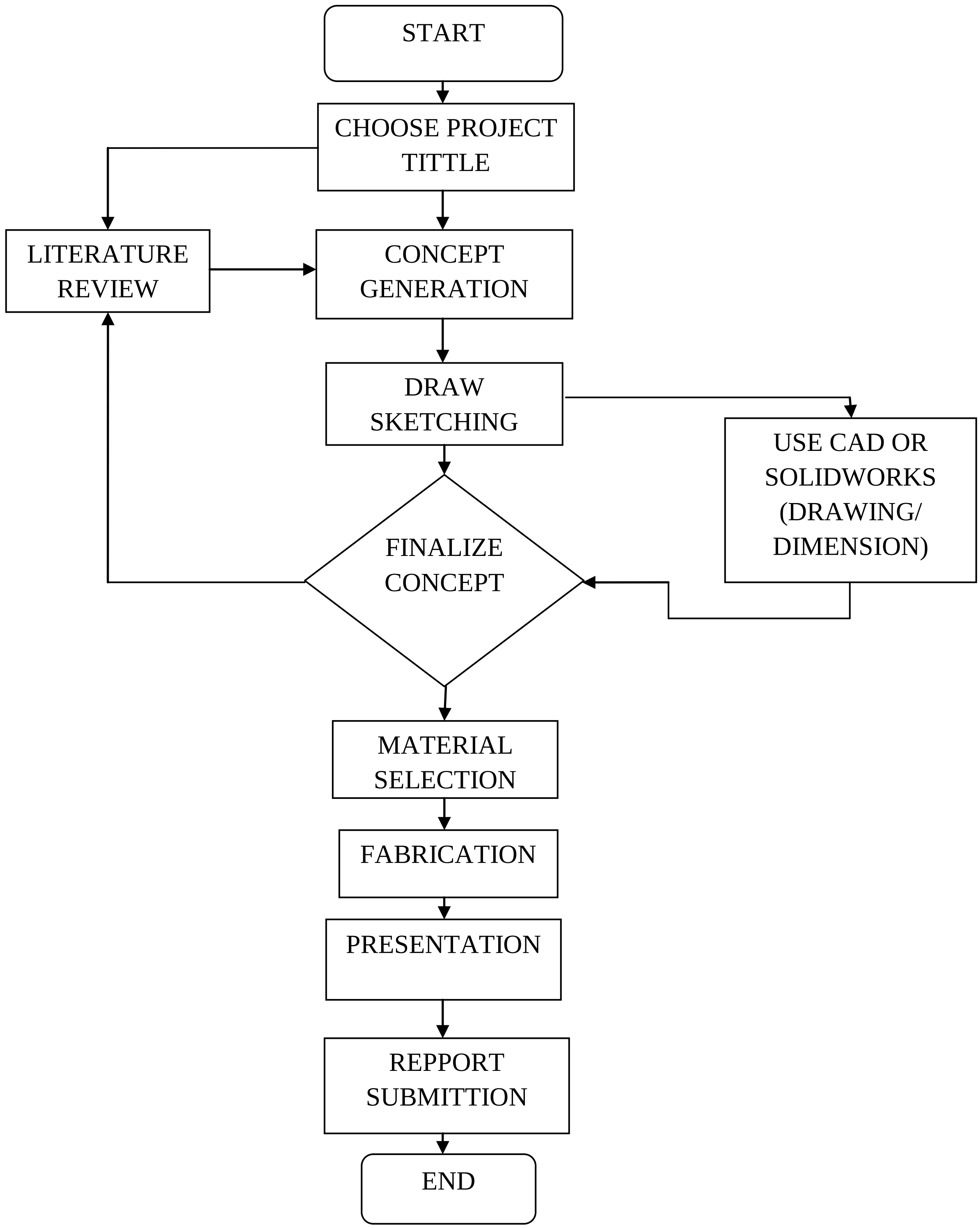

Figure 1.1: Process Flow of the Project

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

2.1.1 FOUR STROKES DIESEL ENGINE

A diesel engine (also known as a compression-ignition engine) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel, which is injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to gasoline), which uses a spark plug to ignite an air-fuel mixture. The engine was developed by Rudolf Diesel in 1893.

The diesel engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed Diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) often have a thermal efficiency which exceeds more than 50 percent.

Diesel engines are manufactured in two-stroke and four-stroke versions. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Use in locomotives, trucks, heavy equipment and electric generating plants followed later. In the 1930s, they slowly began to be used in a few automobiles.

A four-stroke engine, also known as four-cycle, is an internal combustion engine in which the piston completes four separate strokes intake, compression, power, and exhaust during two separate revolutions of the engine's crankshaft, and one single thermodynamic cycle.

There are two common types of engines, which are closely related to each other but have major differences in their operational characteristics. The earliest of these to be developed is the Otto cycle engine which was developed in 1876 by Nikolaus August Otto in Cologne, Germany after the operation principle described by Alphonse Beau de Rochas in 1861. This engine is most often referred to as a petrol engine or gasoline engine, after the fuel that powers it. The second type of four-cycle engine is the Diesel engine developed in 1893 by Rudolph Diesel, also of Germany. Diesel created his engine to maximize efficiency which was lacking in the Otto engine. There are several major differences between the Otto cycle engine and the four-cycle diesel engine. The diesel engine is made in both a two-cycle and a four-cycle version. Ironically Otto's company Deutz AG produces primarily diesel engines in the modern era.

The Otto cycle is named after the 1876 engine of Nikolaus A. Otto, who built a successful four-cycle engine which was based on the previous work of Jean Joseph Etienne Lenoir. It was the third engine type that Otto developed. It used a sliding flame gateway for ignition of its fuel which was a mixture of illuminating gas and air. After 1884 Otto also developed the magneto allowing the use of an electrical spark for ignition, which had been unreliable on the Lenoir engine.

Today, the internal combustion engine (ICE) used in motorcycles, automobiles, boats, trucks, aircraft, ships, heavy duty machinery, and in its original intended use as stationary power both for kinetic and electrical power generation. Diesel engines are found in virtually all heavy duty applications such as trucks, ships, locomotives, power generation, and stationary power. Many of these diesel engines are two-cycle with power ratings up to 105,000 hp (78,000 kW).

The four cycles refer to intake, compression, combustion (power), and exhaust cycles that occur during two crankshaft rotations per power cycle of the four-cycle engines. The cycle begins at Top Dead Centre (TDC), when the piston is farthest away from the axis of the crankshaft. A cycle refers to the full travel of the piston from TDC to Bottom Dead Centre (BDC).

1. Intake stroke: On the intake or induction stroke of the piston, the piston descends from the top of the cylinder to the bottom of the cylinder, reducing the pressure inside the cylinder. A mixture of fuel and air, or just air in a diesel engine, is forced by atmospheric (or greater) pressure into the cylinder through the intake port. The intake valve(s) then close. The volume of air/fuel mixture that is drawn into the cylinder, relative to the volume of the cylinder is called, the volumetric efficiency of the engine.

2. Compression stroke: With both intake and exhaust valves closed, the piston returns to the top of the cylinder compressing the air, or fuel-air mixture into the combustion chamber of the cylinder head.

3. Power stroke: This is the start of the second revolution of the engine. While the piston is close to TDC, the compressed air–fuel mixture in a gasoline engine is ignited, usually by a spark plug, or fuel is injected into the diesel engine, which ignites due to the heat generated in the air during the compression stroke. The resulting massive pressure from the combustion of the compressed fuel-air mixture forces the piston back down toward bottom dead centre.

4. Exhaust stroke: During the exhaust stroke, the piston once again returns to TDC while the exhaust valve is open. This action evacuates the burnt products of combustion from the cylinder by expelling the spent fuel-air mixture out through the exhaust valve(s).

As shown in Figure 2.1, that is an example of a 4 stroke diesel engine that will be mounted on the platform.

Figure 2.1: A 4 Stroke Diesel Engine

2.1.2 DYNAMOMETER

A dynamometer or "dyno" for short, is a device used for measuring force, moment of force (torque), or power. For example, the power produced by an engine, motor or other rotating prime mover can be calculated by simultaneously measuring torque and rotational speed (RPM).

A dynamometer can also be used to determine the torque and power required to operate a driven machine such as a pump. In that case, motoring or driving dynamometer is used. A dynamometer that is designed to be driven is called an absorption or passive dynamometer. A dynamometer that can either drive or absorb is called a universal or active dynamometer.

In addition to being used to determine the torque or power characteristics of a machine under test (MUT), dynamometers are employed in a number of other roles. In standard emissions testing cycles such as those defined by the US Environmental Protection Agency (US EPA), dynamometers are used to provide simulated road loading of either the engine (using an engine dynamometer) or full power train (using a chassis dynamometer). In fact, beyond simple power and torque measurements, dynamometers can be used as part of a test platform for a variety of engine development activities such as the calibration of engine management controllers, detailed investigations into combustion behavior and tribology. Figure 2.2 shows a dynamometer that will be connected to the engine shaft.

Figure 2.2: Engine Dynamometer

2.2 WELDING

2.2.1 INTRODUCTION

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. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space. Welding is a potentially hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense.

Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used for centuries to join iron and steel by heating and hammering. Arc welding and oxy fuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after. Welding technology advanced quickly during the early 20th century as World War I and World War II drove the demand for reliable and inexpensive joining methods. Following the wars, several modern welding techniques were developed, including manual methods like shielded metal arc welding, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as gas metal arc welding, submerged arc welding, flux-cored arc welding and electro slag welding.

Developments continued with the invention of laser beam welding, electron beam welding, electromagnetic pulse welding and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is commonplace in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality and properties.

2.2.2 Arc Welding

Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, and/or slag. Figure 2.3, show an example of an arc welding mechanism.

Figure 2.3: Arc Welding Mechanism

2.3 Metal Inert Gas Welding (MIG)

Gas metal arc welding (GMAW), sometimes referred to by its subtypes metal inert gas (MIG) welding or metal active gas (MAG) welding, is a semi-automatic or automatic arc welding process in which a continuous and consumable wire electrode and a shielding gas are fed through a welding gun. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used. There are four primary methods of metal transfer in GMAW, called globular, short-circuiting, spray, and pulsed-spray, each of which has distinct properties and corresponding advantages and limitations.

Originally developed for welding aluminum and other non-ferrous materials in the 1940s, GMAW was soon applied to steels because it allowed for lower welding time compared to other welding processes. The cost of inert gas limited its use in steels until several years later, when the use of semi-inert gases such as carbon dioxide became common. Further developments during the 1950s and 1960s gave the process more versatility and as a result, it became a highly used industrial process. Today, GMAW is the most common industrial welding process, preferred for its versatility, speed and the relative ease of adapting the process to robotic automation. Unlike welding processes that do not employ a shielding gas, such as shielded metal arc welding, it is rarely used outdoors or in other areas of air volatility. A related process, flux cored arc welding, often does not utilize a shielding gas, instead employing a hollow electrode wire that is filled with flux on the inside. Figure 2.4 shows an example of the structure of MIG welding.

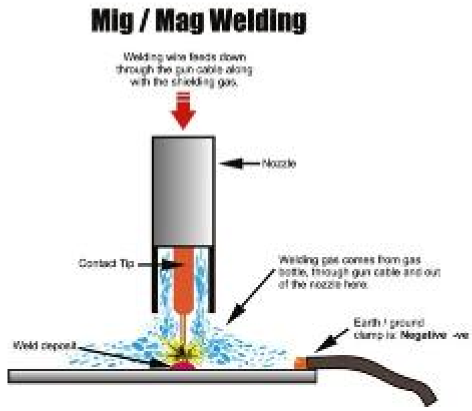

Figure 2.4: Example structure of MIG welding

(Source: http://www.learn-how-to-weld.com/mig-welding/)

2.4 COMPUTER NUMERICAL CONTROL MACHINE (CNC MACHINE)

2.4.1 Introduction

Numerical control (NC) refers to the automation of machine tools that are operated by abstractly programmed commands encoded on a storage medium, as opposed to controlled manually via hand wheels or levers, or mechanically automated via cams alone. The first NC machines were built in the 1940s and 1950s, based on existing tools that were modified with motors that moved the controls to follow points fed into the system on punched tape. These early servomechanisms were rapidly augmented with analog and digital computers, creating the modern computer numerical control (CNC) machine tools that have revolutionized the machining processes.

In modern CNC systems, end-to-end component design is highly automated using computer-aided design (CAD) and computer-aided manufacturing (CAM) programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine via a postprocessor, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools-drills, saws, etc., modern machines often combine multiple tools into a single "cell". In other cases, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the complex series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD design.

2.4.2 Milling Machine

A milling machine is a machine tool used to machine solid materials. Milling machines are often classed in two basic forms, horizontal and vertical, which refer to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, which holds the work piece stationary as the drill moves axially to penetrate the material, milling machines also move the work piece radials against the rotating milling cutter, which cuts on its sides as well as its tip. Work piece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC).

Milling machines can perform a vast number of operations, from simple (e.g., slot and keyway cutting, planning, drilling) to complex (e.g., contouring, die sinking). Cutting fluid is often pumped to the cutting site to cool and lubricate the cut and to wash away the resulting swarf.

CHAPTER 3

METHODOLOGY

3.1 Design

The design of the engine test platform must fulfill all the criteria on needed before it is being fabricated. It is critical to produce the platform that is suitable to combine with the dynamometer that has been set up readily at the laboratory. The aspects that must be considered in designing the test platform as follow:

- Material
  - The materials that will be used must be suitable to fabricate the engine test platform.
- Precision
  - The engine test platform must be measured precisely to avoid any error if the engine has been connected with the dynamometer later on.
- Costing
  - The cost depends on the materials used and manufacturing process should be reduced as minimum as possible.

3.2 Design Specification

3.2.1 Engine test platform

Table 3.1 below indicates the material used for the fabrication of engine test platform.

Table 3.1: Material specification for the engine platform

No.	Material	Length (mm)	Unit
1	25mm x 50mm hollow mild steel square bar	200	1

3.2.2 Coupling shaft

Table 3.2 below indicates the material used for the fabrication of the coupling shaft.

Table 3.2: Material specification for coupling shaft

No.	Material	Thickness (mm)	Diameter (mm)	Unit
1	Mild steel	33	150	2

For the design specification for the engine test platform and the coupling shaft, mild steel have been selected to be the material that is used to fabricate the engine platform and the coupling shaft. Mild steel is a type of steel alloy, that contains a high amount of carbon as a major constituent. An alloy is a mixture of metals and non-metals, designed to have specific properties. Alloys make it possible to compensate for the shortcomings of a pure metal by adding other elements. To get what mild steel is; one must know what alloys that are to be combined to make the steel. So, let see what we mean by steel, which will help us in understanding what mild steel is and also in understanding the properties of mild steel.

Steel is any alloy of iron, consisting of 0.2% to 2.1% of carbon, as a hardening agent. Besides carbon, there are many metal elements that are a part of steel alloys. The elements other than iron and carbon, used in steel are chromium, manganese, tungsten and vanadium. All these elements along with carbon, act as hardening agents. That is, they prevent dislocations from occurring inside the iron crystals and prevent the lattice layers from sliding past each other. This is what makes steel harder than iron. Varying the amounts of this hardening agent creates different grades of steel. The ductility, hardness and mild steel tensile strength are a function of the amount of carbon and other hardening agents, present in the alloy. The amount of carbon is a deciding factor, which decides hardness of the steel alloy. A steel alloy with a high carbon content is mild steel, which is in fact, much harder and stronger than iron. Though, increased carbon content increases the hardness of the steel alloy, it causes a decrease in its ductility.

Mild steel can also be described as steel which is not stainless steel. Mild steel differs from stainless steel in its chromium content. Stainless steel contains a lot more chromium than ordinary carbon or mild steel.

3.3 Fabrication Process

Next, after finishing the design for the engine test platform and the coupling shaft, the fabrication process may start with using the suitable raw material according to the product dimension. There are a lot 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 made. Fabrication process is a process to make only one product rather than manufacturing process that focus on the large scale of production. The manufacturing and fabricating process is differently by quantity of product producing. In this project, the design is to make a real apparatus and can be used fully at the end. The fabrication process for the engine platform is shown in Table 3.3 as listed below;

Table 3.3: Fabrication process for engine platform

No.	Process	Process Description
1	Measuring	Measure the part / material based on the specification design
2	Marking	Mark the material after measuring
3	Cutting	Cut the raw material followed the dimension
4	Filling	Remove the sharp edge at the component
5	Assembly	Assemble all the part / component

3.4 Fabrication Method for the Engine Test Platform

Hollow mild steel square bar is the main material that is used for this project, which is the core structure for the engine test platform. The fabrication processes start with measuring the material needed according to the design and dimension by using tape scale. Mark the material with the L square and marker pen to ensure that the measurement follow the designed dimension.

The next step is to cut the material by using disc cutter and cut it according to the required dimension. After the cutting process is complete, the sharp edge at the end of the material must be filed using hand grinder or angle grinder. As shown in Figure 3.1, it is the design specification of the engine test platform. It should be suitable to sustain the engine weight and horizontally match the height of the dynamometer. The material that is being used is mild steel.

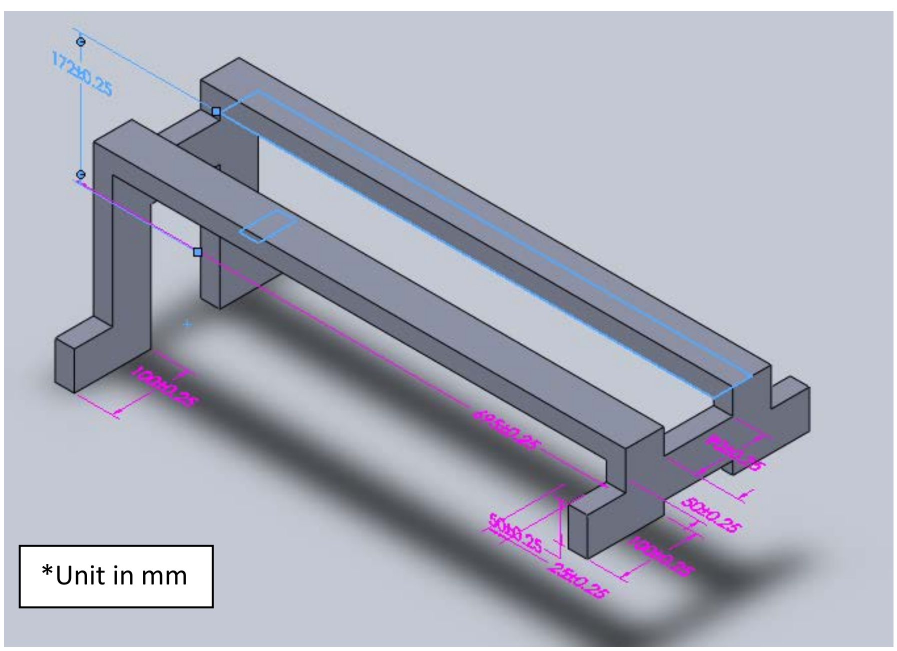

Figure 3.1: Final design of the engine test platform

Figure 3.2 shows the cutting process of 25mm x 50mm hollow mild steel square bar using the disc cutting machine according to the platform dimension. The hollow square bar is being cut at the angle of 45°.

Figure 3.2: Cutting material using disc cutter

Figure 3.3 shows the result after the cutting process. The work piece still has the sharp edge and needed to be grinded. This process is also included in the finishing process for each part.

Figure 3.3: 45° angle of cutting

Figure 3.4 shows the grinding process of the work piece. The sharp edge must be filed using the hand grinder or the angle grinder. This step is to clean up the material from burr and rust. This process is also performed in order to get a precise measurement of work piece according to design specification.

Figure 3.4: Grinding process

After the material has been cut, the assembly process can be started . In this assembly process, it is important to make sure the best step to assemble work pieces. The assemble all the work pieces, it is preferred to use arc welding or metal inert gas welding (MIG welding). These two kinds of welding are the best ways to connect all the platform structure and stand the force that action on the engine test platform after assemble.

Figure 3.5 shows the joining process for the engine test platform. The joining process used is the Metal Inert Gas (MIG) Welding. To start the joining process, the frequency power for the MIG welding must be set. It is important to set the right frequency and suitable for the material that is going to be welded.

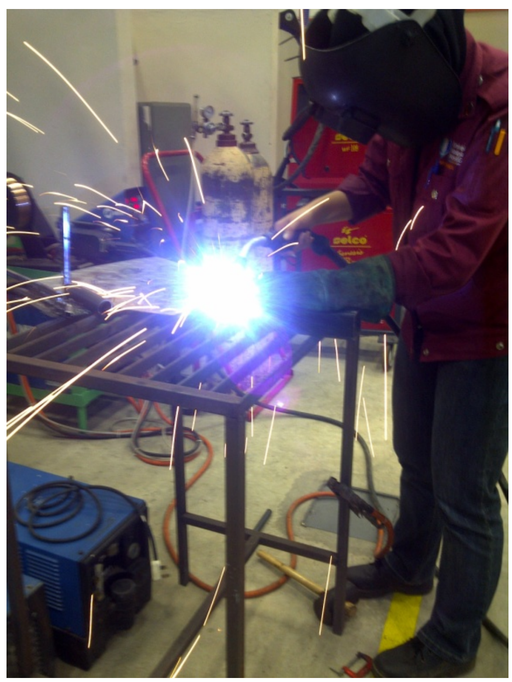

Figure 3.5: Joining the part for the engine test platform

Figure 3.6 shows the result of the joining process using the MIG welding. The joint must be precisely 90°. Use the L square to make sure the angle is 90°.

Figure 3.6: Welded joint

Figure 3.7 shows the complete engine test platform that has gone through all the fabrication process. The engine test platform has been set up with the existing stand at the laboratory.

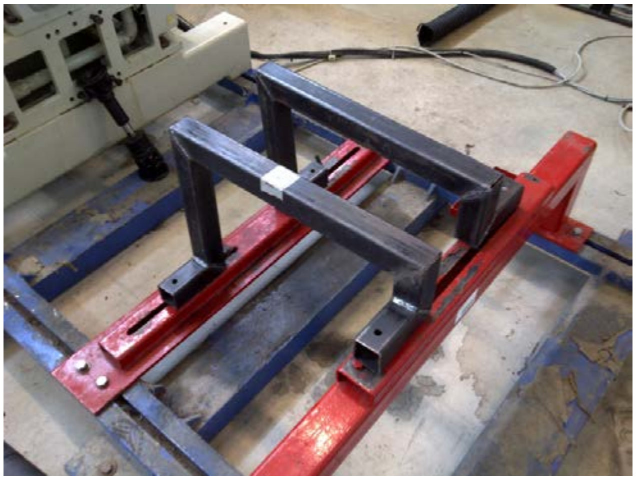

Figure 3.7: Complete engine test platform with the existing stand

3.5 Fabrication of the Coupling Shaft

The next step is to fabricate the coupling shaft for the dynamometer. The coupling shaft is to be connected to dynamometer with engine shaft and the engine shaft with the dynamometer. The coupling shaft is being machined using the CNC. The drawing is being drawn using the Master Cam software. The software then converts the drawing to the numerical coding. Figure 3.8 shows the design specification of the engine coupling shaft.

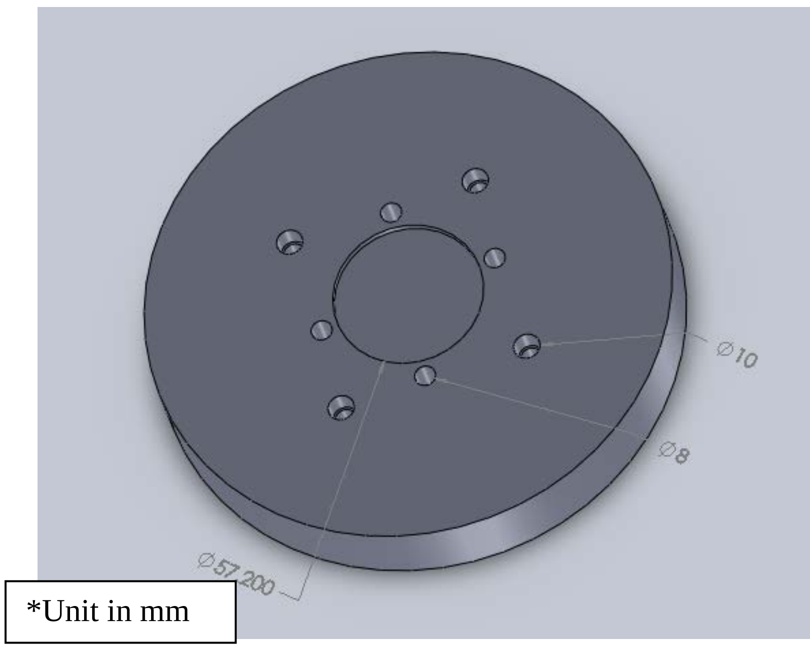

Figure 3.8: Coupling shaft

Figure 3.9 shows when the work piece has been set up at the CNC machine vise for this machine to take place. The work piece must be clamped properly to the machine vise. The clamp must prevent any movement of the work piece.

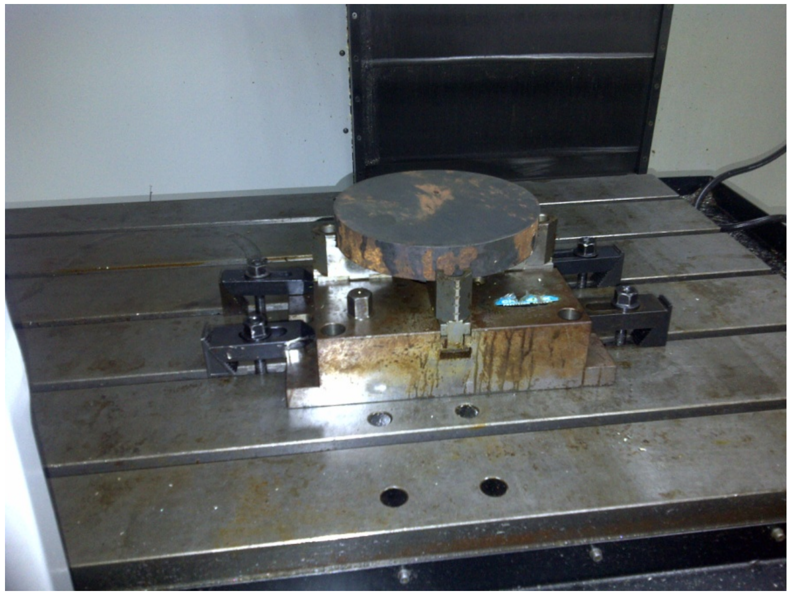

Figure 3.9: Setting the machine vise

Figure 3.10 shows the step to point out the center point of the work piece. The edge finder is used to search the center point. It is important to search for the position of (0,0) so that the fabrication process will run smoothly and there will be no error during this process.

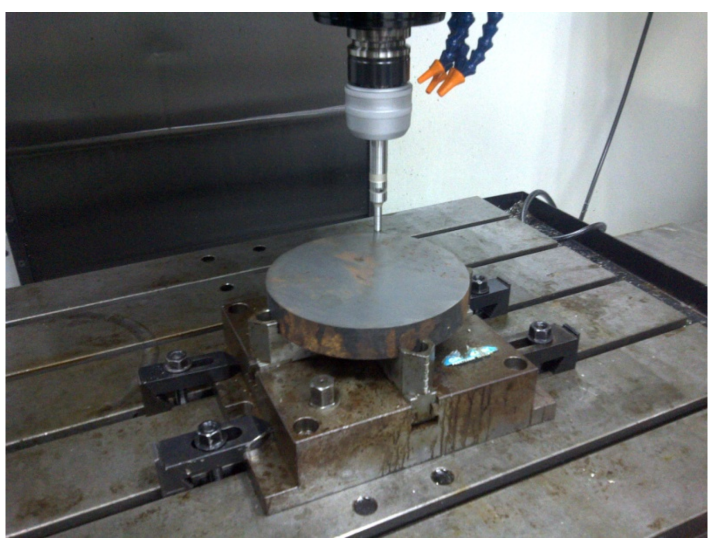

Figure 3.10: Center point finder

Figure 3.11 shows the fabrication process using the CNC machine. Coolant is used when the fabrication process is being done. It is to avoid the drill bit over heated and the drill bit point will be broken. The coolant is being used all the time during this fabrication process.

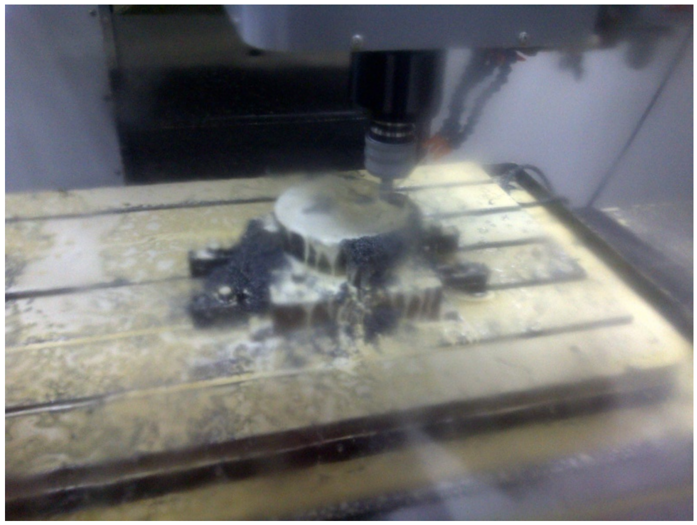

Figure 3.11: Fabrication process using the CNC machine

Figure 3.12 shows the finishing process of the work piece. For this process, the surface grinder is being used to smooth the surface of the work piece.

Figure 3.12: Finishing process

Figure 3.14 shows how the engine shaft will be connected to the coupling shaft. The other side of the coupling shaft will be connected to the dynamometer. Finally the engine test rig and the coupling shaft are completely produced.

Figure 3.12: Connection between engine shaft and coupling shaft

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Introduction

This chapter presents the result of this project and later on, the result is discussed. Result of the analysis is obtained by using SolidWork software which analyzing the effect of the engine load to the platform.

4.2 Result

This part will present about the result of the fabrication of the engine test platform and the coupling shaft. Figure 4.1 shows the full assembly parts consist of the engine test platform, single cylinder diesel engine, coupling shaft, engine shaft and the dynamometer.

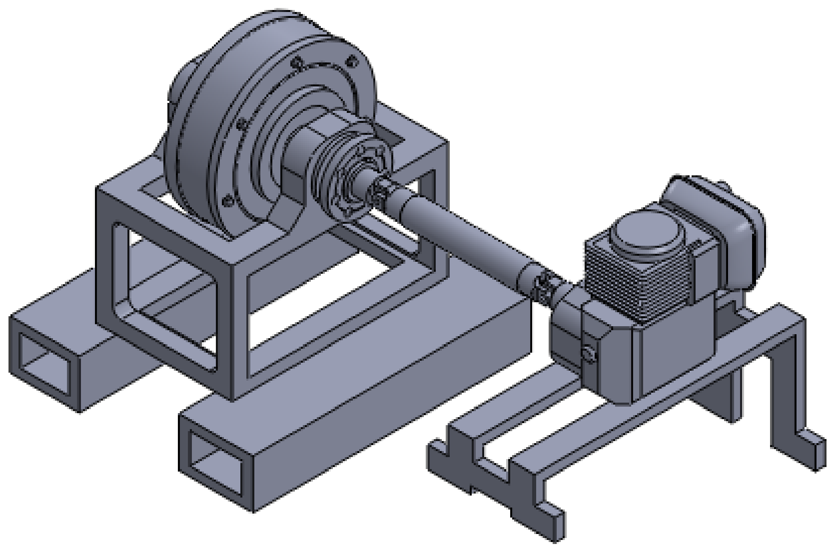

Figure 4.1: Full assembly part

The orthographic view of the full assembly part is shown in figure 4.2. it consist of top, front and side view of the assembly parts.

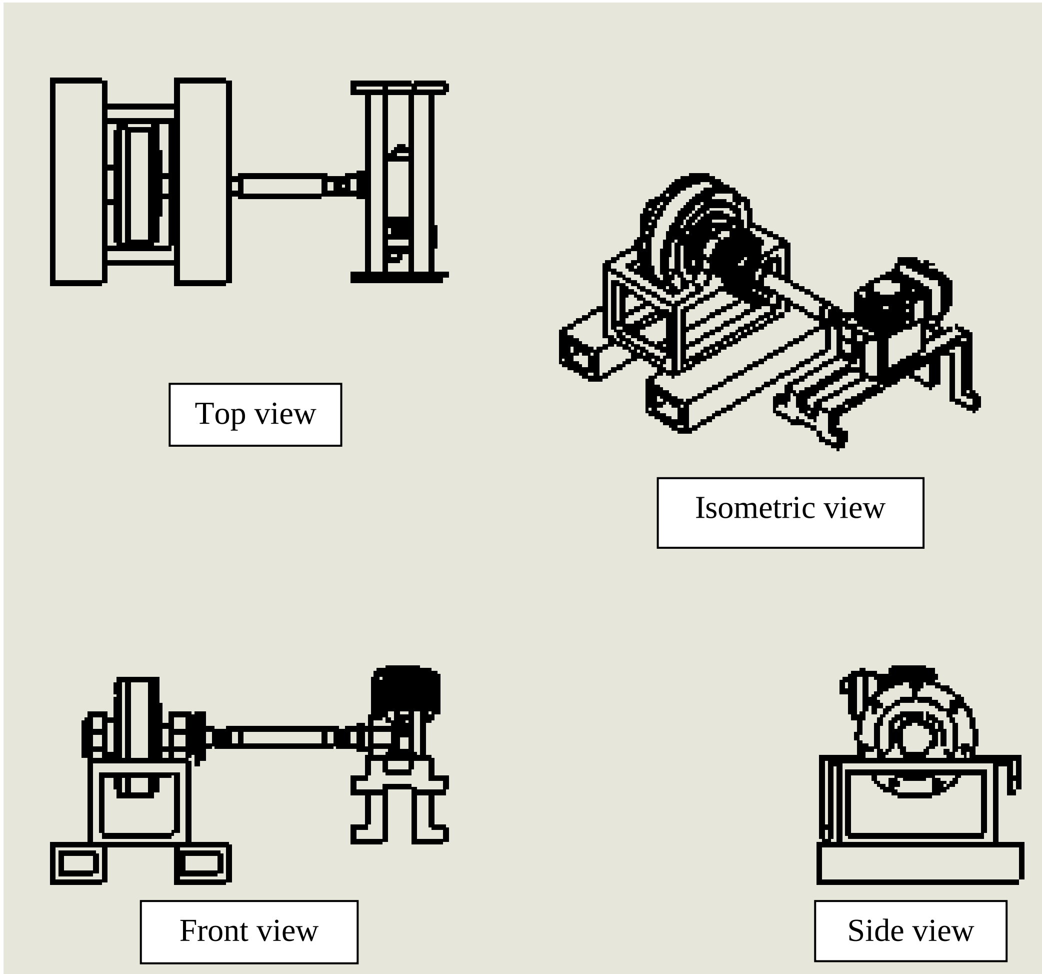

Figure 4.2: Orthographic view of the full assembly part

4.3 Analysis

Before the fabrication process start, it is important to make some analysis for the engine test platform. It is because to avoid problem occur while producing the product. To run the analysis, the Solid Work software is needed to study the analysis. This solid work will help to analyses about the stress, displacement and the deformed shape of the product.

After the analysis study have done, it is safe to start the fabrication process. The analysis data that produced by the solid work software will reveal whether the raw material that are going to use are suitable or not. The data gain from the analysis will be use as the reference to start the fabrication process.

4.3.1 Stress Analysis

Stress analysis is used to determine the stress in materials and structures subjected to static or dynamic forces or loads. The aim of the analysis is usually to determine whether the structure can safely withstand the specified force. This is achieved when the determine stress for applied is 800 kN as the minimum load. The load is just assumption of weight capacity of the single cylinder diesel engine.

Stress is a measure of the average amount of force exerted per unit area. It is measure of the intensity of the total intern force acting within a body across imaginary internal surfaces, as a reaction to external applied forces and body forces. It was introduced into the theory of elasticity by Cauchy around 1822. Stress is a concept that is based on the concept of continuum. In general, stress is expressed as;

$$\sigma = \frac{F}{A}$$

Where:

- σ is the average stress, also called engineering or nominal stress, and
- F is the forces acting over area A

Figure 4.3 shows the stress analysis result. When the load is applied, the stress of the platform is shown in the figure 4.3. The minimum value of the stress when load is applied is 24280.7 N/m². For the maximum value is 21253872.0 N/m². The minimum and maximum point is shown on figure 4.3. This shows that the stress applied to the platform from the load of the engine will not affect the platform.

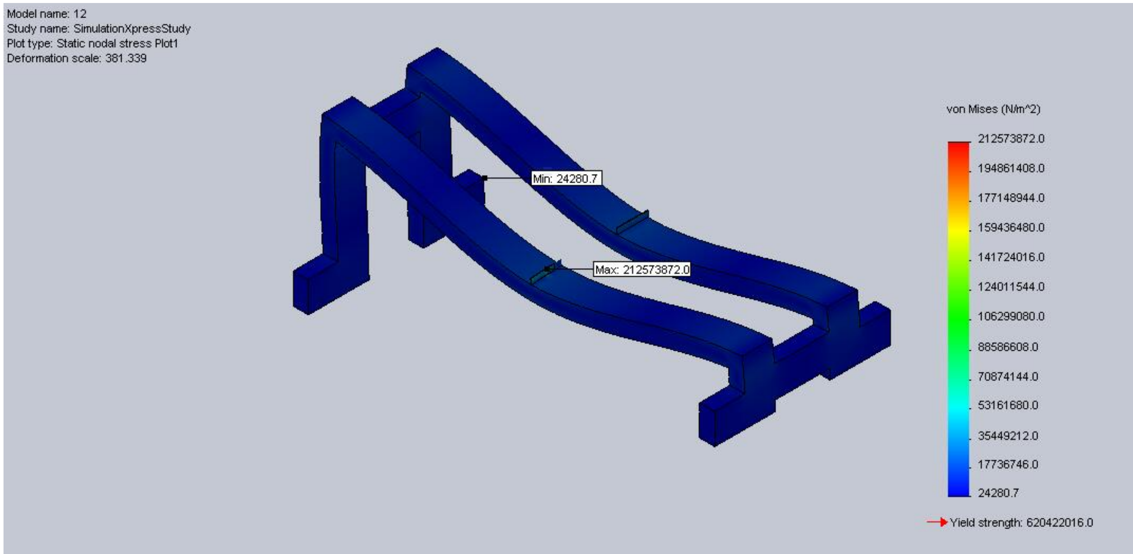

Figure 4.3: Stress analysis result

4.3.2 Deformation Analysis

Deformation is a change in the shape or size of an object due to an applied force. This can be a result of tensile (pulling) forces, compressive (pushing) forces, shear, bending or torsion (twisting). Deformation often describe in terms of strain.

As deformation occurs, internal inter-molecular force arise which oppose the applied force. If the applied force is not too large these force may be sufficient to completely resist the applied force, allowing the object to assume a new equilibrium state and to return to its original state when the load is removed. A large applied force may lead to a permanent deformation of the object or even to its structural failure.

- Elastic deformation

This type of deformation is reversible. Once the force are no longer applied, the object returns to its original shape. Elastic deformation is governed by Hooke's Law which states:

$$\sigma = E\ \varepsilon$$

Where;

- σ is the tensile stress
- E is the young's modulus
- ε is the strain

Where σ is the applied stress, E is a material constant called Young's modulus, and ε is the resulting strain. This relationship only applies in the elastic range and indicates that the slope of the stress vs. strain curve can be used to find Young's modulus. Engineers often use this calculation in tensile tests. The elastic range ends when the material reaches its yield strength. At this point plastic deformation begins.

- Plastic deformation

This type of deformation is not reversible. However, an object in the plastic deformation, which is reversible, when the force is release, the object will return part way to its original shape.

Under tensile stress plastic deformation is characterized by strain hardening region and a necking region and finally, fracture (also called rupture). During strain hardening the material becomes stronger though the movement of atomic dislocations. The necking phase is indicated by a reduction in cross-sectional area of specimen. Necking begins after the Ultimate Strength is reached. During necking, the material can no longer withstand the maximum stress and the strain in the specimen rapidly increases. Plastic deformation ends with the fracture of the material.

Figure 4.4 shows the deformation analysis result of the engine test platform. The platform will deform when the engine load is applied. The analysis shows that the center of the platform will deform about 0.006mm downward.

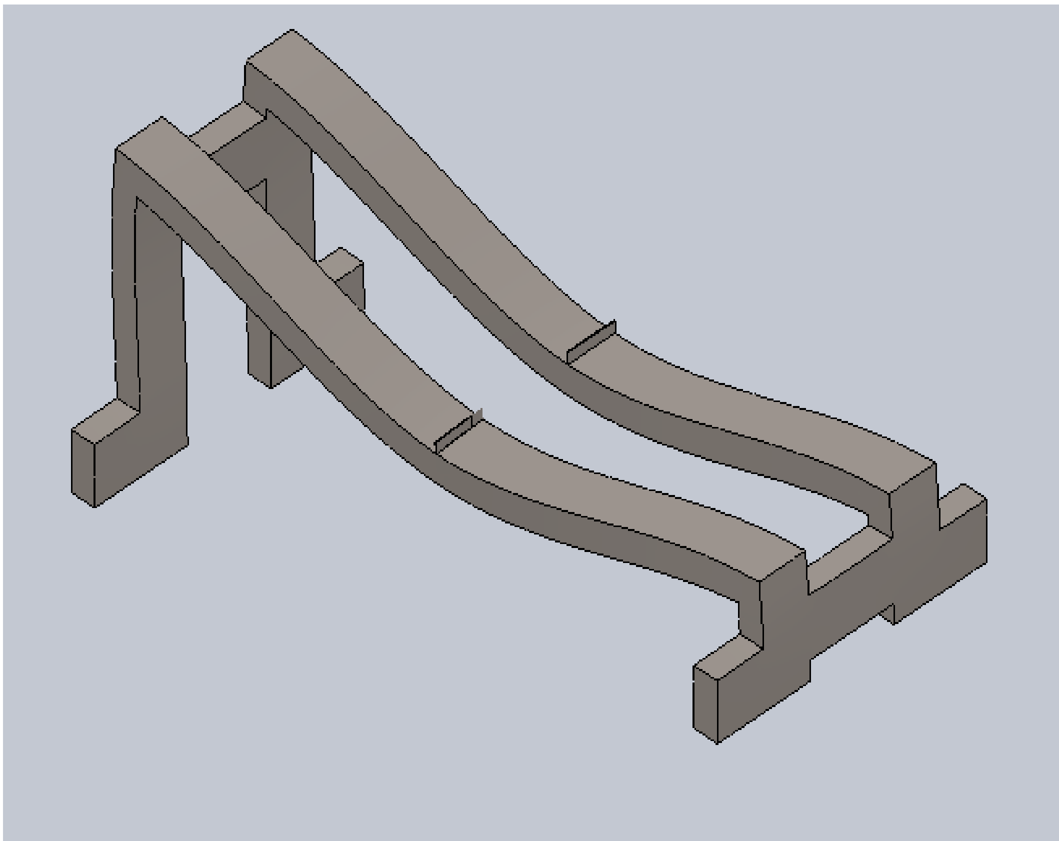

Figure 4.4: Deformation analysis result

4.3.3 Displacement Analysis

Displacement is the vector that specified the position of the point or a particle in the reference to a previous position, or to the origin of the chosen coordinate system. When the reference point is the origin, this is better to as a position.

A displacement vector is simplified represent of motion. Namely, it indicates both the length and direction of hypothetical motion along a straight line from the references point to actual point. A motion along the curved line cannot be represented by a single displacement vector, and may be described as a sequence of a very small displacement. On the other hand, a distance is typically defined as scalar quantity and can be used to indicate both the length of displacement (minimum distance) and the length of a curved path (travelled distance), but not the direction of motion.

When the reference point is a previous position, the displacement vector is difference between the final and the initial position. The difference is divided by the time needed to perform the motion, defines as the average velocity of the point or particle.

Figure 4.5 shows the displacement analysis result of the engine test platform. The displacement of the engine test platform at the point where the load is applied at the center of the platform is about 0.1826m. That is the maximum point of the displacement occurs. For the minimum point, the value is 1.000^{-33}This result of the displacement analysis also shows that the engine test platform can withstand the load of the engine.

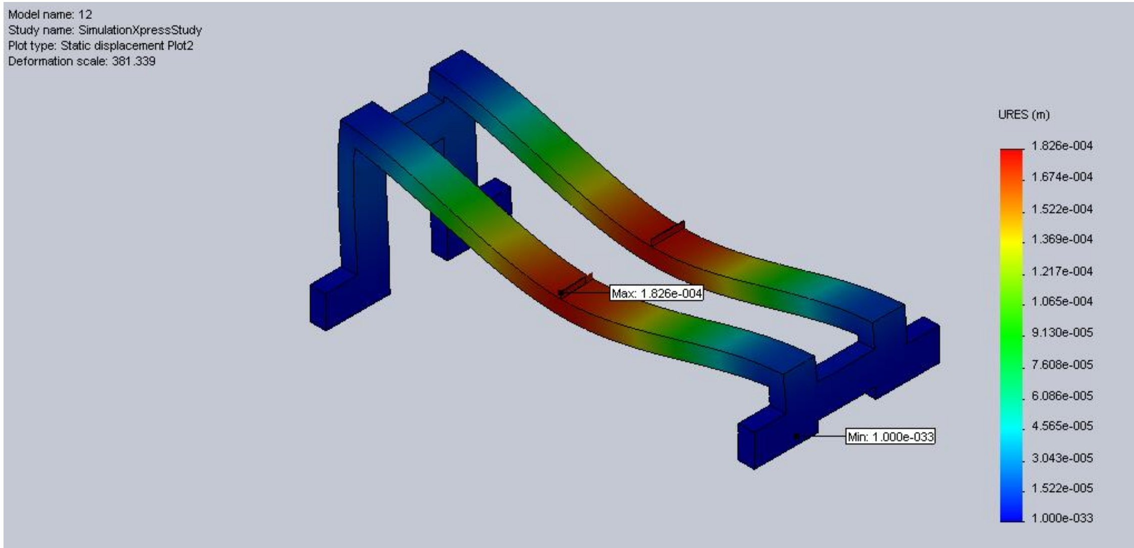

Figure 4.5: Displacement analysis result

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this final chapter is to conclude and recommendation about the project of producing the engine test platform. There are a lot of processes needed to get through before the product is fully produced. In this process, student have apply all the laboratory skill and knowledge such as using computer software like Solid Work, Master Cam, using the laboratory machine such as drill machine, CNC machine, disc cutter machine, welding machine and others. This shows that, this project help student in improving themselves in apply their skill and knowledge.

5.2 Conclusion

The conclusion are, the objective to design and fabrication of a single cylinder engine test platform and design and fabrication of a coupling shaft for the dynamometer finally achieve. The test platform structure is successfully produced according to the dimension as well as the design specification needed.

5.3 Recommendation

After finish produce the test platform structure, this product is ready to use as study by other students. This structure of the engine test platform is being attached with the single engine cylinder that is connected to the dynamometer at the laboratory.

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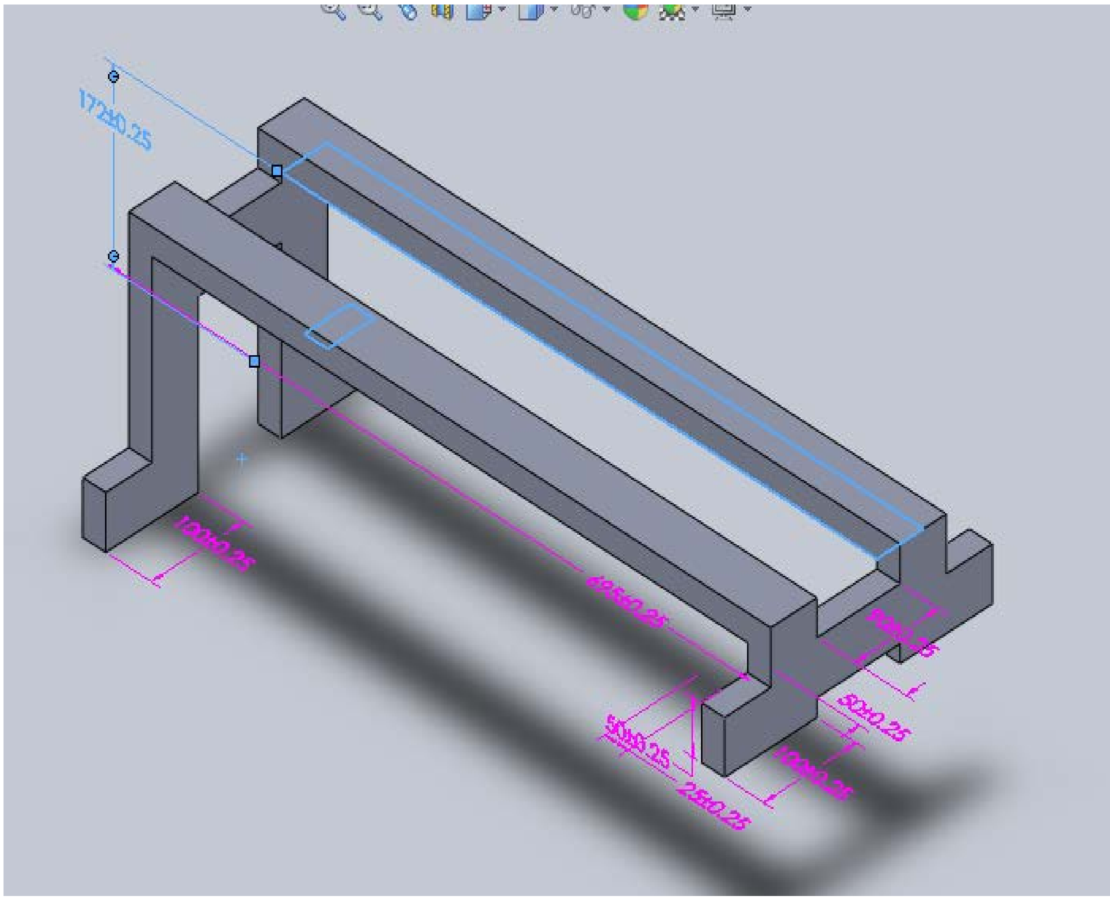
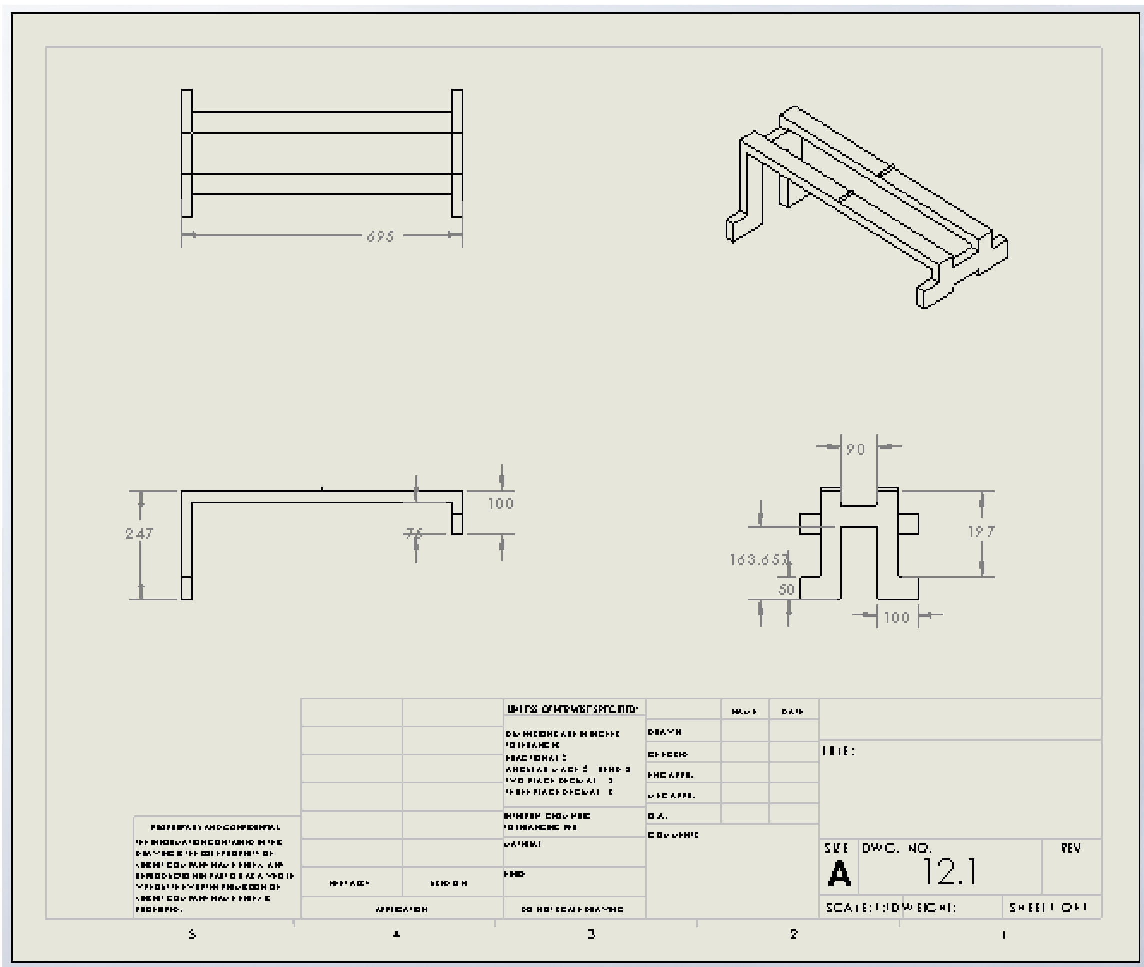
APPENDIX A

ISOMETRIC VIEW OF THE ENGINE TEST PLATFORM



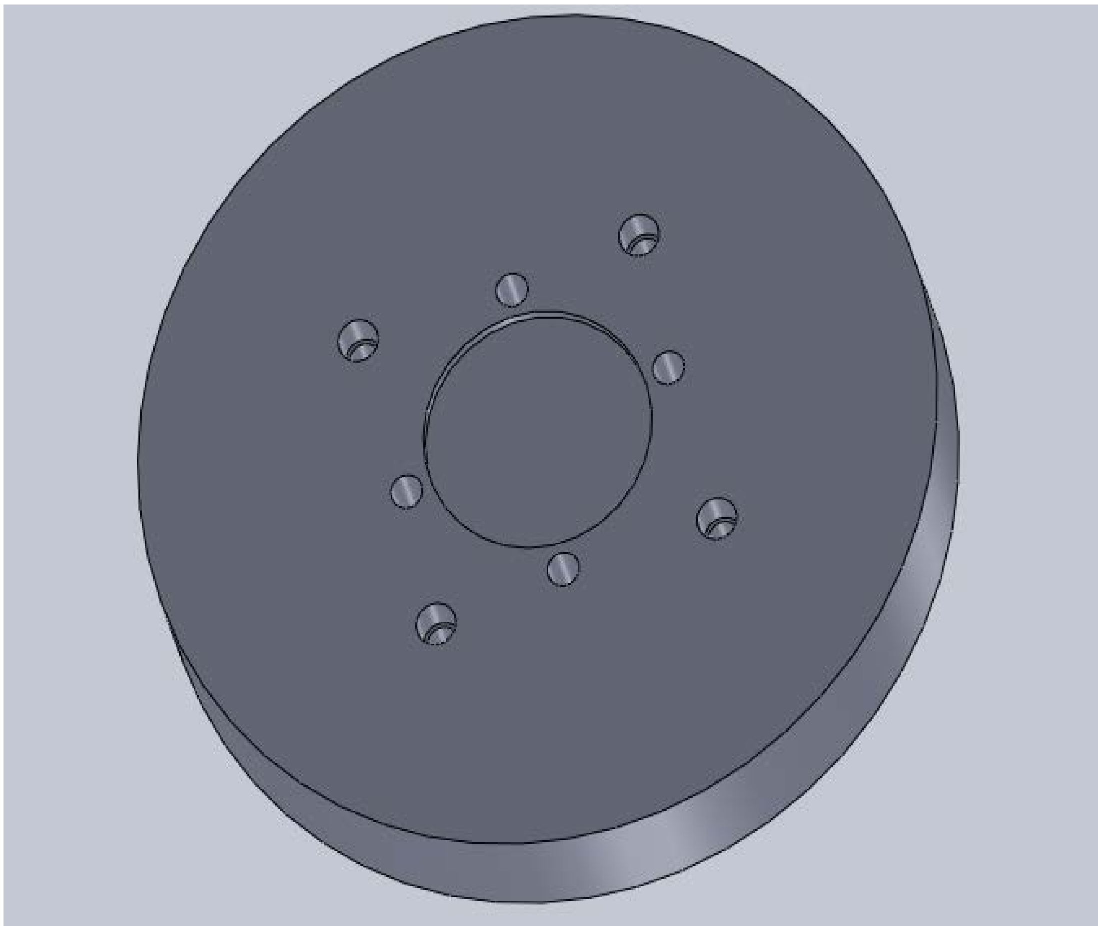
APPENDIX B

ORTHOGRAPHIC VIEW FOR THE ENGINE TEST RIG



APPENDIX C

ISOMETRIC VIEW FOR THE COUPLING SHAFT



APPENDIX D

ORTHOGRAPHIC VIEW FOR THE COUPLING SHAFT