DESIGN AND MANUFACTURE THE TOP HEAD OF A DIESEL FURNACE

AMIRUL SYAZWAN BIN HAJI OMAR

UNIVERSITI MALAYSIA PAHANG

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AMIRUL SYAZWAN BIN HAJI OMAR

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 : ASNUL HADI BIN AHMAD

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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Name : AMIRUL SYAZWAN BIN HAJI OMAR
ID Number : MB08082
Date :

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ABSTRACT

Manufacturing technology is very important to people nowadays in making everyday items and industrial usage. Manufacturing technology grows faster because it is needed in human life. The diesel furnace is a furnace which melts non-ferrous metals for manufacturing purposes. The furnace burns metals with the source of diesel fuel which directed from the exhaust of the furnace. The melted products then poured in a mould which has been formed according to desired shape. This process called sand casting. Top head is one of important part in a diesel furnace. The purpose of the top head is to cover and close the furnace. It also helps to improve the burning performance while melting metals. The project starts with studies and research. From the information, designs created and only one of the designs will be selected from screening process. With the design, manufacturing process held. The processes involved are cutting, rolling, welding and plasma cutting. When the project finishes manufactured, it will be tested to determine the function and performance of the project. Any further problem and recommendation regarding the project is discussed on the last chapter.

ABSTRAK

Teknologi pembuatan begitu penting kepada manusia masa kini dalam membuat keperluan seharian dan kegunaan industri. Teknologi pembuatan berkembang dengan pantas kerana keperluannya dalam kehidupan manusia. Relau diesel ialah sebuah relau yang meleburkan besi bukan ferrous untuk kegunaan pembuatan. Relau membakar besi dengan sumber minyak diesel yang dihalakan dari ekzos relau tersebut. Bahan yang telah dileburkan kemudiannya dituang ke dalam acuan yang dibuat mengikut bentuk yang diingini. Proses ini dinamakan tuangan pasir. Penutup atas merupakan komponen yang penting dalam relau diesel. Fungsi sebuah penutup atas adalah untuk menyelaputi dan menutup relau. Ia juga membantu untuk meningkatkan prestasi pembakaran semasa meleburkan besi. Projek ini bermula dengan pembelajaran dan kajian. Daripada maklumat yang diperoleh, beberapa rekaan dibuat dan rekaan yg terbaik dipilih daripada penapisan konsep. Berdasarkan rekaan tersebut, proses pembuatan dilakukan. Proses ini termasuk pemotongan, penggulungan, pateri dan pemotongan plasma. Apabila projek selesai dibuat, ianya diuji untuk memastikan kegunaan dan prestasi projek tersebut. Segala permasalahan dan cadangan berkenaan dengan projek dibincangkan di bab yang terakhir.

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mm	millimeters
^{o}C	degree Celsius
W/m K	watt per meter per Kelvin
J/kg K	joule per kilogram per Kelvin
kg/m3	kilogram per meter cube
g/cm3	gram per centimeter cube
MPa	mega Pascal
pH	power of hydrogen
dia.	diameter

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

A diesel furnace is a piece of equipment that produces heat by burning diesel. Furnaces in general are designed to produce heat that can be used directly in the heating and melting of structures. In the foundry lab, a diesel furnace had been used for studies of sand casting in the mechanical field. This project is to develop another diesel furnace for foundry usage and focusing on the top head of the diesel furnace

1.2 PROBLEM STATEMENT

The centre hole of the top head is too small which give operators problems on stirring the metal and putting bigger piles of metals in the furnace. Furthermore, it is too heavy to be lifted for cleaning. The top head need to be light in weight for better maintaining procedures.

1.3 OBJECTIVE

The objective for this project is to design and manufacture the top head of a diesel furnace that is easy to operate and suited the furnace.

1.4 SCOPE

In this project, scope needed to specify the range in the completion of the project. The centre hole of the top head has a diameter of 250 mm and it must be as wide as the crucible inside the furnace. The diameter of the top head must be the same as the shell of the furnace so it can be fitted.

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 1.0 shows that process to complete my final year project.

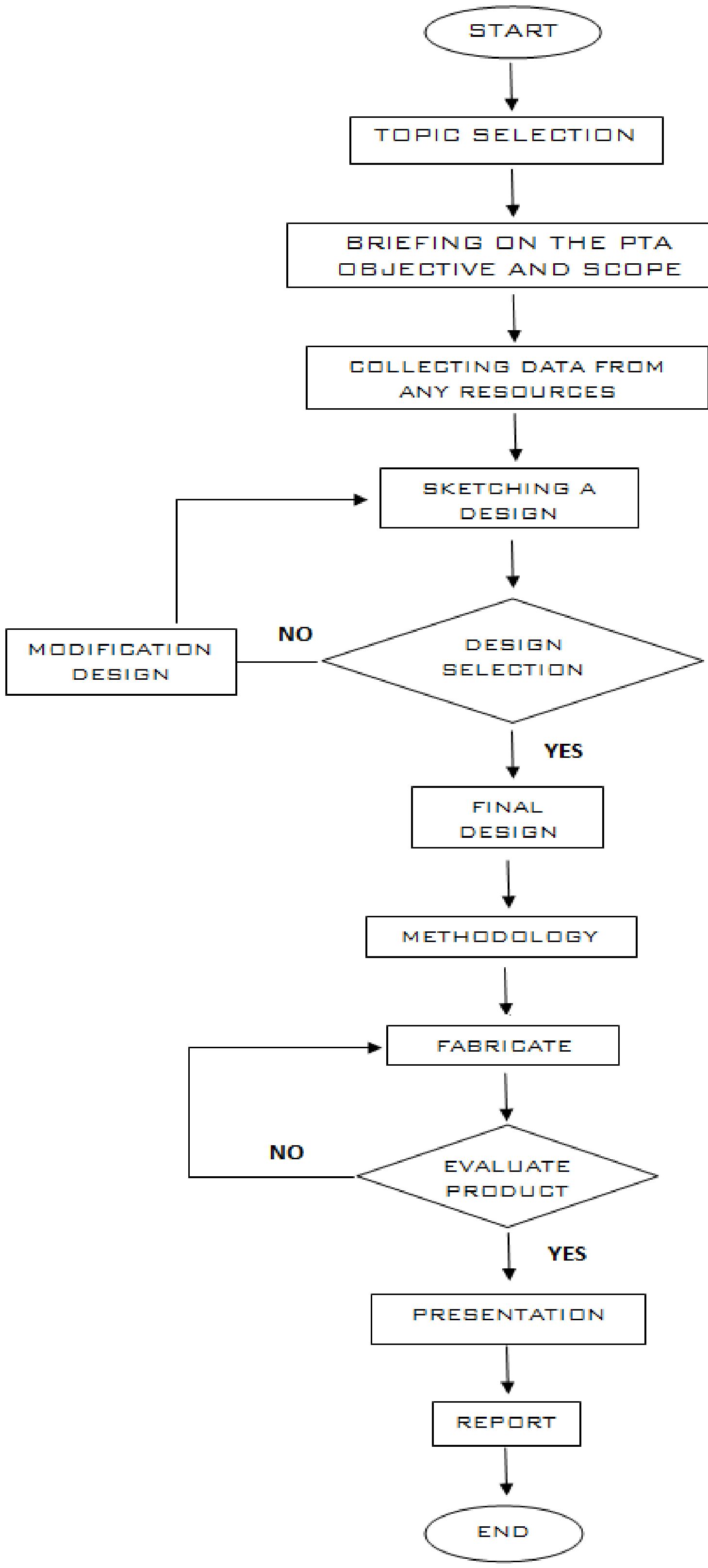

Figure 1.0: Flow Chart

The final year project starts with the title selection that had been given. They have given 31 titles of projects that have been state by final year project coordinator. Then, the topic that had been selected will be briefed about the problem, objective and scope by supervisor. From that data, literature review is needed to achieve the objective. 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 been collected, a design is needed for the manufacturing process. The designs were create 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 of designs and the best design will be a final design and improving the design if needed. Then, it is ready to be manufactured.

A final design must complete with dimensions to proceed to manufacturing process. The manufacturing process involves cutting, welding, grinding, casting and drilling.

Then proceed to the testing and evaluation process. A product will be test to see if it fulfills the requirement such as safety, ability and strength. During the test, if problem occurs, the process of manufacturing the top head 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 with no errors, here comes the phase of result and discussion. In this part, the function will be informed. Beside, how to achieve objective and solve problem statement of the project will be discussed in this phase.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter concludes about general knowledge on furnaces, refractories and energy efficiency then about machining process and materials properties.

2.2 FURNACES

A furnace is equipment used to melt metals for casting or to heat materials to change their shape or properties. Furnace ideally should heat as much of material as possible to a uniform temperature with the least possible fuel and labor. The key to efficient furnace operation lies in complete combustion of fuel with minimum excess air. Furnaces operate with relatively low efficiencies compared to other combustion equipment such as the boiler. This is caused by the high operating temperatures in the furnace. For example, a furnace heating materials to 1200 ^{o}C will emit exhaust gases at 1200 ^{o}C or more, which results in significant heat losses through the chimney [1].

2.2.1 Silicon Carbide Furnace

A silicon carbide furnace with electric, diesel fired and gas fired. This furnace can heat up to 1400 ^{o}C with digital temperature control and other controller.

Figure 2.0: Silicon Carbide Furnace

Source: www.alibaba.com

2.2.2 Standard Furnace

A standard furnace that run with either electrical or diesel fuel. Usually used personally or industrially.

Figure 2.1: Standard Furnace

Source: www.alibaba.com

2.2.3 Round and Stationary Aluminum Melting Furnace

An energy-saving aluminum melting furnace with a melting loss of <1.35%-<1.5%. The round aluminum melting furnace is a highly efficient, energy saving furnace that caters for the needs of melting large amounts of small scrap, accurate alloying and discontinuous producing with large capacity. It reduces energy consumption, melt loss and labor, and improves quality and labor efficiency [2].

Figure 2.2: Round and Stationary Furnace

Source: www.alibaba.com

2.3 REFRACTORIES

Any material can be described as a 'refractory,' if it can withstand the action of abrasive or corrosive solids, liquids or gases at high temperatures. The various combinations of operating condition, in which refractories are used, make it necessary to manufacture a range of refractory materials with different properties. Refractory materials are made in varying combinations and shapes depending on their applications. General requirements of a refractory material are [1]:

i) Withstand high temperatures.
ii) Withstand sudden changes of temperatures.
iii) Withstand action of molten metal slag, glass, hot gases.
iv) Withstand load at service conditions.
v) Withstand load and abrasive forces.
vi) Conserve heat.
vii) Have low coefficient of thermal expansion.
viii) Should not contaminate the material with which it comes into contact.

Table 2.0 compares the thermal properties of typical high density and low density refractory materials.

Table 2.0: Typical Refractory Properties [3]

Property	**High Thermal Mass (High density refractories)**	**Low Thermal Mass (Ceramic fiber)**
Thermal conductivity (W/m K)	1.2	0.3
Specific heat (J/kg K)	1000	1000
Density (kg/m3)	2300	130

2.3.1 Important Properties of Refractories.

Here are some important properties of refractories [1]:

i) **Melting point:** Pure substances melt instantly at a specific temperature. Most refractory materials consist of particles bonded together that have high melting temperatures.

ii) **Size:** The size and shape of the refractories is a part of the design of the furnace, since it affects the stability of the furnace structure. Accurate size is extremely important to properly fit the refractory shape inside the furnace and to minimize space between construction joints.

iii) **Cold crushing strength:** The cold crushing strength is the resistance of the refractory to crushing, which mostly happens during transport. It only has an indirect relevance to refractory performance, and is used as one of the indicators of abrasion resistance. Other indicators used are bulk density and porosity.

iv) **Creep at high temperature:** Creep is a time dependent property, which determines the deformation in a given time and at a given temperature by a refractory material under stress.

v) **Thermal conductivity:** Thermal conductivity depends on the chemical and mineralogical composition and silica content of the refractory and on the application temperature. The conductivity usually changes with rising temperature.

2.4 ENERGY EFFICIENCY

2.4.1 Heat Losses Affecting Furnace Performance

Ideally, all heat added to the furnaces should be used to heat the metals. In practice, however, a lot of heat is lost in several ways as shown in Figure 2.3.

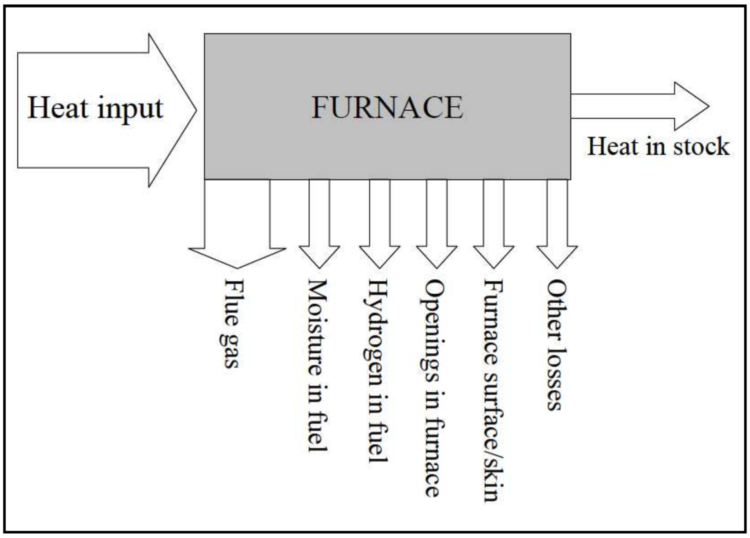

Figure 2.3: Heat losses in a Furnace

Source: oee.nrcan.gc.ca

2.4.2 Energy Efficiencies Opportunities

There was various energy saving opportunities in furnaces [4]. Typical energy efficiency measures for an industry with furnace are:

i) Complete combustion with minimum excess air.
ii) Proper heat distribution.
iii) Operation at the optimum furnace temperature.
iv) Reducing heat losses from furnace openings.
v) Maintaining correct amount of furnace draft.
vi) Optimum capacity utilization.
vii) Waste heat recovery from the flue gases.
viii) Minimum refractory losses.
ix) Use of ceramic coatings.
x) Selecting the right refractories.

2.5 MATERIALS

From the study that I have made, this project requires typical materials usage such as mild steel sheet, stainless steel sheet, deformed bar and sodium silicate for the refractory.

2.5.1 Mild steel

Mild steel is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Low carbon steel contains approximately 0.05–0.15% carbon and mild steel contains 0.16–0.29% carbon, therefore it is neither brittle nor ductile. Mild steel has a relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed, for example as structural steel. The density of mild steel is approximately 7.85 g/cm^3 and the Young's modulus is 210,000 MPa [5].

2.5.2 Stainless Steel

High oxidation-resistance in air at ambient temperature is normally achieved with additions of a minimum of 13% chromium, and up to 26% is used for harsh environments. The chromium forms a passivation layer of chromium(III) oxide (Cr_2O_3) when exposed to oxygen. The layer is too thin to be visible, and the metal remains lustrous. The layer is impervious to water and air, protecting the metal beneath. Also, this layer quickly reforms when the surface is scratched. This phenomenon is called passivation and is seen in other metals, such as aluminum and titanium. Corrosion-resistance can be adversely affected if the component is used in a non-oxygenated environment, a typical example being underwater keel bolts buried in timber.

When stainless steel parts such as nuts and bolts are forced together, the oxide layer can be scraped off, causing the parts to weld together. When disassembled, the welded material may be torn and pitted, an effect known as galling. This destructive galling can be best avoided by the use of dissimilar materials for the parts forced together or even different types of stainless steels, when metal-to-metal wear is a concern [6].

2.5.3 Refractory

Refractory materials must be chemically and physically stable at high temperatures. Depending on the operating environment, they need to be resistant to thermal shock, be chemically inert, and/or have specific ranges of thermal conductivity and of the coefficient of thermal expansion. The oxides of aluminium, silicon and magnesium are the most important materials used in the manufacturing of refractories. Another oxide usually found in refractories is the oxide of calcium. Fireclays are also widely used in the manufacture of refractories. Refractories must be chosen according to the conditions they will face. Some applications require special refractory materials. Zirconia is used when the material must withstand extremely high temperatures. Silicon carbide and carbon are two other refractory materials used in some very severe temperature conditions, but they cannot be used in contact with oxygen, as they will oxidize and burn.

Usually, refractories require special heat-up techniques to ensure that their performance will be attained as designed, and to avoid thermal shock and drying stresses until the operational status is achieved [7].

2.5.4 Deformed Bar

Common deformed bar is made of unfinished tempered steel, making it susceptible to rusting. Normally the concrete cover is able to provide a pH value higher than 12 avoiding the corrosion reaction. Too little concrete cover can compromise this guard through carbonation from the surface. Too much concrete cover can cause bigger crack widths which also compromises the local guard. As rust takes up greater volume than the steel from which it was formed, it causes severe internal pressure on the surrounding concrete, leading to cracking, spalling, and ultimately, structural failure. This is a particular problem where the concrete is exposed to salt water, as in bridges built in areas where salt is applied to roadways in winter, or in marine applications. Epoxy-coated, galvanized or stainless steel deformed bar may be employed in these situations at greater initial expense, but significantly lower expense over the service life of the project. Special care must be taken during the installation of epoxy-coated deformed bar, because even small cracks and failures in the coating can lead to intensified local chemical reactions not visible at the surface.

Fiber-reinforced polymer rebar is now also being used in high-corrosion environments. It is available in many forms, from spirals for reinforcing columns, to the common rod, to meshes and many other forms. Most commercially available deformed bar are made from unidirectional glassfibre reinforced thermoset resins [8].

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter discusses about all information and data that required and the manufacturing process for this project. In designing the top head of a diesel furnace, drawing skill and time are required. With the studies of literature, the designs are fixed in dimensions so the top head suited the shell of the furnace.

3.2 DESIGN CONCEPT

3.2.1 DESIGN 1

The first design was a simple design of common top head for a diesel furnace. This design has fixed inner diameter of 250 mm which is as wide as the crucible inside the furnace. This design helps users to easily stir the melted metal inside the furnace.

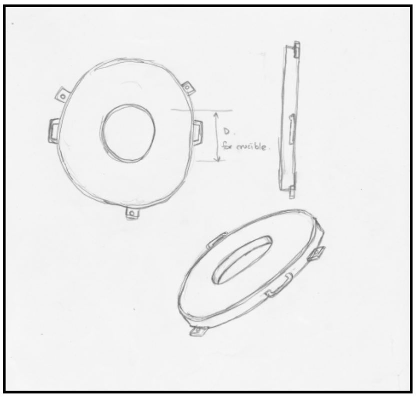

Figure 3.0: Design 1

3.2.2 DESIGN 2

The second design is an idea which improves the first design by making the top head able to slide. By putting a connector between the top head and the shell, the top head able to be slide instead of lifting it. It is better for cleaning and maintenance check.

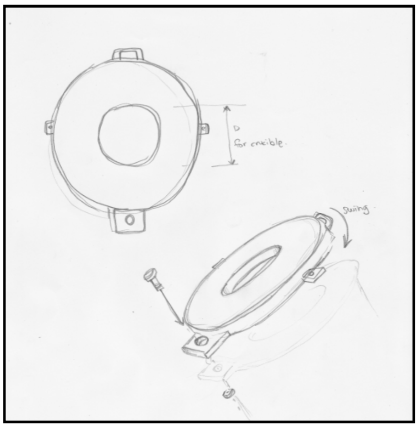

Figure 3.1: Design 2

3.2.3 DESIGN 3

The third design is the idea of putting a cover on the top head with smaller inner diameter. This way, the hole is smaller so heat loss will be decreased. It is also easier for users to clean or maintain the furnace by just sliding the cover.

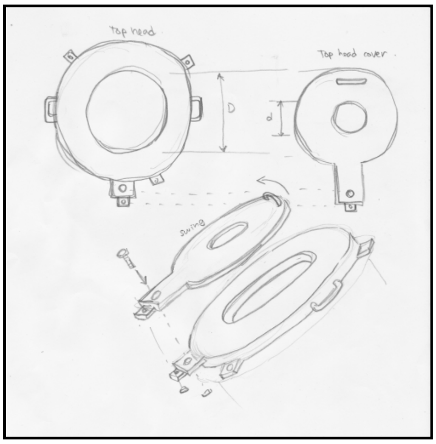

Figure 3.2: Design 3

3.3 DESIGN SELECTION

After designing concepts, comparisons from all of the designs were made and study the best design related with the given criteria. Then, decision was made for the best design.

Table 3.0 shows the concept screening for each of the designs to select which design have the highest point of advantages. The datum design is the current design that is already in the foundry lab.

Table 3.0: Concept Screening

Selection criteria	Design			
	Datum	**Design 1**	**Design 2**	**Design 3**
Diameter of centre hole	0	0	+	+
Burning performance	0	0	0	+
Easy to manufacture	0	+	0	-
Easy to operate	0	-	+	+
Manufacturing cost	0	0	-	-
Safety on operating	0	-	-	+
Practical usage	0	-	-	+
∑+	0	1	2	5
∑0	7	3	2	0
∑-	0	3	3	2
Net score	0	-2	-1	3
Rank	2	4	3	1

Notes:

+ = Better than - = Worse than 0 = Same as

3.4 FINAL DESIGN

Final design is the design that I have chosen to manufacture. As in the concept screening, this design have highest net score and rank. Therefore, design 1 is the best to be manufactured.

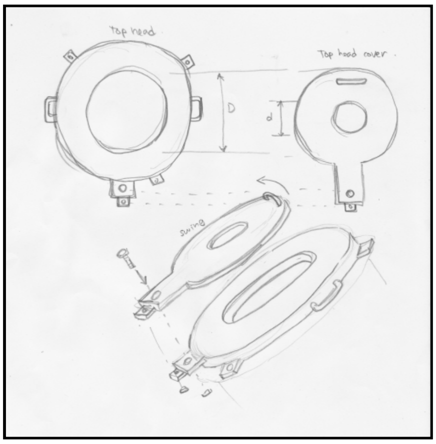

Figure 3.3: Final Sketch

After I done with the design, I'm forwarding it to my supervisor for approval. After approval, figure 3.4 shows my 3D modeling for final design and ready to be manufactured.

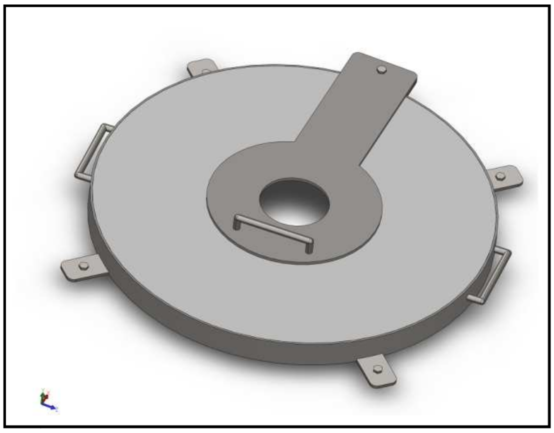

Figure 3.4: 3D Modeling for Final Design

Before the fabrication process run, the final design must have a dimension for the size of part that will be manufacture. A drawing will show the dimension of the part, I used SolidWorks software to get the dimension of part and 3D modeling of project shown in figure 3.4. All drawing part is shown in Appendix B.

3.5 MATERIAL SELECTION

Table 3.1 shows the bill of materials that I will be used for manufacturing process.

Table 3.1: Bill of Materials

Bil.	Materials	Size	Quantity
1.	Mild steel sheet 3mm	1800mm X 80mm	1
2.	Stainless steel sheet 5mm	220mm X 450mm	1
3.	Sodium silicate (refractory)	-	40kg
4.	Deformed bar 10mm dia.	2000mm	1

3.6 MANUFACTURING PROCESS

Manufacturing, 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 manufacturing session were describing from the selection of materials until the end of project which is finishing. Figure 3.5 shows the method that will be conducted on this project.

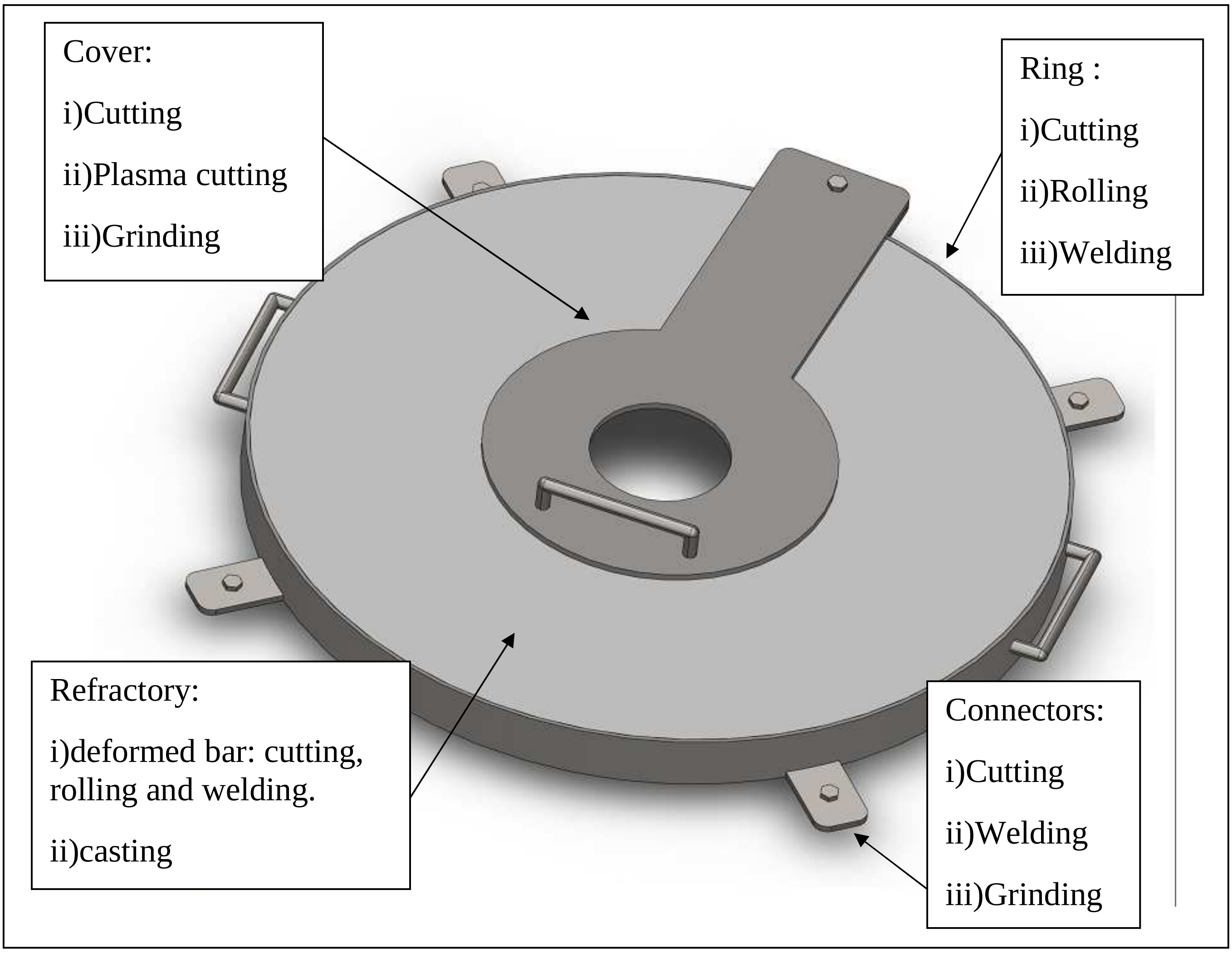

Figure 3.5: Manufacturing Method

3.6.1 Measuring

Measurement is important to maintain the shape and accuracy of a project. It helps to determine the exact length or amount of material that need to be used. Taking measurement can avoid mistakes in dimensions of the project. For my project I use measuring tape to measure the length of material shown in figure 3.6 and a vernier caliper to check the thickness of materials that will be used in this project.

Figure 3.6: Measuring

3.6.2 Cutting

Then, all of the materials were cut into its dimensions according to the drawing. The mild steel and stainless steel sheet were cut with a shearing machine shown in figure 3.7 while the deformed bar was cut with a disk cutter shown in figure 3.8.

Figure 3.7: Shearing Machine

Figure 3.8: Disk Cutter

After cutting the basic shape of the top head cover, it was then cut using plasma cutter to make a round shape shown in figure 3.9 and finished it with grinder.

Figure 3.9: Plasma Cutter

3.6.3 Rolling

When the sheet metal finished cut, it is rolled with rolling machine in figure 3.10 and the deformed bar is rolled to make a round shape.

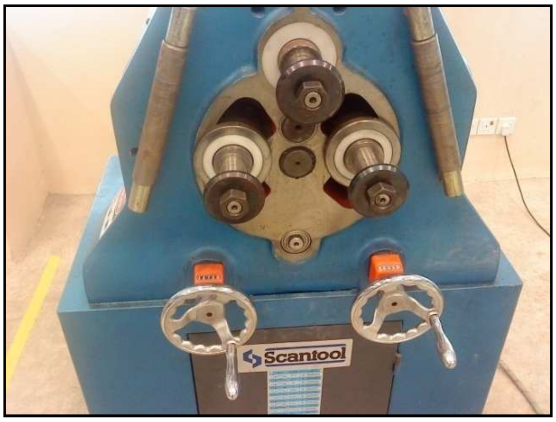

Figure 3.10: Rolling Machine

3.6.4 Joining (Welding)

The rolled materials then joined together by arc welding shown in figure 3.11. The same method also used for the connectors and the deformed bars. The whole parts were then welded together. Then the welded parts were grinded for smooth finish.

Figure 3.11: Welding process

3.6.5 Casting

Casting was the main process in the manufacturing of the top head. The cast can withstand the heat while burning. Mixing the cast was the first procedure shown in figure 3.12. Before that, the cast was separated between rough and smoother cast shown in figure 3.13. Then the mixing was poured in the ring starting from rougher to smoother finish shown in figure 3.14 and 3.15. Then it left to dries.

Figure 3.12: Mixed Cast

Figure 3.13: Separating cast

Figure 3.14: Rougher cast

Figure 3.15: Smoother cast

3.6.7 Finishing

Finishing process required to improve appearances. All finished product would not be finish if it did not through a finishing process. In my project, I used grinder for my finishing touch shown in figure 3.16.

Figure 3.16: Finishing

CHAPTER 4

RESULTS & DISCUSSION

4.1 INTRODUCTION

This chapter covers the discussion on the results for modification of this project and several problems occur in the project. This chapter also discusses mainly about the problems encountered during the whole project been carried out.

4.2 PROJECT PROBLEMS

4.2.1 Designing and Sketching

The designs of the top head in the market are hard to find and too many shape. It causing the problems on choosing the reference design.

4.2.2 Material Preparation

Some of the materials need to be ordered from the factory and taking time to arrive.

4.2.3 Manufacturing Process

While casting, the cast easily breaks because it was not fully dried.

4.3 PROJECT DESCRIPTION

The problem statement for this project is the centre hole was too small and it was too heavy to be lifted. The solution found by making a design with bigger centre hole. When it was too heavy, a cover on top of the top head is made so users don't have to lift the whole top head. The top head also tested for compatible with the shell of the furnace. It covers the whole top of the furnace and well functioned.

Figure 4.0: Finished Product

4.4 PRODUCT FUNCTION

This product has basic top head function. It covers and closes the furnace as shown in figure 4.1. The cover can be slide to reach the inner part of the furnace with bigger centre hole shown in figure 4.2.

Figure 4.1: Placed Top Head

Figure 4.2: Opened Cover

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter is about the conclusion and recommendation of this project. In this chapter, it includes the fulfillment of the objective and some weaknesses that need to be improved.

5.2 CONCLUSION

This project has practice and gives more knowledge about many mechanical skills such as machining and using tools. I also gain knowledge about material structure and strength. This product produced to make an improvement with the other top head that ever designated. The objective of this project that is to design and manufacture the top head of a diesel furnace has been achieved.

5.3 RECOMMENDATION

This recommendation can improve this product in the future:

i) In rolling process of the ring must be accurate so that it matches the size of the shell of the furnace.

ii) The connector between the top head and the body must be the same so that it will be possible to lock both of them with bolts.

iii) The casting area must be flat to get flat surface on the bottom of the top head so it will not produces problems while matching it with the shell.

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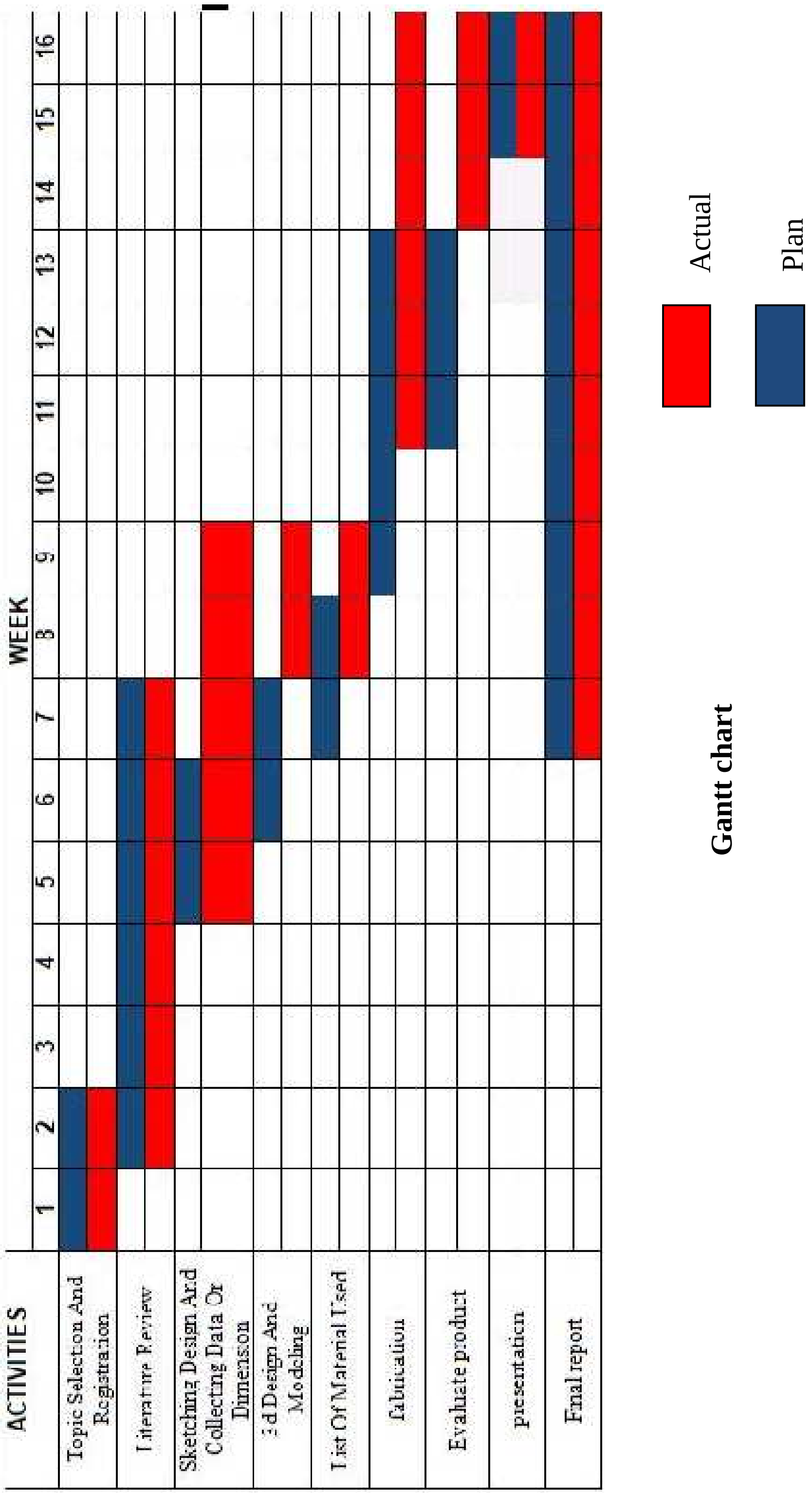
[5] http://en.wikipedia.org/wiki/Carbon_steel, dated on 22nd October 2010

[6] http://en.wikipedia.org/wiki/Stainless_steel, dated on 22nd October 2010

[7] http://en.wikipedia.org/wiki/Refractory, dated on 22nd October 2010

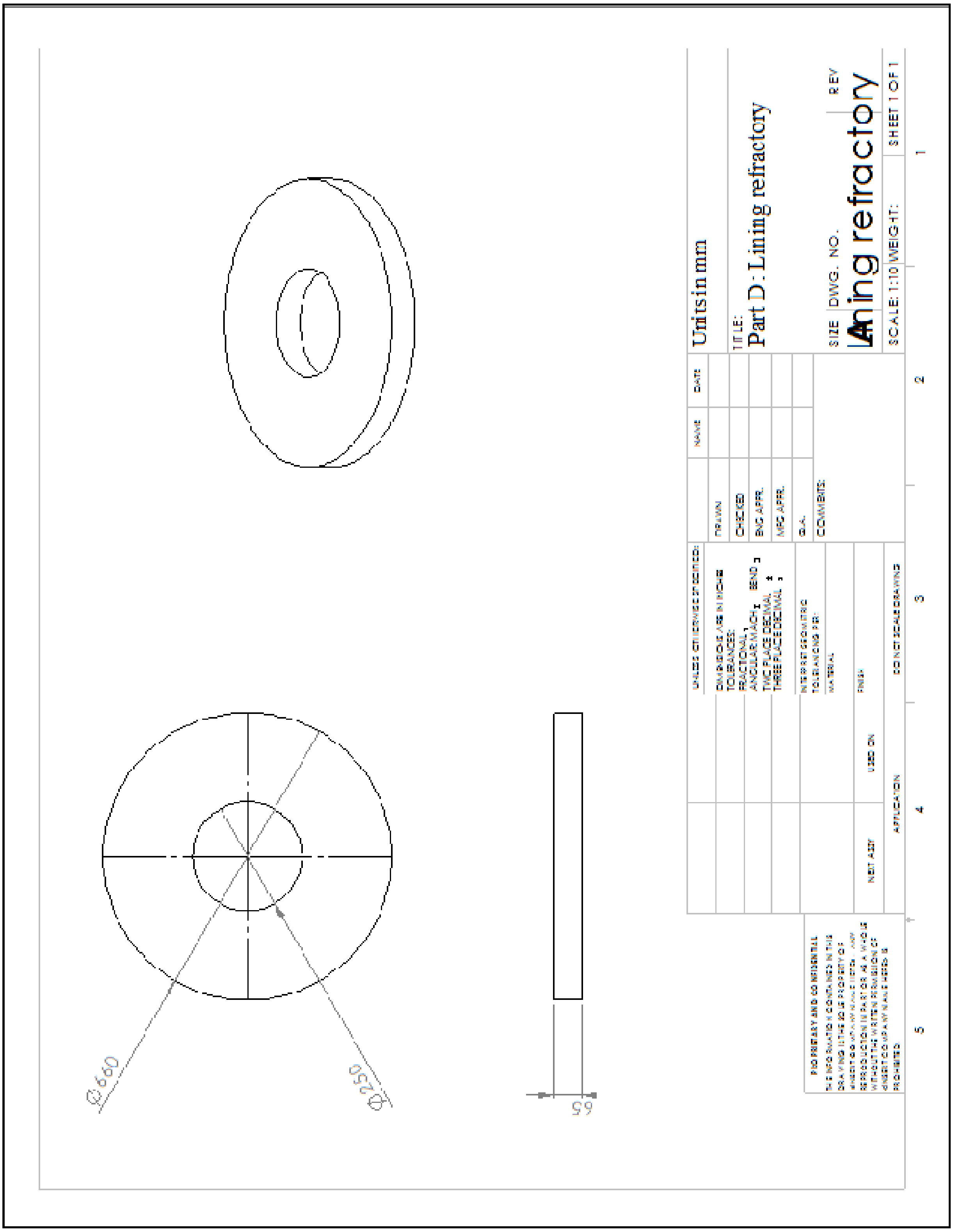
[8] http://en.wikipedia.org/wiki/Rebar, dated on 22nd October 2010

APPENDIX A

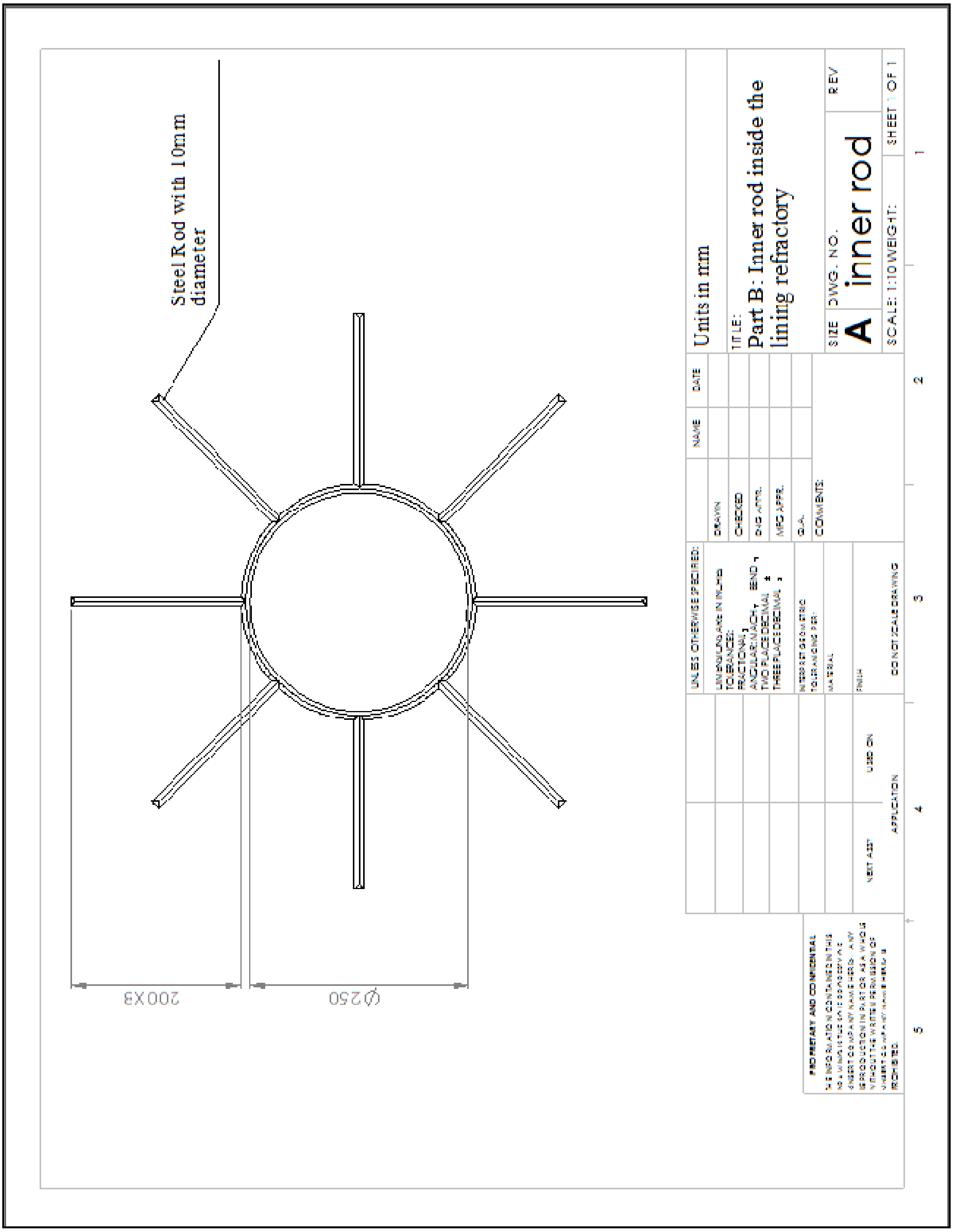


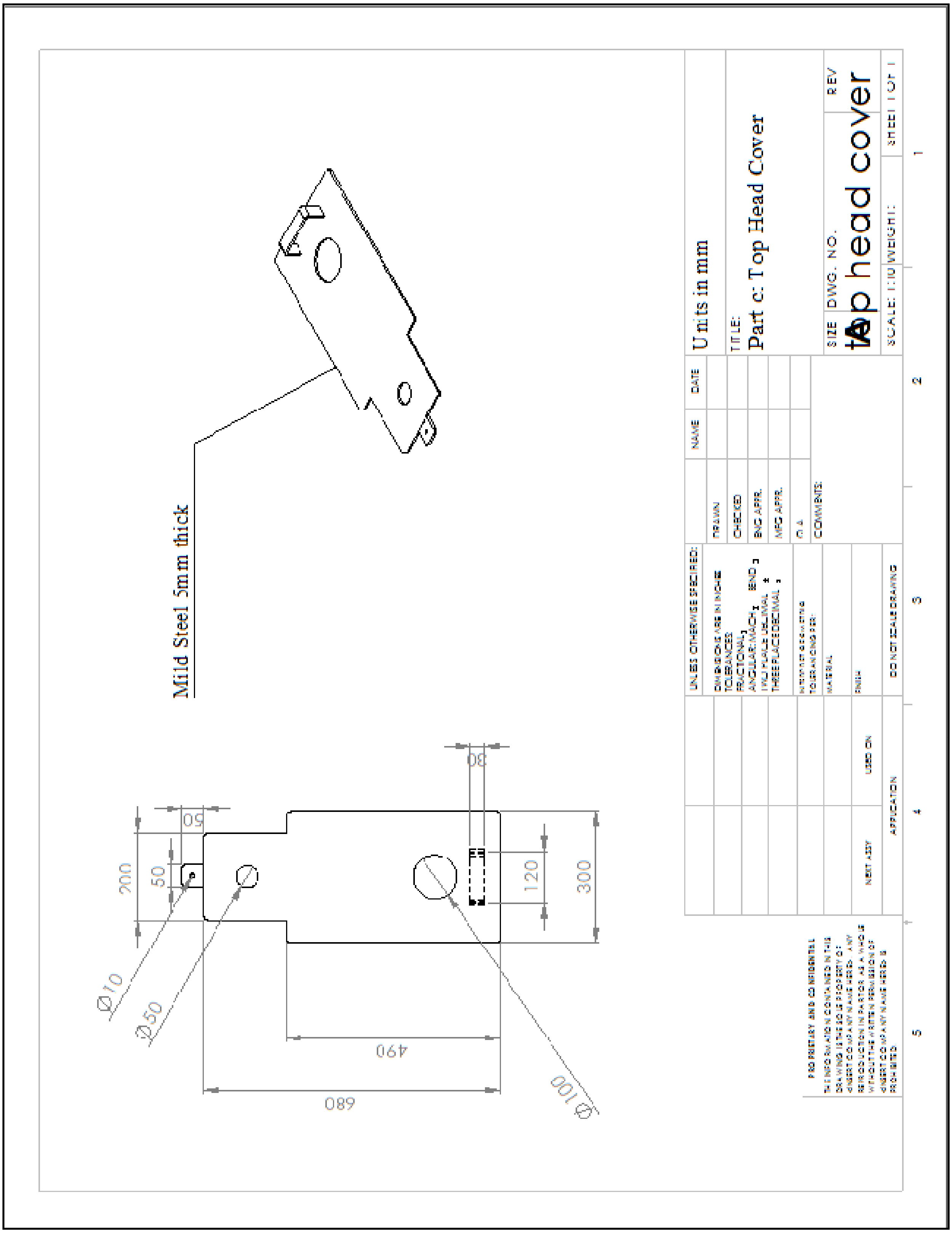
Gantt chart

APPENDIX B

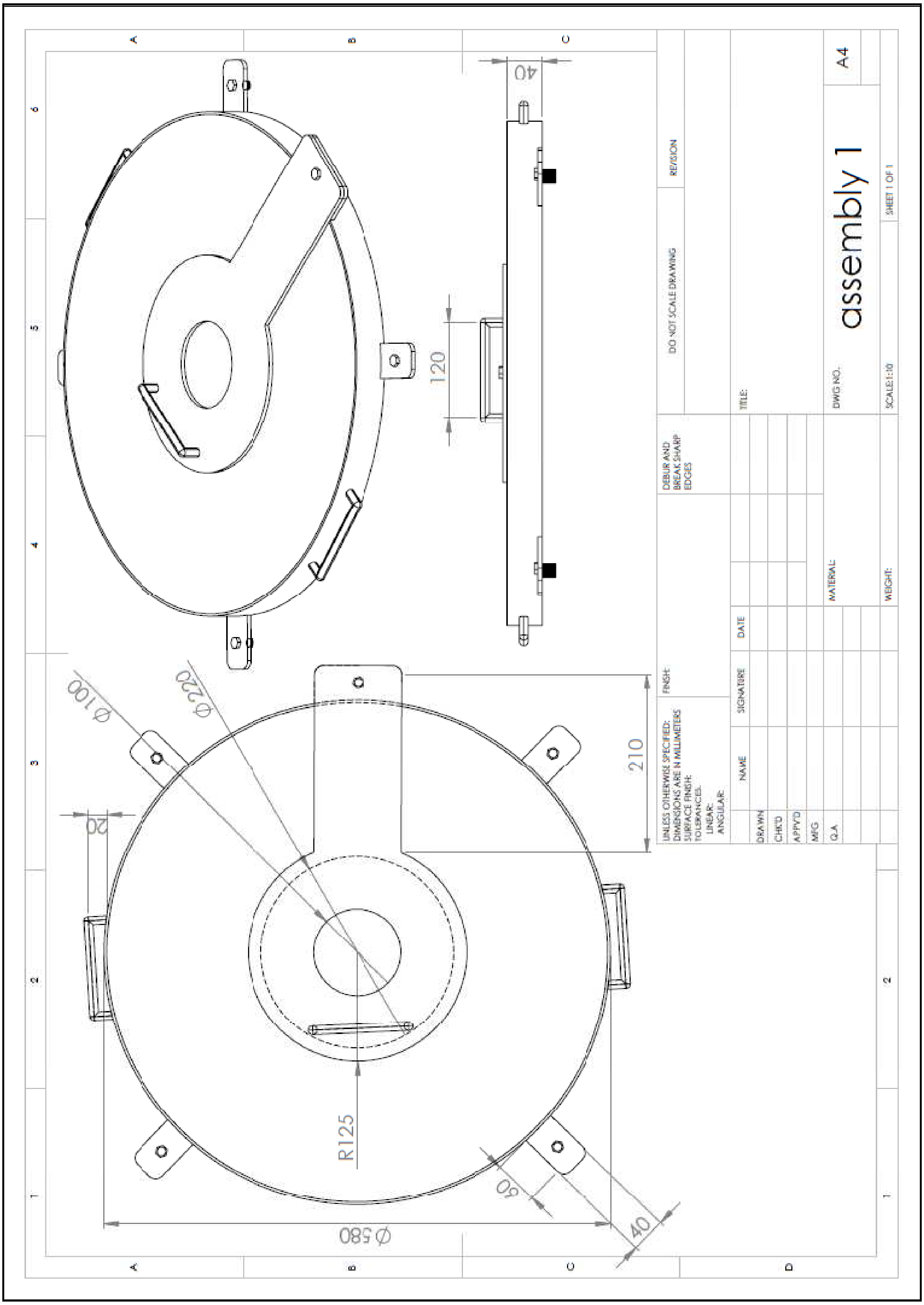


Units in mm
TITLE:
Part D: Lining refractory
SIZE
DWG. NO.
REV
A
Lining refractory
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
Φ660
Φ250
65


Steel Rod with 10mm diameter
200X3
Ø250
Units in mm
TITLE:
Part B: Inner rod inside the lining refractory
SIZE
A
DWG. NO.
inner rod
REV
SCALE: 1:10 WEIGHT:
SHEET 1 OF 1
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
UNLESS OTHERWISE SPECIFIED:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL



Mild Steel 5mm thick
Units in mm
TITLE:
Part c: Top Head Cover
SIZE
A
DWG. NO.
top head cover
REV
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
200
50
50
80
120
300
490
680
Ø10
Ø50
Ø100


40
120
210
Ø100
Ø220
20
R125
60
40
Ø580
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
MATERIAL:
DWG NO.
assembly 1
A4
WEIGHT:
SCALE:1:10
SHEET 1 OF 1