

**DESIGN AND FABRICATION OF HOLE COVER BY CASTING PROCESS**

**MUHAMMAD KAMILI BIN ZAHIDI**

**UNIVERSITI MALAYSIA PAHANG**

### **SUPERVISOR'S DECLARATION**

I hereby declare that we have checked this project and in our opinion this project is satisfactory in term of scope and quality for the Final Year Project.

Signature :  
Name of Supervisor : Mr. Nasrul Hadi Bin Johari  
Position :  
Date :

DESIGN AND FABRICATION OF HOLE COVER BY CASTING PROCESS

MUHAMMAD KAMILI BIN ZAHIDI

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

Faculty of Mechanical Engineering  
University Malaysia Pahang

DECEMBER, 2011

## **AUTHOR'S DECLARATION**

I hereby declare this report entitled “*Design and Fabrication of Hole Cover by Casting Process*”. This result of my own research except as stated in the references. This thesis/report has not been accepted for any diploma and is not concurrently submitted in candidature of any other diploma.

Signature	:	
Name	:	Muhammad Kamili Bin Zahidi
ID Number	:	MB 09064
Date	:	

To my beloved family,  
Tok Wan and family,  
And a very special friend.

## **ACKNOWLEDGEMENTS**

In preparing this project, I was in contact with many people such as academicians. They have contributed towards my understanding and thoughts. In particular, I would like to express my sincere appreciation to my main project supervisor, Mr. Nasrul Hadi Bin Johari for encouragement, guidance, critics and friendship.

My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. I would like to thank them for their views, tips and encouragement which are useful indeed. I also want thank to my family for their motivation support to finish my project.

Finally, I want give special appreciation to Universiti Malaysia Pahang (UMP) for providing lab and also library for relevant literatures.

## **ABSTRACT**

This report is an outcome of carrying out and completing the Final Year Project in Diploma Mechanical Engineering. The project entitled Design and Fabricate of Hole Cover by Casting Process. This project focus on redesign electrical output hole cover. The objective of this project is redesigning hole cover with Computer Aid Design (CAD) and fabricating by using casting process. In overall this project started with designing process by using Solid Work software. Then it has followed by casting process. The casting process has a few steps. The first step is making pattern by using wood material. Then preparing mold by using the finished pattern. The process continues with melting the material in furnace and pouring them into mold. After that is cooling the material. The material must be cool sufficiently before remove the mold by wire brush. Lastly is finishing process by machine to remove any excessive material. As the result, a new pattern of electric output hole cover has been designed and fabricated it by casting process. After all the process had been done, this project helps in gaining knowledge about designing by Solid Work software and fabricating by casting process.

## **ABSTRAK**

Laporan ini adalah hasil setelah menjalankan dan menyiapkan Projek Tahun Akhir Diploma Kejuruteraan Mekanikal. Projek ini bertajuk Mereka Bentuk dan Fabrikasi Penutup Lubang dengan Proses Penuangan. Projek ini fokus kepada mereka bentuk semula penutup lubang punca elektrik. Objektif projek ini adalah mereka bentuk penutup lubang dengan “Computer Aided Design”(CAD) dan fabrikasi dengan menggunakan proses penuangan. Secara keseluruhan, projek ini bermula dengan mereka bentuk dengan menggunakan perisian “Solid Work”. Kemudian ia diikuti dengan proses penuangan. Proses penuangan mempunyai beberapa langkah. Langkah pertama ialah mengukir corak pada kayu. Kemudian membuat acuan menggunakan kayu yang telah di corakan tersebut. Proses di teruskan dengan mencairkan besi di dalam relau dan menuangkan ke dalam acuan. Selepas itu adalah proses penyejukan bahan. Bahan mestilah sejuk secukupnya sebelum di dikeluarkan dari acuan dan di berus dengan berus dawai. Terakhir adalah proses membuang besi-besi yang berlebihan. Keputusan nya adalah terhasil satu corak baru penutup lubang punca elektrik dan di fabrikasi dengan proses penuangan. Selepas melakukan proses-proses tersebut, projek ini telah meningkatkan pengetahuan tentang cara mereka bentuk dengan mengguna perisian “Solid Work” dan cara fabrikasi dengan proses penuangan.



## TABLE OF CONTENTS

	<b>PAGE</b>
<b>SUPERVISOR’S DECLARATION</b>	<b>ii</b>
<b>PROJECT TOPIC</b>	<b>iii</b>
<b>AUTHOR’S DECLARATION</b>	<b>iv</b>
<b>DEDICATION</b>	<b>v</b>
<b>ACKNOWLEDGEMENTS</b>	<b>vi</b>
<b>ABSTRACT</b>	<b>vii</b>
<b>ABSTRAK</b>	<b>viii</b>
<b>TABLE OF CONTENTS</b>	<b>ix</b>
<b>LIST OF TABLES</b>	<b>xii</b>
<b>LIST OF FIGURES</b>	<b>xiii</b>
<b>LIST OF APPENDICES</b>	<b>xv</b>
<b>CHAPTER 1            INTRODUCTION</b>	
1.1            Introduction	1
1.2            Problem Statement	2
1.3            Project Objective	2
1.4            Project Scope	2
1.5            Project Flow Chart	3
1.6            Project Planning	4
<b>CHAPTER 2            LITERATURE REVIEW</b>	
2.1            Introduction	6

2.2	Hole Cover	6
2.3	Design of Hole Cover	7
2.3.1	First Design	7
2.3.2	Second Design	8
2.3.3	Third Design	9

### **CHAPTER 3            PROJECT METHODOLOGY**

3.1	Introduction	10
3.2	Flow Chart	10
3.3	Design Selection	11
3.3.1	Propose Design	11
3.3.2	Concept Evaluation	13
3.3.3	Suggestion Design Selection	14
3.3.4	Engineering Drawing for Selected Design	15
3.3.5	Design Dimension	16
3.4	Material Selection	18
3.5	Fabrication	19

### **CHAPTER 4            RESULT AND DISCUSSION**

4.1	Introduction	20
4.2	Hole Cover	20
4.2.1	Pattern of product	21
4.2.2	After casting product	21
4.2.3	After clearing product	23
4.2.4	Product specification	27
4.3	Discussion	27
4.3.1	Defect of project	28
4.3.2	Problem during select material	29
4.3.3	Problem during literature review	29
4.3.4	Problem during design	30
4.3.5	Problem during fabrication	30

**CHAPTER 5                    CONCLUSION AND RECOMMENDATION**

5.1	Introduction	31
5.2	Conclusion	31
5.3	Recommendation	32
	<b>REFERENCES</b>	33
	<b>APPENDIX</b>	34

**LIST OF TABLE**

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
1.1	Gantt chart of the project	5
3.1	The evaluation process through matrix chart	14
4.1	Pattern specification	21
4.2	Product specification	27

## LIST OF FIGURES

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
1.1	Project's flow chart	3
2.1	Round design of hole cover	8
2.2	Square design of hole cover	8
2.3	Grid design of hole cover	9
3.1	Flow chart of project's methodology	11
3.2	First sketch for hole cover design	12
3.3	Second sketch for hole cover design	12
3.4	Third sketch for hole cover design	12
3.5	Fourth sketch for hole cover design	12
3.6	Fifth sketch for hole cover design	13
3.7	An existing product used as a reference	13
3.8	The selected design for hole cover	15
3.9	The produced engineering drawing for frame	15
3.10	The produced engineering drawing for Hole Cover	16
3.11	Engineering drawing for Hole Cover and Frame	16
3.12	Dimension of Hole Cover	17
3.13	Dimension of Frame	18
4.1	After casting the frame, top view	21
4.2	After casting the frame, front view	22
4.3	After casting the hole cover, top view	22
4.4	After casting the hole cover, front view	22
4.5	The hole cover without the sprue, top view	23

4.6	The hole cover without the sprue, front view	23
4.7	The hole cover without sprue, side view	24
4.8	The frame without the sprue, top view	24
4.9	The frame without the sprue, front view	24
4.10	The frame without the sprue, side view	25
4.11	The frame without the sprue, bottom view	25
4.12	Frame and hole cover without the sprue	26
4.13	The product assembled together, top view	26
4.14	The product assembled together, front view	27
4.15	Drop Defect	28
4.16	Drop Defect. It has contour on flat surface	28
4.17	Leakage from cavity mould	29
4.18	Have gap between hole cover and frame	29

**LIST OF APPENDICES**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A	3D Drawing Hole Cover	34
B	2D Drawing Hole Cover	36
C	Pattern	38
D	Machine	40
E	Tools, equipment and material	42

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

Final Year Project is one of compulsory subject for Diploma Mechanical Engineering. In this subject, a project must be done to fulfill the subject requirement. So, the purpose project is to Design and Fabricate Hole Cover by Casting Process. Hole cover is a removable plate forming the lid over the opening of a manhole. It is to prevent anyone from falling in manhole. It has many shapes, such as round, square and rectangular. Each shape has its advantage and disadvantage. Usually hole cover is made by casting process and the main material is iron. Electric output hole cover is one of type hole cover. It is to cover the electric plug in floor being step by someone or vehicle. After finished this project, the knowledge in designing and fabricating will increase.



## **1.2 Problem Statement**

Electric hole cover in mechanical laboratory are thin. When forklift step on electrical output hole cover, it will bend. It is not suitable to be use in mechanical laboratory. So, the problem with current electric output hole cover is the product cannot withstand high load. Then a new design must be done to replace the hole cover.

## **1.3 Project Objective**

Basically, the specific objectives of this project are:

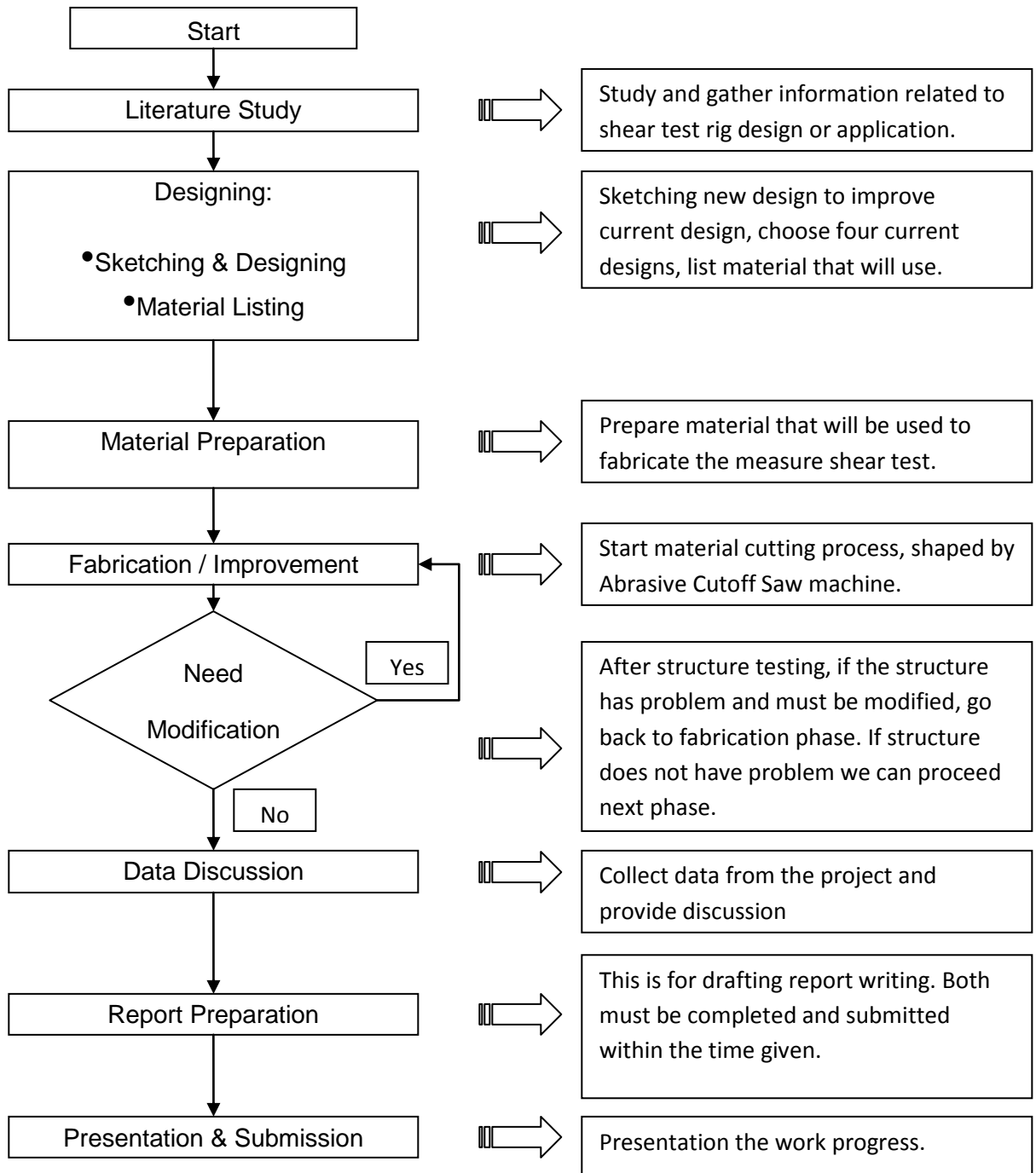
1. To design a electrical output hole cover by using Solid Work software.
2. To fabricate electrical output hole cover by casting process.

## **1.4 Project Scope**

The scopes of the project are:

1. Designing electrical output hole cover using Solid Work software.
2. Fabricating the electrical output hole cover by casting process.

### 1.5 Project Flow Chart



**Figure 1.1:** Project's flow chart

## **1.6 Project Planning**

This project started with investigation about the issue occurred. Then literature reviews are done via internet, reference books, reference to supervisor and other relevant academic material that are related to this project. To make this project more accurate and suitable, more studies are done about this topic. It takes more than two weeks to make the literature review. Every week, improvement of knowledge needed to make sure this project will be performed very well.

First week, we need to do some schedule management for this project which includes schedule management to all members in the group. All schedules will be created in a Microsoft Excel to make a Gantt chart. It takes a week to accomplish all schedules.

The next task is preparation of progress presentation and report writing. These tasks take two weeks to be finished. On that particular week, preparation is needed to make a presentation.

Fabrication process started after midterm. Fabrication process includes making pattern, mould, melting and pouring. This task is scheduled for several weeks to finish.

Lastly is to do the final report writing phase and preparation of the presentation. These two phases will start from the beginning of the project till the end to arrange and completion. The report is guided by UMP thesis format and also guidance from the supervisor. All task scheduled will take around fourteen weeks to complete.

**Table 1.1:** Gantt chart of the project.

Work \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Discussion and selection of project title	/													
Literature review	/	/	/	/	/								/	/
Concept generation		/	/											
Sketching		/	/	/	/									
Finalizing concept				/								/		
CAD				/	/	/	/					/	/	
Material selection							/	/						
Fabricating the project									/	/	/	/	/	/
Evaluation														
Report preparation				/	/	/	/					/	/	/
Final presentation														/

	Planning progress
/	Actual progress

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Final Year Project of design and fabrication hole cover by casting process requires a lot of knowledge about manufacturing process and design consideration. Therefore, research is necessary to get all information available that related to the topic. The information can be finding in books, internet and journal. With this research, the project can be done correctly. Then the project will be achieving the target mark.

#### **2.2 Hole Cover**

Hole covers started off as slabs of stone or pieces of wood allowing access to covered trenches that carried sewage. This basic design was in use from 3500 BC. In the nineteenth century, modern manholes and the modern hole cover were developed. For the last 200 years, iron works have made cast-iron manhole covers, some weighing as much as 100kg. Design not has really changed in the years between the 1870s until nowadays.

There are a few types of hole cover. The first type of hole cover is manhole cover. Access ways to subsurface is called manholes. Manholes are dug down to subsurface conduits at regular intervals to allow maintenance workers to reach them. The subsurface utilities can be as sewers, storm drains, steam tunnels, or utility corridors. Normally, it is underground of a major city. Manhole covers are the round iron plates sunk into streets and sidewalks that keep passers-by from falling into manholes. Manhole covers must be a minimum of 56 cm in diameter, but can be as much as 1.5 m in diameter. The average cover weighs between 113-136 kg.

## **2.3 Design of Hole Cover**

There are many design of hole cover. It can be round, square or rectangular. Each shape has its own purpose. For example round shape is to avoid hole cover from sink into hole. It can be injure worker if it sink in the hole. So, almost all heavy hole cover has round design. Weight of hole cover have also their own purpose. The heavy hole cover is purpose to avoid hole cover fly went vehicle pass through it. Another purpose is to sealed methane gas or noxious gas escape from sewer. These gas are harmful to human being.

### **2.3.1 First Design**

First design is round hole cover. Normally round hole cover is used for sewer, utilities or water tunnel. Iron is main material used in this hole cover design. The diameter can be between 500mm until 800mm. It is depend on customer design. The product weight is between 50kg until 120kg. The surface is coated with black bitumen or hot galvanized. It has high breaking strength about 14Mpa. It also has low water absorption.



**Figure 2.1:** Round design of hole cover (Source: [http://www.alibaba.com/product-gs/338649579/Ductile\\_iron\\_manhole\\_cover.html](http://www.alibaba.com/product-gs/338649579/Ductile_iron_manhole_cover.html))

### 2.3.2 Second Design

Second design is square hole cover. Main material for this design can be ductile iron or grey iron. The dimension of hole cover can be 300mmX300mm until 800mmX800mm and weight can be between 7kg until 55 kg.



**Figure 2.2:** Square design of hole cover. (Source: [http://www.alibaba.com/product-gs/222467273/Square\\_Manhole\\_Cover.html](http://www.alibaba.com/product-gs/222467273/Square_Manhole_Cover.html))

### 2.3.3 Third Design

Third design is grids hole cover. Normally it is use for drain. This design used iron as main material. The dimension is as customer request and weight can be between 2kg until 250kg.



**Figure 2.3:** Grid design of hole cover. (Source:

[http://btzxzy.en.alibaba.com/product/461157342-209635552/MANHOLE\\_COVER\\_COVER\\_WITH\\_FRAME\\_grating\\_grids\\_ductile\\_iron\\_manhole\\_cover\\_iron\\_cover\\_well\\_SGS\\_EN124\\_.html](http://btzxzy.en.alibaba.com/product/461157342-209635552/MANHOLE_COVER_COVER_WITH_FRAME_grating_grids_ductile_iron_manhole_cover_iron_cover_well_SGS_EN124_.html))



## **CHAPTER 3**

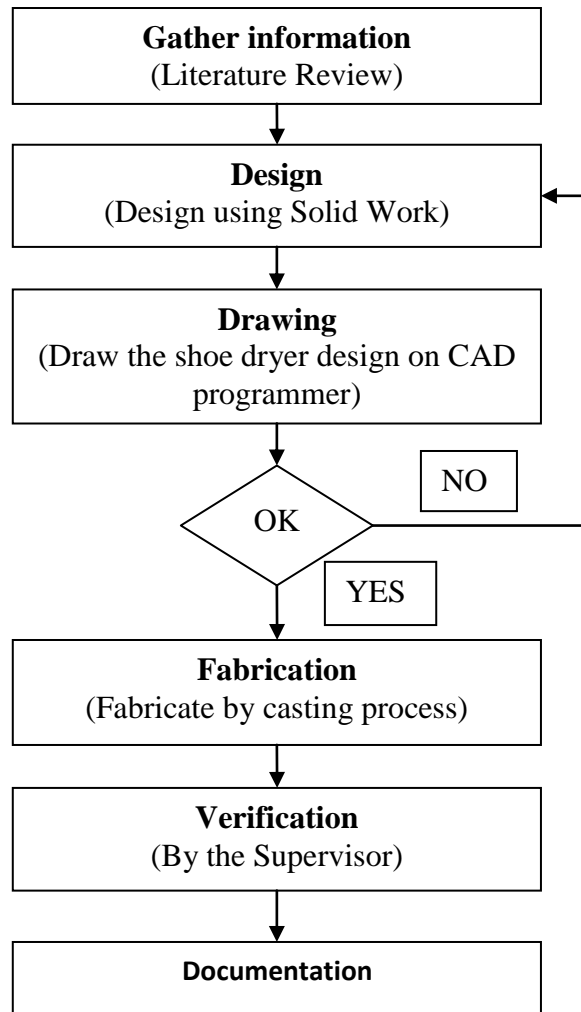
### **METHODOLOGY**

#### **3.1 Introduction**

Methodology is a system of methods used in finishing this project. In design and fabrication hole cover, there are several step must be follows. So, a flow chart is charted out as a guideline to be followed. Besides knowing procedure of project, the procedure of designing and fabricating should be known very well. It will produce the product batter. Design has 3 steps. It is sketching, evaluating and drawing. Meanwhile, fabrication has few steps. It is carving, molding, melting, pouring, and trimming.

#### **3.2 Flow Chart**

In fabrication of hole cover, there is a planning of the overall progress to assure the project can be finish on schedule, as shown in Figure 3.1:



**Figure 3.1:** Flow chart of project's methodology.

### 3.3 Design Selection

#### 3.3.1 Propose Design

Many designs have been made by sketching. From many design of hole cover, a few design has been chosen to be consider. The sketches are as shown below; see Figure 3.2 until Figure 3.6:



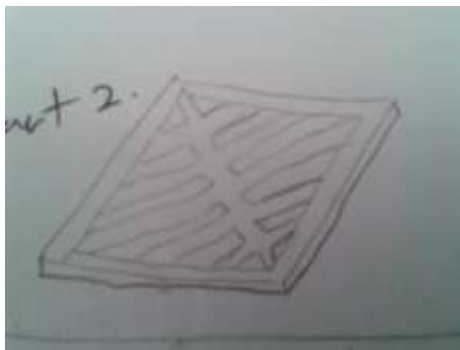
**Figure 3.2:** First sketch for hole cover design.



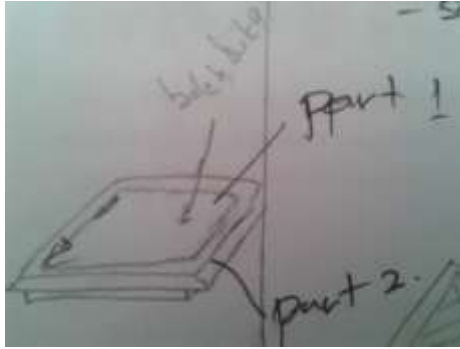
**Figure 3.3:** Second sketch for hole cover design.



**Figure 3.4:** Third sketch for hole cover design.



**Figure 3.5:** Fourth sketch for hole cover design.



**Figure 3.6:** Fifth sketch for hole cover design.

### 3.3.2 Concept Evaluation

Five concept hole cover had been sketched. From these sketches, an evaluation is made to evaluate the best concept or combine the concept. The evaluation is based on a exist product. Picture of the existed product is as below (Figure 3.7).



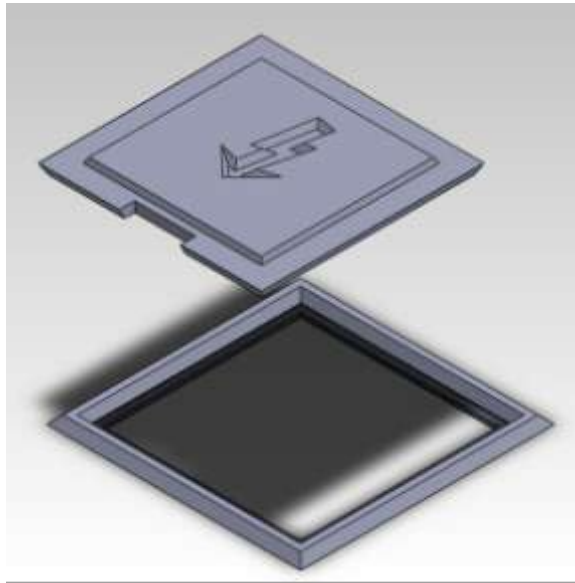
**Figure 3.7:** An existing product used as a reference.

**Table 3.1:** The evaluation process through matrix chart.

Criteria		Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Reference
Light weight		-	-	-	-	-	0
Good looking		+	0	+	0	0	0
Ease of manufacture		+	0	+	-	+	0
Ease of handling		0	+	-	-	+	0
Ease of use		+	+	-	-	0	0
Material cost		-	-	-	-	-	0
Protection		0	+	-	-	+	0
							0
	Pluses	3	3	2	0	3	
	Same	2	2	0	1	2	
	Minuses	2	2	4	6	2	
	Net	1	1	-2	-6	1	
	Continue?	Yes	Yes	No	No	Yes	

### 3.3.3 Suggestion Design Selection

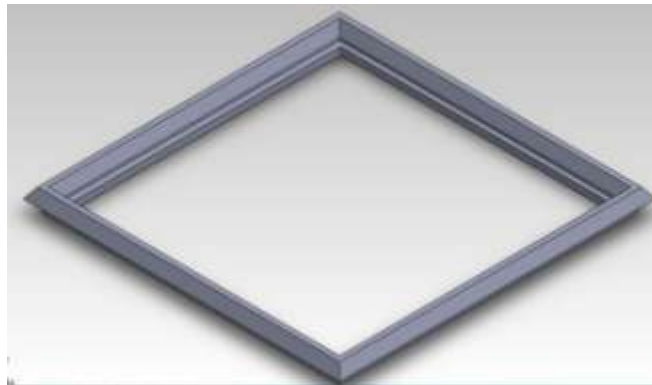
After the process of sketching and evaluation, the selected design for hole cover is as below, refer Figure 3.8.



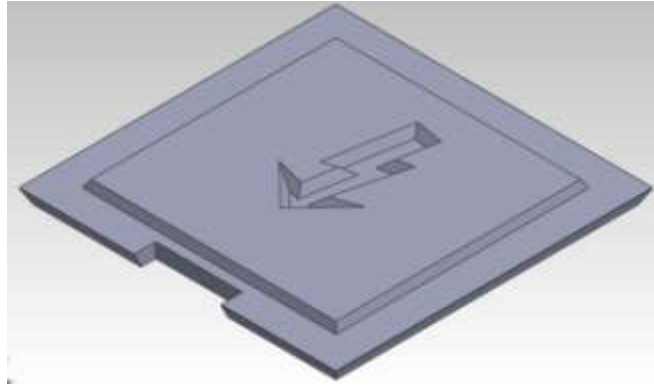
**Figure 3.8:** The selected design for hole cover.

#### **3.3.4 Engineering Drawing for Selected Design**

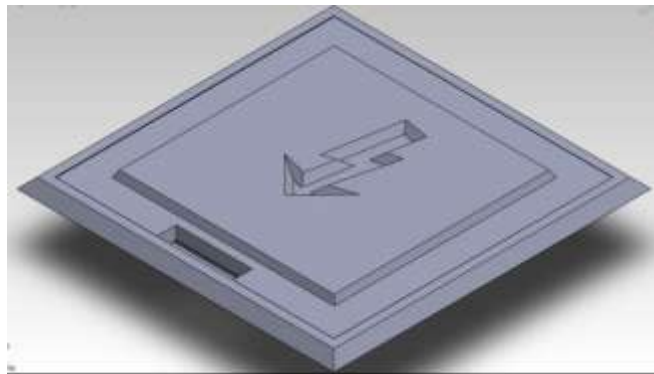
For the selected design, engineering drawing are produced through running out the Solid Work software (refer Figure 3.9 until Figure 3.11).



**Figure 3.9:** The produced engineering drawing for frame.



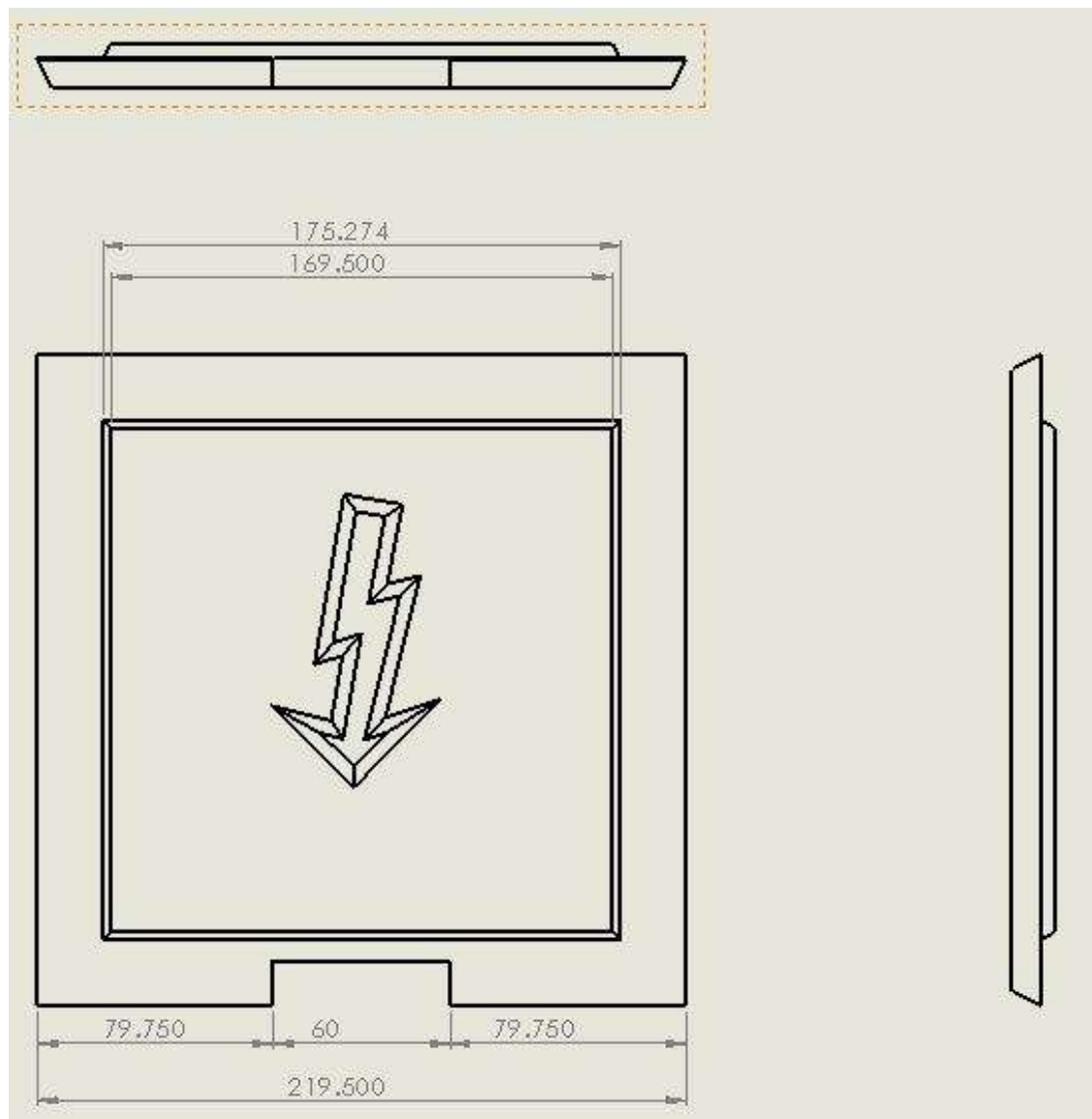
**Figure 3.10:** The produced engineering drawing for Hole Cover.



**Figure 3.11:** The Combination of engineering drawing for Hole Cover and Frame.

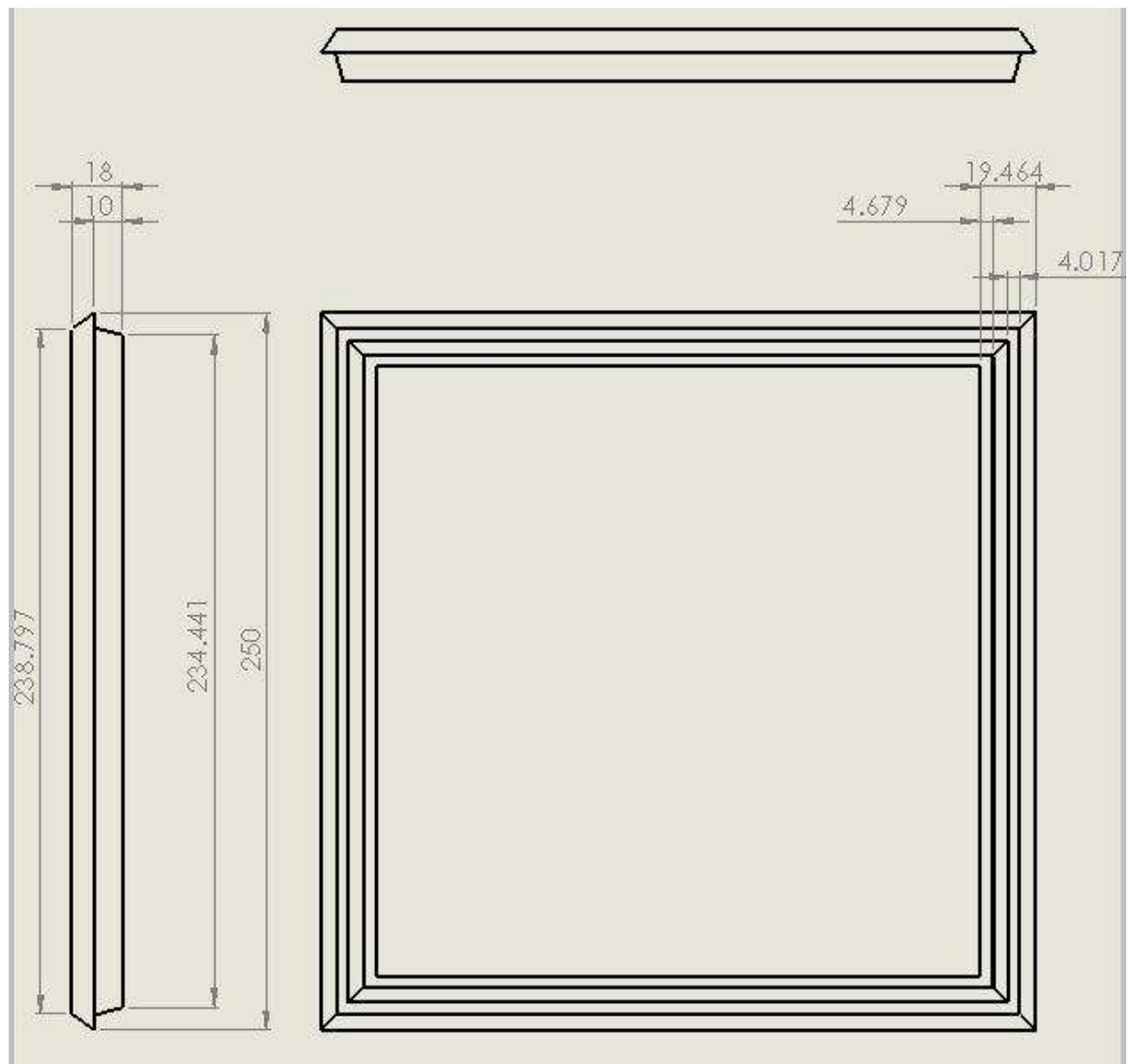
### 3.3.5 Design Dimension

From the Solid Work software, it generates the appropriate dimension for the hole cover. This dimension will be used in producing the real hole cover in the laboratory. The dimension can be seen as below (Figure 3.12 and Figure 3.13).



**Figure 3.12:** Dimension of Hole Cover





**Figure 3.13:** Dimension of Frame

### 3.4 Material Selection

There are four types of material selected, which are;

- i. Wood,
- ii. Sand,
- iii. Sodium silicate, and
- iv. Cast iron

### **3.5 Fabrication**

Fabrication process is difference from manufacturing process in term of production quantity. Fabrication process is a process to make only one product rather than manufacturing process that focus to large scale production. In the hole cover project, fabrication process was used at the whole process.

In making the design become a real product, several processes have been used to fabricate the hole cover, which is;

- I. Measuring: Measuring the material into dimension needed.
- II. Marking: Mark the material after measuring it.
- III. Carve: Carve the wood to make a mould
- IV. Joining: Joining the wood.
- V. Molding: Making mould by silicate process to make cavity for pouring molten cast iron.
- VI. Melting and pouring: melting the cast iron by furnace and pour into the mould cavity.
- VII. Clearing: clear the materials that are not part of the finished casting

## **CHAPTER 4**

### **RESULT AND DISCUSSION**

#### **4.1 Introduction**

This chapter will reveal and elaborate the result and discussion throughout the project encounter before, during and after. For this part, the result is found after finishing hole cover fabrication. The result is shown in figure and/or table of specification. Besides that, this chapter also make discussion based on the result. It discusses about the how the product work, function and problem while fabricated.

#### **4.2 Hole Cover**

The fabrication process for hole cover is as explained in the previous Chapter 3 and its dimension also has been shown in the chapter.

#### 4.2.1 Pattern of Product

Pattern is one of needs in casting process. It is because the cavity of mould is depend on the pattern. If the pattern is square, the , mould and final product will be square. This project pattern is in square shape and has two part. It is hole cover part and frame. Size of pattern can refer to Table 4.1.

**Table 4.1:** Pattern specification.

Aspect	Description
Total length	29cm
Total width	29cm
Total thickness	2cm
Type of material	Wood

#### 4.2.2 After Casting Product

In the laboratory, the process of pattern, molding and casting has been carried out. After several day, the product of hole cover and its frame has been completed. The product after casting are as shown in Figure 4.1-4.2 for the frame while Figure 4.3-4.4 for the hole cover. The figures demonstrate the product in two different angle which from the top view and the front view.



**Figure 4.1:** After casting the frame, top view.



**Figure 4.2:** After casting the frame, front view.



**Figure 4.3:** After casting the hole cover, top view.



**Figure 4.4:** After casting the hole cover, front view.

### 4.2.3 After Clearing Product

As can be seen in previous figures, there are sprue and riser used in casting the product. From Figure 4.5 until Figure 4.12, they display the product without these sprue and riser in various angles.



**Figure 4.5:** The hole cover without the sprue and riser, top view.



**Figure 4.6:** The hole cover without sprue and riser, front view.



**Figure 4.7:** The hole cover without sprue and riser, side view.



**Figure 4.8:** The frame without the sprue and riser, top view.



**Figure 4.9:** The frame without the sprue and riser, front view.



**Figure 4.10:** The frame without the sprue and riser, side view.



**Figure 4.11:** The frame without the sprue and riser, bottom view.





**Figure 4.12:** Both of the frame and hole cover without the sprue and riser.

Then, after the sprue and riser were taken out from the product, they were assemble together, refer Figure 4.13 and Figure 4.14.



**Figure 4.13:** The product has been assembled together, top view.



**Figure 4.14:** The product has been assembled together, front view.

#### 4.2.4 Product Specification

Table 4.1 tabulated the specification of the product which is its total length, width, thickness and type of material used.

**Table 4.2:** Product specification.

Aspect	Description
Total length	29cm
Total width	29cm
Total thickness	2cm
Type of material	Cast iron

#### 4.3 Discussion

In this part, a discussion about the product was done. It comprised of the defect in the product and the encountered problems throughout the project.

### 4.3.1 Defect of project

In this project, there are few defect occur. Drop defect is one of them. Drop defect is an irregular shape projection on the cope surface caused by dropping of sand, refer Figure 4.15 and Figure 4.16. Another defect is leakage. Leakage is caused by gap between cope and drag of mould, refer Figure 4.17. One more defect occurred is gap between hole cover and frame, refer Figure 4.18. It is caused by pattern.



**Figure 4.15:** Drop Defect.



**Figure 4.16:** Drop Defect. It has contour on flat surface.



**Figure 4.17:** Leakage from cavity mould.



**Figure 4.18:** Have gap between hole cover and frame.

#### **4.3.2 Problem during select material**

Material in casting lab is limited to cast iron and aluminum only. Select cast iron for this project because want to increase the strength of hole cover. However, cast iron is very weight and will rust in time.

#### **4.3.3 Problem during literature review**

The problem exist when get the title of the final year project and how to find an information about the hole cover in market product. The product not widely sells

in market. But hole cover for sewer can find easily. It also include the material choose and process fabrication for the project. It is very hard to decide the correct material and setup a machine to fabricate the product. So, students should come with their ideas on the project properly. The problem is like, limited resources to get the relevant material such as books and internet connection problem.

#### **4.3.4 Problem during design**

It's also very hard to make a good design to fabricate the hole cover because the reference is limited. The student had to sketch as many as can design to choose the good model. The ideas were from the student directly to avoid any plagiarize. Design also should have many advantages compare with reference product.

#### **4.3.5 Problem during fabrication**

During fabrication has also problem occur. First problem is did not have a few type of tool for fabrication in lab such as file. So the tool must be find by own at hardware. Second problem is lack of carving skill. Carving skill is importance for this project because pattern is shaped by carving.

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1 Introduction**

In this chapter, a summary is established to conclude the whole final year project and summing up the project objective archive or not. There will be also the recommendation to improve the project of the same kind in future. Therefore, the product can be improve their function, safety, and suitable fabrication.

#### **5.2 Conclusion**

For the conclusion, overall perception of the project carried out was good. This project gains my knowledge by searching information in the internet and from expert technician. The project also generates my capability to make a good research report in thesis form or technical writing. I also get all the objective of this project are accomplished, which are to design and fabricate hole cover by using casting process.

### **5.3 Recommendation**

Several recommendations would like to express:

- 1.** Add a port to connect earth wire avoid current shock.
- 2.** Add a handle to open the hole cover easily.
- 3.** Make to suitable plastic case at wire out.
- 4.** Colour it nicely.

## REFERENCES

### BOOKS

1. Muhammad Hanis Bin Muhammad Zulkifli(2008). Design a of Recycle Bin Tin Crusher. University Malaysia Pahang. Diploma project report.
2. Ulrich K. T. and Eppinger S. D,(2004). Product Design and Development. USA: McGraw-Hill.

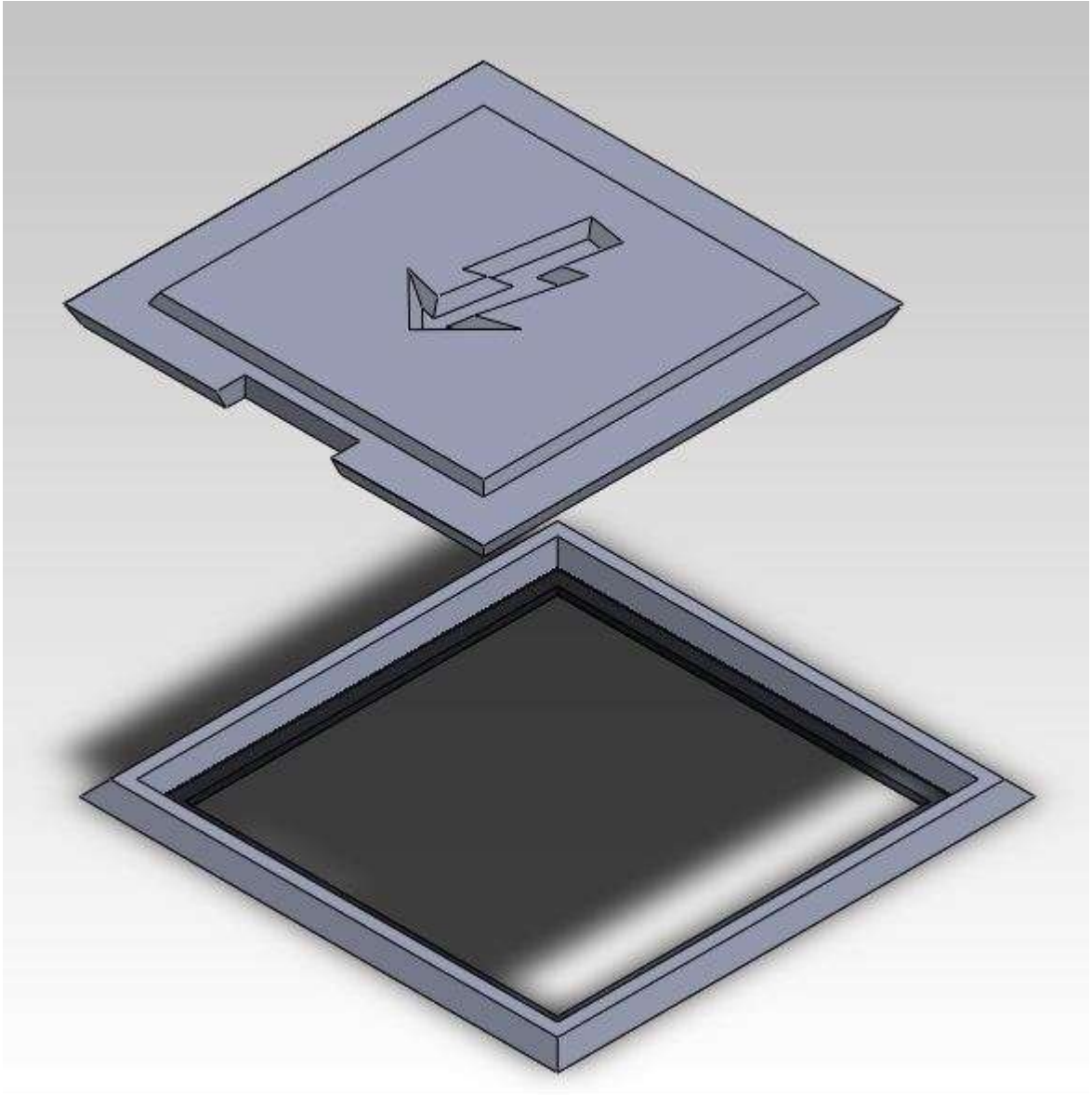
### WEBSITE

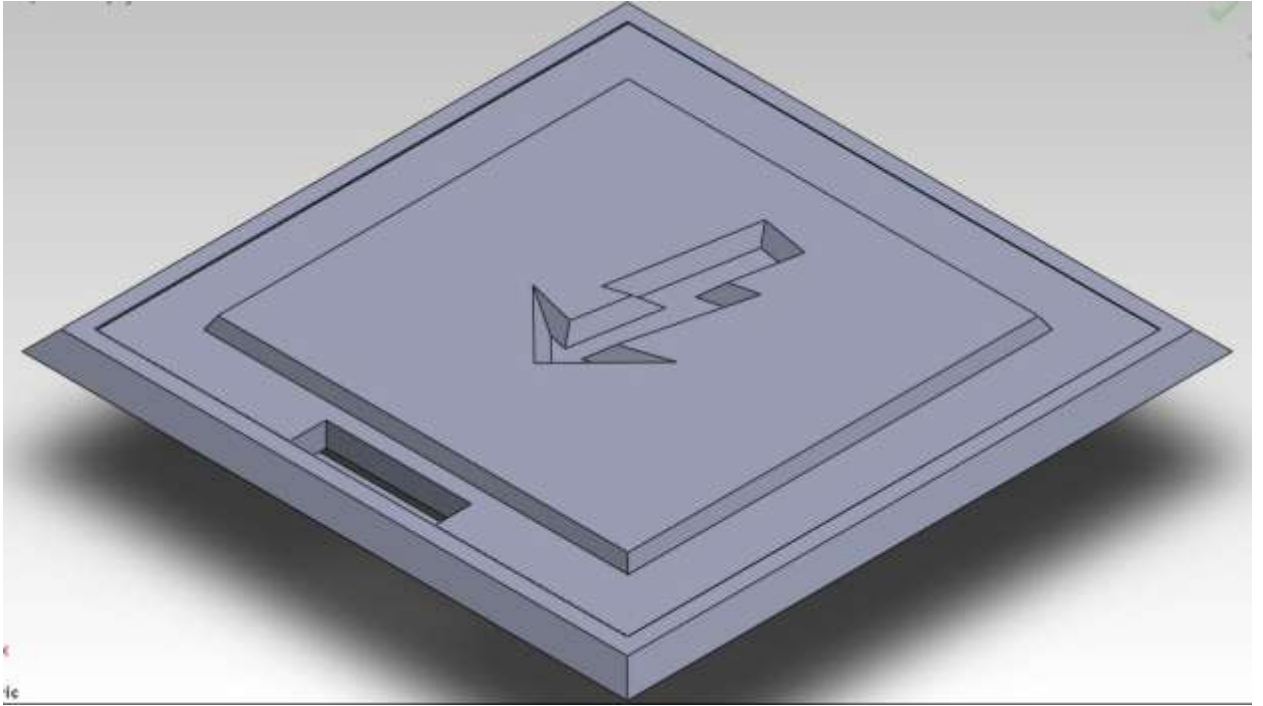
1. <http://www.sewerhistory.org/articles/compon/mhcovhist.htm> dated on 4th January 2012.
2. [http://www.alibaba.com/product-gs/338649579/Ductile\\_iron\\_manhole\\_cover.html](http://www.alibaba.com/product-gs/338649579/Ductile_iron_manhole_cover.html) dated on 4th January 2012.
3. [http://www.alibaba.com/product-gs/222467273/Square\\_Manhole\\_Cover.html](http://www.alibaba.com/product-gs/222467273/Square_Manhole_Cover.html) dated on 4th January 2012.
4. [http://btzxzy.en.alibaba.com/product/461157342-209635552/MANHOLE\\_COVER\\_COVER\\_WITH\\_FRAME\\_grating\\_grids\\_ductile\\_iron\\_manhole\\_cover\\_iron\\_cover\\_well\\_SGS\\_EN124\\_.html](http://btzxzy.en.alibaba.com/product/461157342-209635552/MANHOLE_COVER_COVER_WITH_FRAME_grating_grids_ductile_iron_manhole_cover_iron_cover_well_SGS_EN124_.html) dated on 4th January 2012.
5. [http://www.efunda.com/prodresses/metal\\_processing/sand\\_casting\\_info.cfm](http://www.efunda.com/prodresses/metal_processing/sand_casting_info.cfm) dated on 4th January 2012.
6. <http://www.sciencedirect.com/science/article/pii/S0959652608001807#sec1.2> dated on 4th January 2012.
7. <http://www.enotes.com/manhole-cover-reference/manhole-cover> dated on 4th January 2012.



## APPENDIX A

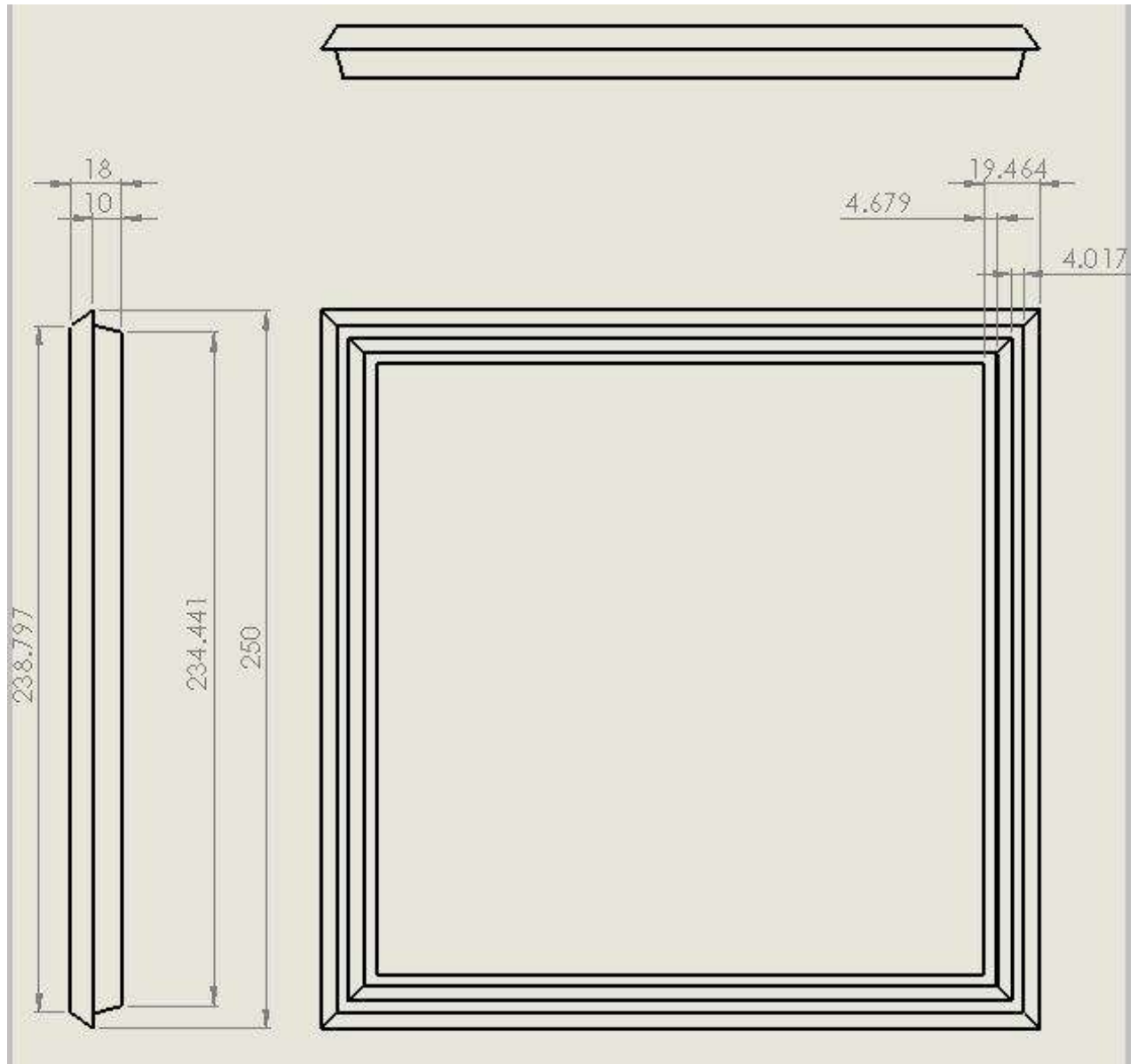
### 3D Drawing Hole Cover

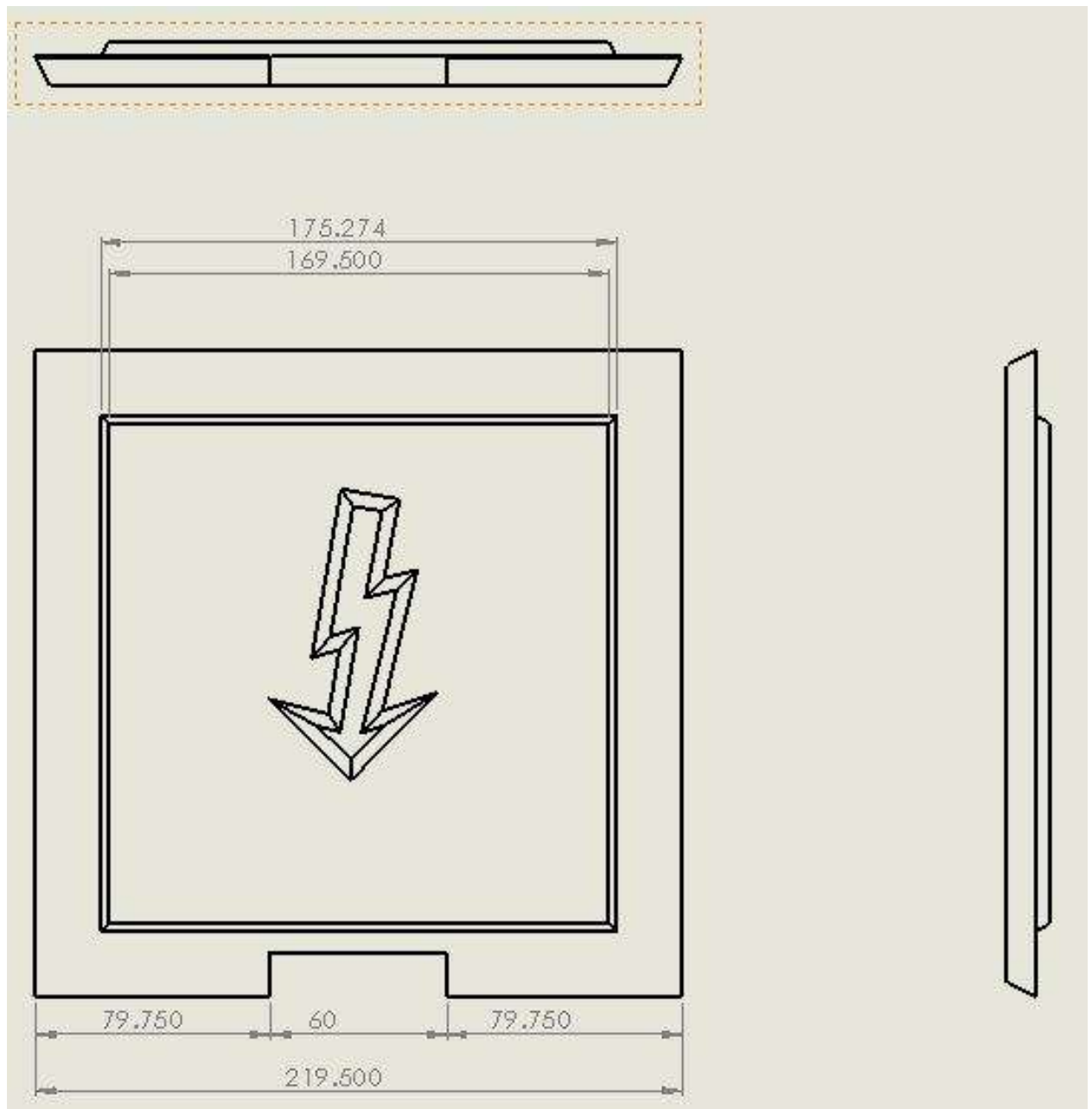




## APPENDIX B

## 2D Drawing Hole Cover





## APPENDIX C

### Pattern



Top view of hole cover pattern



Bottom view of hole cover pattern



Front view of hole cover pattern



Angle view of hole cover pattern



Top view of frame pattern



Bottom view of frame pattern



Front view of frame pattern



Angle view of frame pattern

## APPENDIX D

### Machine



Jointer machine



Mixing machine



Vertical band saw



Sander machine



Furnace



## APPENDIX E

### Tools, equipment and material



Saw



PPE



Heck saw



Carbon Dioxide



Mold



Sand



Sodium Silicate



Wood