DESIGN AND MANUFACTURE THE INNER SHELL OF DIESEL FURNACE

MUHAMMAD MUIZZUDDIN BIN YUSOF

UNIVERSITI MALAYSIA PAHANG
DESIGN AND MANUFACTURE THE INNER SHELL OF DIESEL FURNACE

MUHAMMAD MUIZZUDDIN BIN YUSOF

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

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

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SUPERVISOR DECLARATION

I hereby declare that I had read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the purpose of the granting of Diploma of Mechanical Engineering.

Signature : 

Name of Supervisor : EN. ASNUL HADI BIN AHMAD

Position : Lecturer

Date : 

AUTHOR DECLARATION

I declare that this thesis entitled “DESIGN AND MANUFACTURE THE INNER SHELL OF DIESEL FURNACE” is the result of my own research except as cited in references. The thesis has not been accepted for any diploma and is not concurrently submitted in candidature of any other diploma.

Signature : 

Name : MUHAMMAD MUIZZUDDIN BIN YUSOF

ID Number : MB08064

Date : 
DEDICATION

To my beloved father and mother

YUSOF BIN MUDA

ZAUYAH BINTI HAMZAH
ACKNOWLEDGEMENTS

First of all I am grateful to ALLAH S.W.T for blessing me in finishing my final year project (FYP) with success in achieving my objectives to complete this project.

Secondly I want to thank my family for giving morale support and encouragement in completing my project and also throughout my study in UMP as they are my inspiration to success. I also would like to thank my supervisor EN ASNUL HADI BIN AHMAD for guiding and supervising my final year project throughout this semester. He has been very helpful to me in finishing my project and I appreciate every advice that he gave me in correcting my mistakes. I apologize to my supervisor for any mistakes and things that I done wrong while doing my project. The credits also goes to all lecturers, tutors, teaching engineers (JP) and assistant teaching engineers (PJP) for their cooperation and guide in helping me finishing my final year project.

Last but not least I want to thank all my friends that have given me advice and encouragement in completing my project. Thank you very much to all and may ALLAH bless you.
This report is about the design and manufactures the inner shell of diesel furnace. This project encourages the study of melting furnace. Melting furnace is a device used to melt the metal for casting metal application. The project is start with the study and research. From the information gathered from literature study, four designs had been created. One of the designs is chosen using screening concept and final design is decided. The fabrication process consists of cutting process and construction of the wall inside the furnace. By putting the buffers will keep the heat inside the furnace and make the crucible melt the metal faster. Furthermore, the furnace is heat up by the burning of diesel fuel to blow the fire into the combustion chamber. When the product is finished, it is tested to determine the time of metal to melt completely and to prove the product is working and success. All of the problems faced during and after making the product are discussed. Some recommendation base on the problems also discussed in the last chapter of this report to improve the product in the future.
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<th>Description</th>
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<td>Kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>Mm</td>
<td>Milimeter</td>
</tr>
<tr>
<td>s</td>
<td>Second</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celcius</td>
</tr>
<tr>
<td>C</td>
<td>Carbon</td>
</tr>
<tr>
<td>Cr</td>
<td>Chromium</td>
</tr>
<tr>
<td>Fe</td>
<td>Ferum / iron</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
</tr>
<tr>
<td>Mo</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>Ni</td>
<td>Nickel</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>S</td>
<td>Sulfur</td>
</tr>
<tr>
<td>Si</td>
<td>Silicon</td>
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LIST OF ABBREVIATIONS

BC         Before Century
CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is explaining about the project background, problem statement, project objective and scope of the project.

1.2 PROJECT BACKGROUND

This project is about designing and manufacturing the inner shell of diesel furnace. The furnace is use to heat and melt the solid metal and transform it to the liquid state. The furnace use combustion of diesel as a fire source to heat the crucible and melt the solid metal inside that for a certain time. The firebrick coated with refractory inside the furnace will keep the heat around crucible to make sure heat not loss and save the time while melting the metal. After the metal totally melt, the liquid will flow out and use for casting.

1.3 PROBLEM STATEMENT

Although there are firebrick and refractory inside the furnace, the heat still flow unregulately. This will make the melting process take about two until 3 hours for melt completely. A alternative way must be adapt to solve this problem.
1.4 PROJECT OBJECTIVE

The main objective of this project is to design and manufacture the heat flow system of the inner part furnace.

1.5 PROJECT SCOPE

The scopes of this project are:

(i) Design the buffer plate to keep the heat on the crucible
(ii) This project focused on melting non-ferrus metal only.
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The oldest extant blast furnaces were built during the Han Dynasty of China in the century BC. However, cast iron farm tools and weapons were widespread in China by the 5th century BC, while third century BC iron smelters employed an average workforce of over two hundred men. These early furnaces had clay walls and used phosphorus that containing mineral as a flux. The effectiveness of the Chinese blast furnace was enhanced during this period by the engineer, Du Shi who applied the power of waterwheels to piston bellow in forging cast iron.

2.2 FURNACE ONE

This furnace are custom homemade. It used propane tank as shell that will be cutted to fix the refractory castable. As the propane under pressure can penetrate the steel of the tank, the hot water was fill to moisture the content inside the tank. The crucible only use a small diameter with depth tube that welded to a chunk of one over four inch plate. The bolts welded to the top side for lifting and the nut on the bottom is used to aid in pouring.
As the refractory rated to 1650°C, this requires no additional sand. It just mix with water with a suitable amount.

The refractory was left to set-up over night before the forms were removed and left to cure for a week. Both forms have a slight taper and were removed without damage to the refractory. The fire up procedure on the bag states to raise the temp in 75°C increments every 30 minutes per inch of refractory thickness. This was given that only 24 has elapsed since mixing. As this had sat for a week, it was fired up for a burn without incident.
2.3 FURNACE TWO

Figure 2.3: Flowerpot crucible furnace

This is the simplest and cheapest furnace. It just use flowerpot as crucible. Then, the charcoals are use to heat the crucible wholly but it need to be replace for a certain time. The heat source from the burning fo diesel fuel blow from a external pipe into the furnace.

Figure 2.4: Inside the furnace
2.4 FURNACE THREE

This furnace is using a rolled sheet metal as its shell. Inside it, the firebricks are arranged to form a large combustion chamber.

![Combustion chamber of furnace](image)

**Figure 2.5:** Combustion chamber of furnace

A graphite crucible used includes a lid on it. That will keep the heat from being lost while the melting process.

![Graphite crucible with lid](image)

**Figure 2.6:** Graphite crucible with lid

This furnace uses diesel fuel as the fire source and added an oxygen port to speed things up. The result is only 15 minutes for aluminium to melt completely.
CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter is discusses about all the information and data that required for this project. Methodology is a description of process, or may be expanded to include a philosophically coherent collection of theories, concepts or ideas as they relate to a particular discipline or field of inquiry.

3.2 PROJECT FLOW CHART

There were eight phase conclude in this project, which are :

(i) Phase 1 – Project discussion
(ii) Phase 2 – Literature review
(iii) Phase 3 – Sketch and design
(iv) Phase 4 – Final sketching
(v) Phase 5 – Finalize design
(vi) Phase 6 – Fabrication
(vii) Phase 7 – Test, analysis and discussion
(viii) Phase 8 – Report
Figure 3.1: Flow chart
3.3 DESIGN GENERATION

3.3.1 First Sketch

![First Sketch](image)

**Figure 3.2:** First sketch

Advantages

The crucible is very depth and it heated by charcoal wholly.

Disadvantages

The crucible not stand properly. The charcoal used need to be replace.
3.3.2 Second Sketch

Figure 3.3: Second sketch

Advantages

This design idea has a very thick wall of castable. It also have a very depth of crucible.

Disadvantages

The thick of wall cause the shell was heavy weight. The wall also may crack as it does not use firebrick.
3.3.3 Third Sketch

![Third sketch](image)

**Figure 3.4:** Third sketch

Advantages

The buffers use are from firebricks that attach to the wall. So, the crucible are wholly heat.

Disadvantages

However, only a small crucible can be put. As there are many firebricks use, the shell become very weight.
3.3.4 Fourth Sketch

Figure 3.5: Fourth sketch

Advantages

This furnace use buffers metal plate to keep the heat. So, the crucible are heat wholly. It also can decrease the weight of shell.

Disadvantage

It only use a medium size crucible.
3.4 CONCEPT SCREENING

A problem that often faced while making decisions to choose the best design is there are many different people with many different opinions. Concept screening use a simple matrix between a number of options and typically done with a representative team of cross-functional people. Then, the concepts will be compare against each criteria that have been decided. Each concept has its score totalled to show its overall score and then will be rank.

Table 3.1: Concept screening

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Datum</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Weight</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Crucible size</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Combustion chamber area</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Crucible supporter</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Heat performance</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Use of buffers</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Ease of manufacture</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Sum of (+)</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Sum of (0)</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Sum of (-)</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Net score</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Rank</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>
3.5 FINALIZE DESIGN

The data from concept screening show that the fourth design was better than the others three designs. So, fourth design will be final design.

3.5.1 Solid Work

Figure 3.6: External view
Figure 3.7: Cross section view

3.5.2 Design Dimension

Figure 3.8: Dimension of design
3.6  MATERIALS SELECTION

3.6.1  Stainless Steel Sheet

Stainless steels are alloys and therefore do not melt and freeze at a fixed temperature as do metallic elements, but over a temperature range depending on the chemical composition of the steel. The melting range of stainless steel is 1375-1400 °C for type 316.

Figure 3.9: Stainless steel sheet

Table 3.2: Elements in 316-stainless steel

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.08</td>
</tr>
<tr>
<td>Cr</td>
<td>18 max</td>
</tr>
<tr>
<td>Fe</td>
<td>82</td>
</tr>
<tr>
<td>Mn</td>
<td>2</td>
</tr>
<tr>
<td>Mo</td>
<td>3 max</td>
</tr>
<tr>
<td>Ni</td>
<td>14 max</td>
</tr>
<tr>
<td>P</td>
<td>0.045</td>
</tr>
<tr>
<td>S</td>
<td>0.03</td>
</tr>
<tr>
<td>Si</td>
<td>1</td>
</tr>
</tbody>
</table>
Stainless steel sheet will be used to make buffers. With 4mm thickness, it can support the fire that blow in the furnace.

3.6.2 Stainless Steel Rod

Stainless steel rod are remarkably strong and resistant to the elements. It is manufactured using a low alloy composition, with high level of chromium. With that strength, it can support the center firebricks at the bottom of the furnace.

![Stainless steel rod](image)

Figure 3.10: Stainless steel rod

3.6.3 Graphite Crucible

A crucible is needed to withstand the extreme temperatures encountered in melting metals. The crucible material must have a much higher melting point than that of the metal being melted and it must have good strength even when white hot. The crucible have two type, that are ‘Bilge’ shape and ‘A’ shape. For this project, it will use ‘A’ shape crucible.
Figure 3.11: Cross section of ‘A’ shape crucible

Figure 3.12: The ‘A’ type graphite crucible

The ‘A’ shape crucible has straighter sides that taper outward. Note that there is no ‘Bilge’ diameter for an ‘A’ shape because the diameter constantly increases from the bottom to the top. This shape is easier to make than the bilge shape and therefore is lower cost. Also note that ‘A’ shape sizes and capacities don't correspond to ‘Bilge’ shape sizes and capacities.

3.6.4 Firebrick

A firebrick is built primarily to withstand high temperature, but should also usually have a low thermal conductivity to save energy. In any case, firebricks
should not spall under rapid temperature change, and their strength should hold up well during rapid temperature changes.

Figure 3.13: A few of firebricks

Firebricks usually contain 30-40% aluminium oxide and 50% silicon dioxide. For extreme use, the aluminium oxide content can be as high as 50-80% and silicon carbide may also be present. The silica firebricks could stand at 1650ºC.

3.6.5 Castable Refractory

Castable are use to coat the firebricks. It can withstand the heat about 1427ºC. The whole of combustion surface are finish with that. It just mix with water to stick on firebrick.

Figure 3.14: Castable before mix up with water
3.7 BILL OF MATERIAL

Table 3.3: Bill of material

<table>
<thead>
<tr>
<th>Parts</th>
<th>Material</th>
<th>Size (mm)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crucible</td>
<td>Graphite</td>
<td>Height : 245</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal Diameter : 200</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>External Diameter : 220</td>
<td></td>
</tr>
<tr>
<td>Buffer</td>
<td>Stainless steel</td>
<td>Length : 1260</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width : 580</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hight : 4</td>
<td></td>
</tr>
<tr>
<td>Rod</td>
<td>Stainless steel</td>
<td>Length : 1000</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diameter : 10</td>
<td></td>
</tr>
<tr>
<td>Firebrick</td>
<td>Ceramic</td>
<td>Length : 230</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hight : 115</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width : 77</td>
<td></td>
</tr>
<tr>
<td>Refractory</td>
<td>Castable</td>
<td>25 kg/bag</td>
<td>4</td>
</tr>
</tbody>
</table>

3.8 FABRICATION

3.8.1 Cutting Process

The process of cutting involve two parts. The first one is to cut the stainless steel sheet to form buffers. As the sheet is thick and hard, the plasma cutting machine was use.
The second part is to cut the firebrick by using portable grindle machine. The firebricks are cut to fix the arrangement on the wall and easy to place buffers.

Figure 3.16: Cutting the firebricks

3.8.2 Construction of Inner Part

This is the main part in fabrication of the furnace. It may result the strong of wall. The firebricks are arrange almost similar to the construction of wall’s building. The castable was use to stick between the firebricks and also with the inner surface of shell. It also use to make finishing on the surface of wall.
After that, a graphite crucible is place on two firebricks at the center of shell. That firebricks was support with four stainless steel rod planting in the floor before coated with castable. The crucible was support with the castable that stick with firebrick under it and also buffers at the circumference. Additional supporter was placed at the top of crucible.
Figure 3.19: Firebricks under the crucible

Figure 3.20: Graphite crucible support by buffers

Figure 3.21: Top crucible’s supporter (in the red circle)
Buffers are placed between two firebricks. Before that, the buffers were coated with castable on its surface to increase its strength while the combustion process.

**Figure 3.22:** Coated buffer

**Figure 3.23:** The position of first buffer

**Figure 3.24:** Second buffer position
Figure 3.25: Third buffer position

Last but not least, the output channel between the crucible and shell. This channel will act as a bridge to flow the melting metal inside the crucible.

Figure 3.26: Output channel