

# DESIGN AND FABRICATED PUMP TROLLEY

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UNIVERSITI MALAYSIA PAHANG

JUNE 2013

UNIVERSITI MALAYSIA PAHANG

**BORANG PENGESAHAN STATUS TESIS**

**JUDUL: DESIGN AND FABRICATED PUMP TROLLEY**

**SESI PENGAJIAN: 2012/2013**

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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 the Diploma in Mechanical Engineering.

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Position : LECTURER

Date : JUNE 2013

### **AUTHOR DECLARATION**

I declare that this report entitled “Design and Fabrication of Pump Trolley” is the result of my own research except as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidature for any other degree.

Signature : .....

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Dedicated to my parents

## ACKNOWLEDGEMENTS

Alhamdulillah, first of all, the deepest sense of gratitude to the God, who guided and gave me the strength and ability to complete this final year project. Infinite thanks I brace upon Him.

In preparing this thesis, I was receiving help from many people to get detail information about diploma project. They have contributed a lot into my understanding, thoughts, and ideas in preparing and completing my thesis. I would like to take this opportunity to forward my appreciation in those who are helping me in my thesis preparation.

First of all I am very grateful to my supervisor Miss Miminorazeansuhaila binti Loman for his patience, trust and supporting for guide me finished this project. I also sincerely thanks for the time spent proofreading and correcting my mistakes. Also not to forget the lectures especially at the Faculty of Mechanical Engineering who have been teaching me and give me advice on this thesis. Without them, this project would not have been the same as presented here.

Then, my deepest appreciation to mechanical laboratory instructors for their cooperation while I am conducting this project at the laboratory. I would also like to express my deepest to my beloved family and all my friends that always is there for me when I needed and always support me and motivate me to complete this final year project.

Last but not least, to all individual who has involved neither directly nor directly in succession of this thesis. Indeed I could never adequately express my indebtedness to all of them. Hope all of them stay continue support me and give confidence in my effort in future. Thank you.

## ABSTRACT

In this modern era, so the pump is used in our daily activities whether at home or in industries. However, the difficulty to bring the pump from one place to another place is difficult because of the heavy pumps. This problem has led to produce a special trolley pump special for the pump. There are several steps that must be taken to design and produce a pump trolley.

To get something good, the design of a product is important. Several designs have been developed based on the desired characteristics. The concept has been used for the selection of appropriate design to problems encountered. Drawing three-dimensional structure has been developed to facilitate the process of measuring and producing products. This three-dimensional drawings were produced with software engineering drawings "Solidworks".

Fabrication process has undergone steps such as measuring, marking, cutting, welding, drilling and finally paint product. In conclusion, the objective of the trolley pump design that fulfill the criteria were reached. Results are also able to reduce costs, improve customer trust and confidence in this product.

## ABSTRAK

Dalam era moden ini, pam sangat digunakan dalam aktiviti harian kita tidak kira di rumah mahupun di industry-industri. Walaubagaimanapun, kesusahan untuk membawa pam dari satu tempat ke satu tempat lain adalah susah kerana berat pam tersebut.. Masalah ini telah mendorong untuk menghasilkan sebuah troli pam yang khas untuk pam. Terdapat beberapa langkah yang perlu diambil untuk mereka bentuk dan menghasilkan troli pam.

Untuk mendapatkan sesuatu yang bagus, reka bentuk sesuatu produk adalah mustahak. Beberapa reka bentuk telah dihasilkan berdasarkan cirri-ciri yang dikehendaki. Konsep pemilihan telah digunakan untuk mendapat reka bentuk yang sesuai dengan masalah dihadapi. Lukisan struktur tiga dimensi telah dihasilkan untuk memudahkan lagi proses mengukur dan menghasilkan produk. Lukisan tiga dimensi ini telah dihasilkan dengan perisian lukisan kejuruteraan “ Solidworks”.

Proses fabrikasi juga telah menjalani langkah-langkah seperti mengukur, menanda, memotong, kimpalan, mengerudi dan akhirnya mengecat produk tersebut. Kesimpulannya, objektif reka bentuk pam troli yang memenuhi criteria telah tercapai. Keputusan juga berupaya menurunkan kos, memperbaiki kepercayaan produk dan kenyakinan pelanggan.



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**LIST OF ABBREVIATION**

UMP	Universiti Malasysia Pahang
MIG	Metal Inert Gas

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 BACKGROUND OF THE PROJECT**

Pump is a device that moves fluids (liquid and gases ) or sometimes slurries, by mechanical action. Pumps be classified into 3 major group according to the method they use to move the fluid. Trolley is a wheeled device that works to help people to move something heavy from one place to another. Trolley is also very much used in industries to simplify and expedite the process industrial production.

Pump trolley is the trolley is designated pump to move the pump from one place to another. Pump trolley can help to prevent the user from the back injuries result from lifting and carrying the heavy loads of pump.



## **1.2 PROBLEM STATEMENT**

In the fluid lab of faculty of mechanical engineer in University Malaysia Pahang (UMP) the pump is use to make the lab session and for student or staff to carry out the experiment about fluid. In order to keep the pump after use, the pump had been placed in store. The problem arose when the staff want to move the pump from store to lab and from lab to store, this problem arose because the pump has the heavy load and make the difficult to move the pump.

To overcome the problem, the trolley that special to pump must to fabricate to make easier the staff to move the pump. There have a lot of type of pump trolley in the market. But, there is currently less pump trolley has the stability when the pump is working.

## **1.3 OBJECTIVES**

The main objectives of this project is to design and fabricate the pump trolley that portable and easy to storage, easy to operate, it is extensive for warehouse and workshop and have stability when the pump is working.

## **1.4 SCOPES**

In order to achieve the objective, several scopes had been set up. The first scope is doing a literature review. The purposed of literature reviewis to see the good element in a product at the market. The next scope is to set the design criteria to overcome the problem arose. The third scopes is design concept. Design concept is idea behind the design. It is generated based on

design criteria >the purpose the design concept design is to create a few design before evaluate it to be the final design. The fourth scope is final design and the last cope is fabricated the product from the final design.

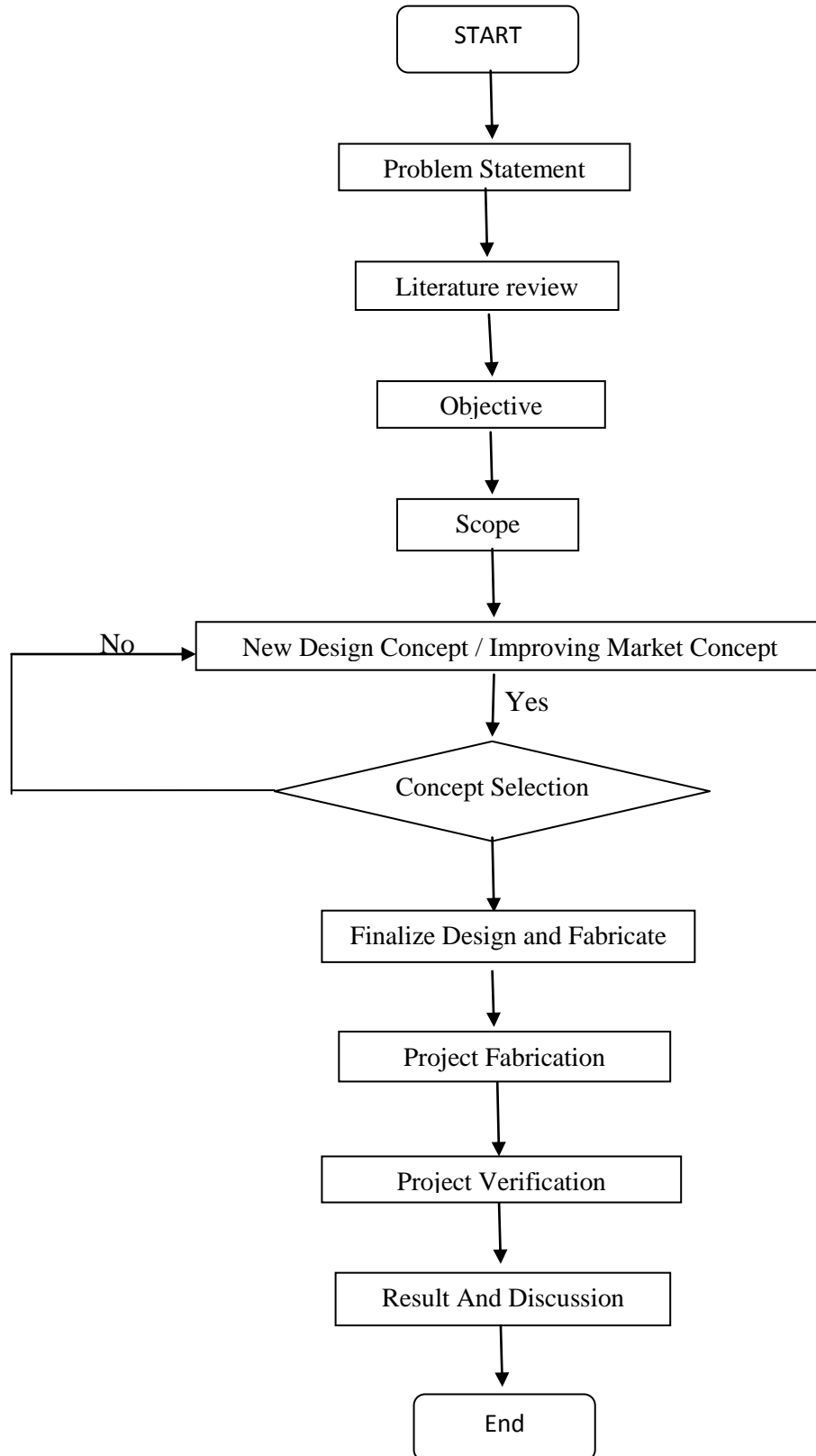
## **1.5 PROJECT PLANNING**

Figure 1.1 is the flow chart of the whole Final Year Project. To start this project, an appointment with the supervisor is done to understand about the project title given and manage the schedule of weekly meeting.

Problem are then indentified and objective and the scopes of the project is then fixed. Designing phase start of by sketching few design and model on the A4 papers. Then, analyze the design and choose an appropriate design to finalize. After that , the design propose to the supervisor. Next, convert the design to the three dimensional drawing using SolidWorks software.

Following up, the study for the material needed. The modification is done on the design so as the model will operate better. Once receive the materials, start the fabrication of the pump trolley.

Fabrication start with the selection of material, cutting process, shearing process, bending process, welding process, drilling process grinding machine, and lastly, painting the pump trolley.



**Figure 1.1** : Project Flow Chart

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter investigate the different types of pump trolley design that currently available at the market. From the observation and research we can know about the advantage and disadvantage of that product and can know the type of material that use. We can also solve the disadvantage from the pump trolley that currently at the market.

#### **2.2 TYPES OF PUMP TROLLEY**

##### **2.2.1 Firefighting Pump Trolley**



**Figure 2.1** : Firefighting Pump Trolley

The firefighting pump trolley is easy to use, strong and easy to operate. This trolley has 2 wheels. The advantages of this trolley are light in weight, durable, and easy to operate. It is extensively suitable for warehouses and workshops. The disadvantage of this trolley is that it can load easily when the pump is operating.

The material used to manufacture this product consists of black pneumatic wheels, hollow bars, and stainless steel sheet metal. Black pneumatic tires on welded-steel rims. Maximum speed is 4 kph. The pattern of the tire is a ribbed pattern. This pattern makes fewer rolling resistances, fewer noise generations, superior water drainage performance, and also less skidding. This wheel is suitable for cemented roads.

From this product, hollow bars are used to make the main body. Heavy loads can be supported because this part is made from hard material. Moreover, this material has a property of being light in weight so it can reduce the weight of the trolley. Stainless steel sheet metal is used for the base where the pump is placed. It offers good corrosion resistance while maintaining formability and weldability.

### 2.2.2 Gasolinne Water Pump Trolley



**Figure 2.2 :** Gasoline Water Pump Trolley

The gasoline water pump trolley is easy to use, strong and easy to operate. This trolley has 2 wheels. The height of this trolley is 860 mm, the length is 880 mm and the width is 680 mm. The advantages of this trolley are that it is stable during pump operation, durable, and easy to operate. It is suitable for use in warehouses and workshops. The disadvantage of this trolley is that it is difficult to use because of the front tire.

The material used to manufacture this product consists of hollow bars, pneumatic wheels, and stainless sheet metal. For this product, hollow bars are used to make the main body. Heavy loads can be supported because this part is made from hard material. Moreover, this material has the property of being lightweight so it can reduce the weight of the trolley.

Pneumatic wheels are suitable for use because they are shock absorbing. It also has 3-piece detachable hubs. The tires are tube-type tires, which can be changed when the tube is leaking or faulty. The tires also have a diamond pattern. This pattern is suitable for use on normal cemented roads and uncemented ones.

for work sites such as building site Maximum speed this wheel is 4 kph . The Stainless steel sheet metal use for the base of the place the pump. It offers good corrosion resistance while maintaining formability and weld ability.

### 2.2.3 Magnetic Drive Pump Trolley



**Figure 2.3 :** Magnetic Drive Pump Trolley

The magnetic drive pump trolley easy to use, strong and easy to operation. This trolley has 2 wheel. The advantage of this trolley are light in weight ,stable when the pump operation, and durable. It extensive suitable for warehouse and workshop. The disadvantage of this trolley is the user difficult to use because the tire at front.

The material used to manufacture this product consists of stainless steel hollow bar, stainless steel hollow square, pneumatic wheel, stainless steel sheet metal and the rubber From this product, it used hollow bar to make the stand. This material it can be support the weight of the pump when this trolley it use. The stand preferred to be tough and strong. This material also guarantee high resistance to any kind of corrosion, high strength and high processing factor.

The hollow bar use at the base as the place to put the pump. This base must be made from hard material to accommodate the weight of pump. In metallurgy, stainless steel is defined as a steel alloy with a minimum of 10% chromium content by mass. Stainless steel does not stain, corrode, or rust as easily as ordinary steel but it is not stain-proof. It is also called corrosion-resistant steel or CRES when the alloy type and grade are not detailed, particularly in the aviation industry.

Red polypropylene rim centre fitted with block pattern tire. This pattern are excellent drive and braking force. The maximum speed for this wheel is 4 kph. Stainless steel sheet metal use for the base of the place the pump. It offers good corrosion resistance while maintaining formability and weld ability. Rubber is use to serve as the holder because of the gripping and can prevent the hand from slipping.

## 2.3 MATERIAL STUDY

### 2.3.1 Hollow bar



**Figure 2.4** : Steel hollow bar

Hollow bar, otherwise known as seamless mechanical tubing, is a tubular product made with characteristics and properties suitable for subsequent transformation into a great variety of hollow products and cylindrical components for general engineering purposes. The hardness of



steel hollow bar is regarded as the resistance of a material to indentations and scratching. This is generally determined by forcing an indenter on to the surface. The resultant deformation in steel is both elastic and plastic. From the characteristic of steel hollow bar, it is suitable for made the body of pump trolley.

### 2.3.2 Hollow Square



**Figure 2.5 :** Steel Hollow Square

Hollow square bar, otherwise known as seamless mechanical tubing, is a tubular product made with characteristics and properties suitable for subsequent transformation into a great variety of hollow square products for general engineering purposes. The hardness of steel hollow square bar is regarded as the resistance of a material to indentations and scratching. This is generally determined by forcing an indenter on to the surface. The resultant deformation in steel is both elastic and plastic. From the characteristic of steel hollow square , it is suitable for made the body of pump trolley.

### 2.3.3 Sheet Metal



**Figure 2.6** : Sheet metal

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking and can be cut and bent into a variety of different shapes. There are many different metals that can be made into sheet metal, such as aluminum, brass, copper, steel, tin, nickel and titanium. For decorative uses, important sheet metals include silver, gold, and platinum..The three most common stainless steel grades available in sheet metal are 304, 316, and 410. Grade 304 is the most common of the three grades. It offers good corrosion resistance while maintaining formability and weldability. Grade 316 possesses more corrosion resistance and strength at elevated temperatures than 304. It is commonly used for pumps, valves, chemical equipment, and marine applications. Avail. Grade 410 is a heat treatable stainless steel, but it has a lower corrosion resistance. It is commonly used in cutlery. The only available finish is dull.

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 INTRODUCTION**

This chapter cover process in methodology throughout this project designation and fabrication progress. A detail related literature review was done and important information were required and explained in previous chapter. Therefore, in this chapter, rough idea of required parts and components are listed measurement each component are also determined accordingly.

The content for this chapter are project flowchart, concept selection among 4 concept designated, from the best ranking of design concept the design was continue at Solidwork software. The fabrication including cutting, shearing, roll bending, welding and drilling.

#### **3.2 DRAWING**

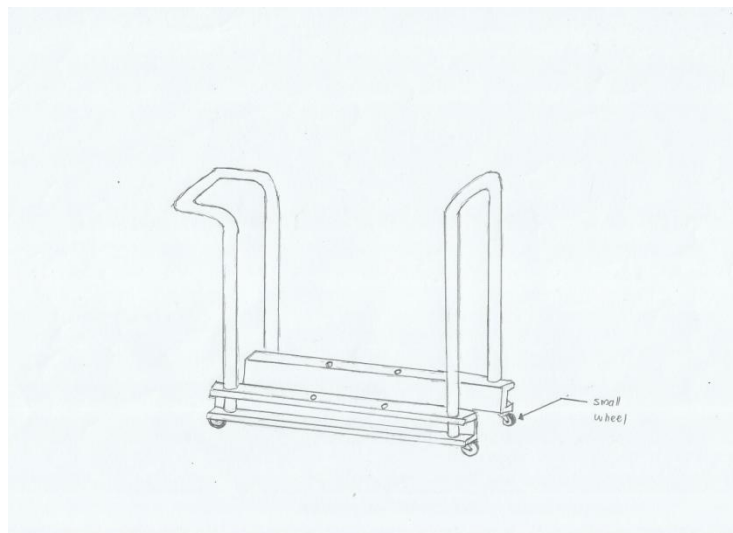
The drawing are dividing into two categories sketching and use SolidWords software. Sketching are all idea will be sketch on paper. This step will proceduce 4 sketching and choose it by scoring and screening process. Solidwork is use after choosing one concept, it will transfer into SolidWorks for 3D and it also for getting the correct dimension for this pump trolley.

The design of pump trolley must be compliance to several aspect. The aspect that must be considered in the pump trolley is stability of pump trolley, ease of design, durability of design and cost. Finally, the design of the pump trolley table should be to easy to fabricate and assemble.

### 3.3 SKETCHING AND DRAWING SELECTION

From the existing idea, 4 concepts had been come out to select as a final design. The drawing selection will evaluate according the advantage and disadvantage of concept.

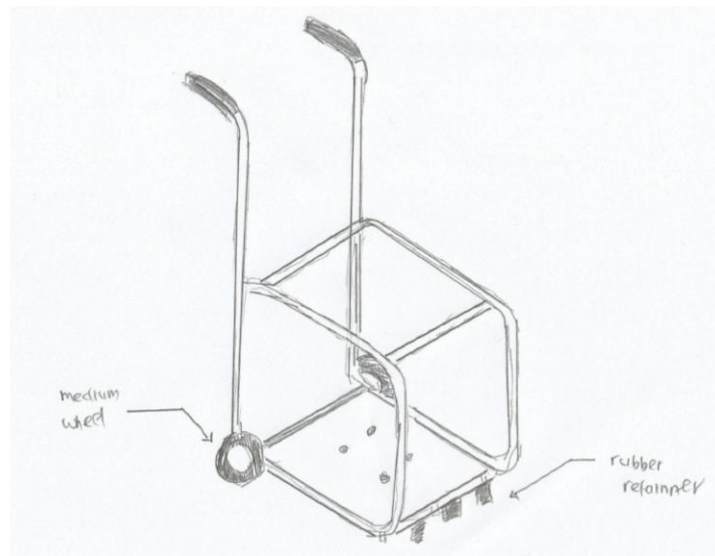
#### 3.3.1 Concept 1



**Figure 3.1** : Sketching concept 1

Figure 3.1 show the sketching of the concept 1. This design is based on the problem statement because it solved the problem arose. The material that has be used are 4 small wheel, hollow bar and hollow square. This concept use 4 small when for the stability when the pump working. It also easy to move because has 4 wheel.

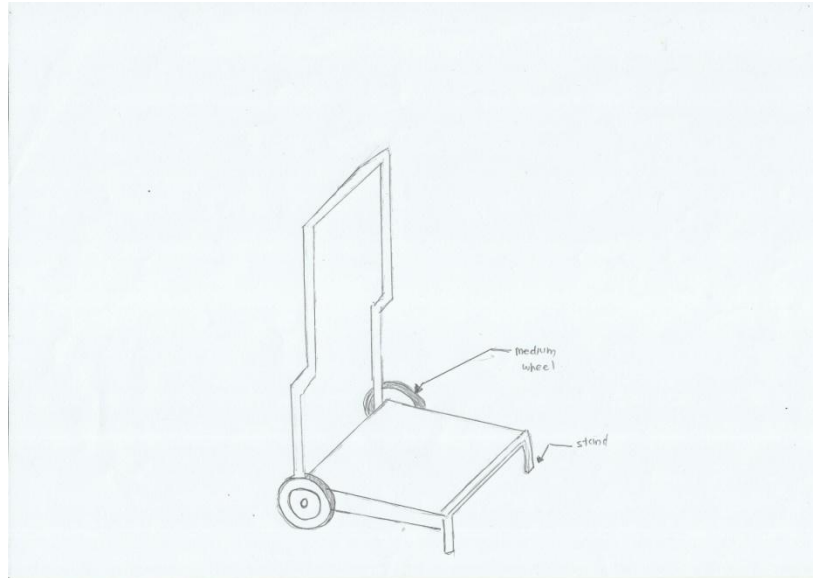
### 3.3.2 Concept 2



**Figure 3.2** : Sketch concept 2

Figure 3.2 show the sketching of the concept 2. This design is based on the problem statement because it solved the problem arose. This concept use the medium size of the wheel at back of pump trolley. The main material for the body it use hollow bar and hollow square. The sheet metal has use as the base of pump. This design also has the rubber retainer at the front of the pump trolley to make the pump trolley has stability when the pump is working.

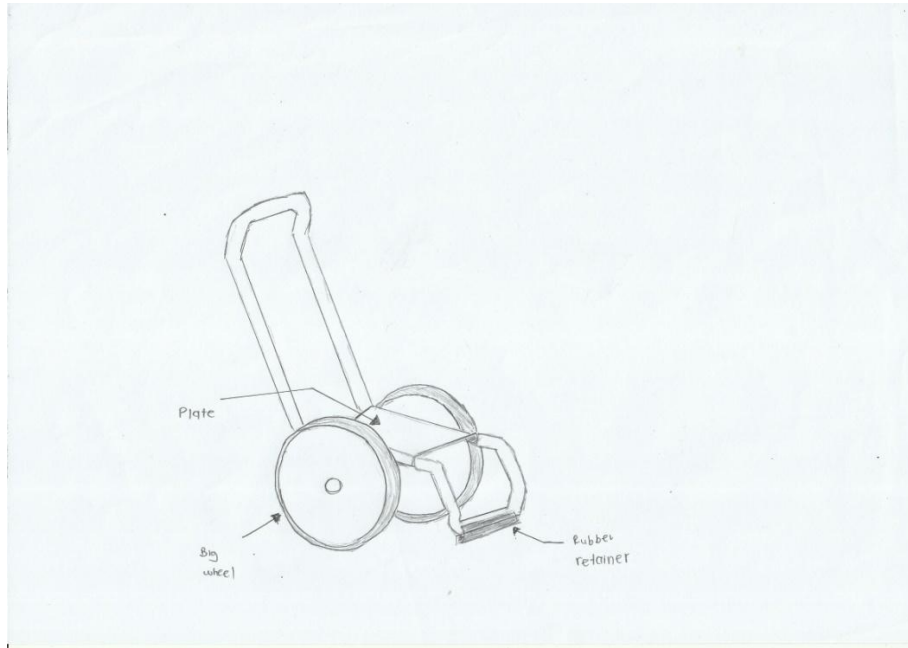
### 3.3.3 Concept 3



**Figure 3.3:** Sketching concept 3

Figure 3.3 show the sketching of the concept 3. This design is based on the problem statement because it solved the problem arose. The material has been use for this concepts are 2 medium size of wheel, hollow square and sheet metal. 2 medium size of wheel has been use at the rear the pump trolley. It also use the sheet metal as the base to put the pump. At the front of the trolley has the stand to make the pump trolley stabilize.

### 3.3.4 Concept 4



**Figure 3.4** : Sketching Concept 4

Figure 3.1 show the sketching of the concept 4. This design is based on the problem statement because it solved the problem arose. The main material of this design it use the hollow bar to make the body of pump trolley . This concept also use the 2 large size wheel at the rear trolley and at the front of the trolley has the rubber retainer for the stopper and to make the trolley stability when working. This design also use sheet metal as the place to put the pump.

## **3.4 CONCEPT SELECTION**

### **3.4.1 Concept Screening**

Concept screening is the narrow the number of concepts and determining the selection criteria to be compared. From this situation, 4 concept has been compared to choose the final design for pump trolley to solve problem that arose.



**Table 3.1 : Concept Screening**

	Concept			
Selection	1	2	3	4
Criteria				
Portable	+	+	+	+
Stability	+	+	0	-
Ease to storage	0	+	+	0
Ease to	+	0	+	0
Manufacture				
Safety	-	+	0	-
Sum +' s	3	4	3	1
Sum 0' s	1	1	2	2
Sum -' s	1	0	0	2
Net Score	2	4	3	-1
Rank	3	1	2	4
Continue	No	YES	NO	YES

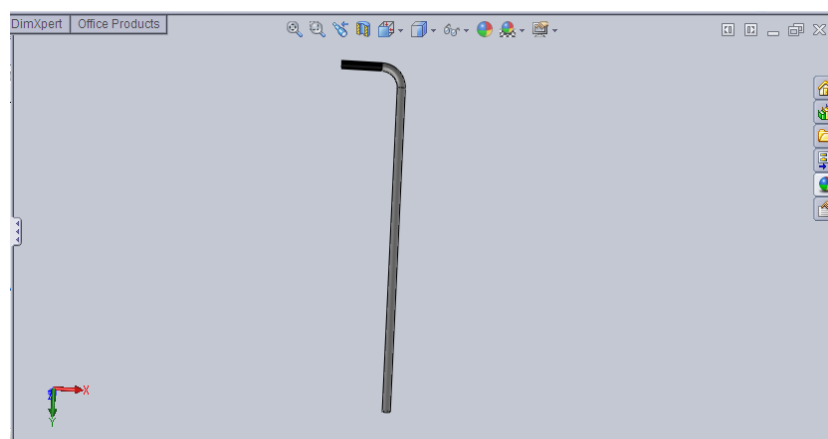
From table 3.1, the important criteria that has been take in order to fabricate pump trolley are portable, stability of trolley, ease to storage, ease to manufacture and safety. The rating of the criteria has been rate according the suitability. Besides, the score is given by see if the design has same criteria with the design criteria. Finally the total scored is calculated by summation the total “+” and “-“. It was shown that concept 2 was selected as the concept to fabricated. It net score is highest marks in design comparison and proves to be able to be fabricated in the time frame given. Compared to other design, it has an advantage in safety, ease to storage and has stability of pump trolley. Therefore, an improved product will be fabricated based on the criteria that have been chosen from each concept.

### 3.5 DESIGNATION METHOD

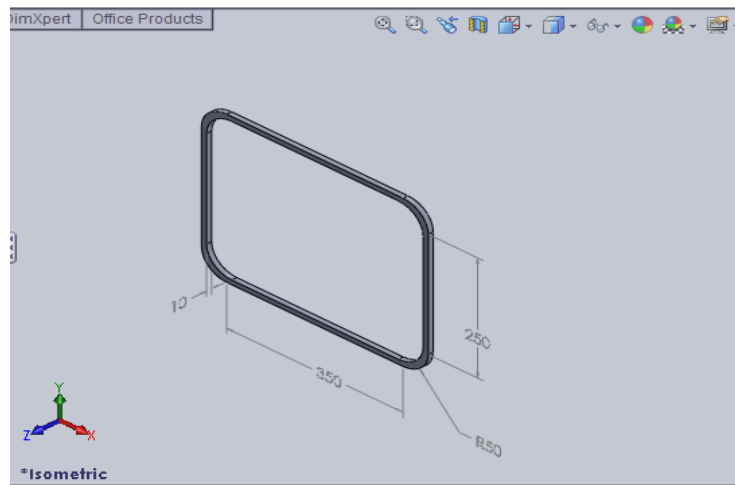
From the concept selection, concepts 2 was chosen and made into 3D use Solidworks 2011 software. This software has help in designing 3d drawing and dimensioning part of the pump trolley.

### 3.6 FINAL PRODUCT DESIGN

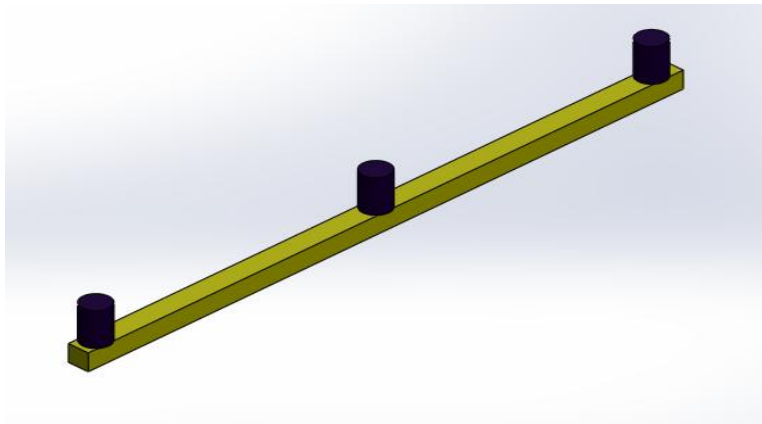
#### 3.6.1 Part by Part



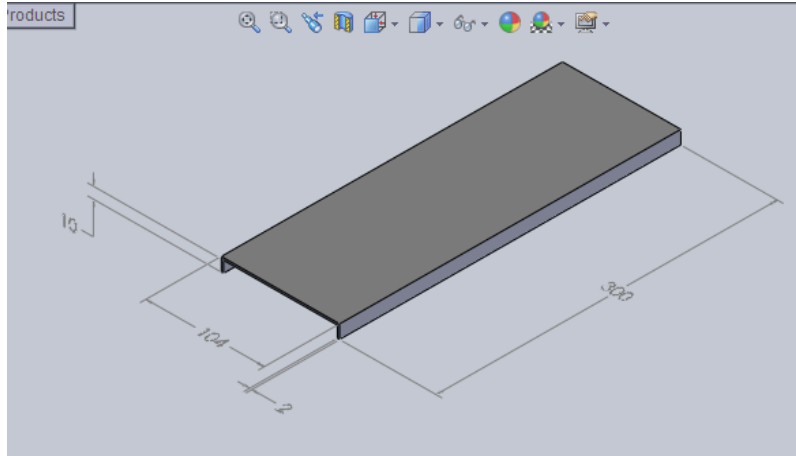
**Figure 3.5 : Part 1**



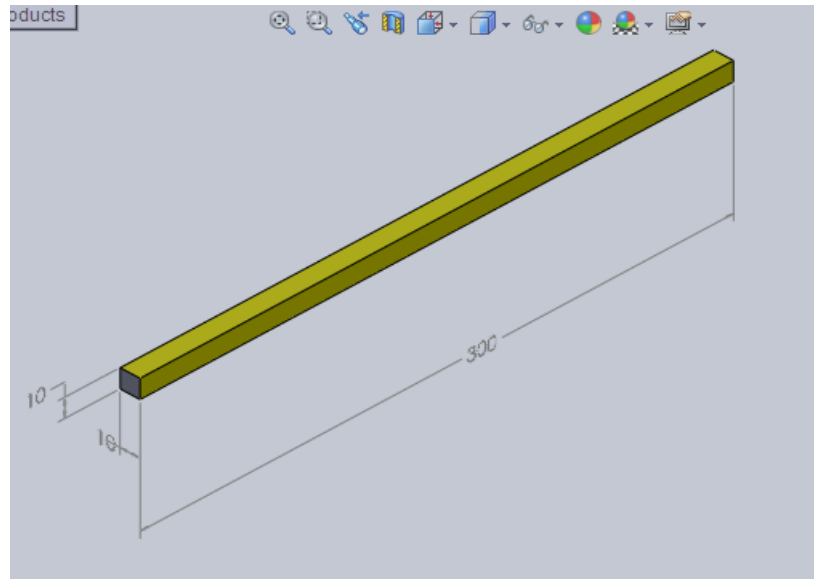
**Figure 3.6 : Part 2**



**Figure 3.7 : Part 3**

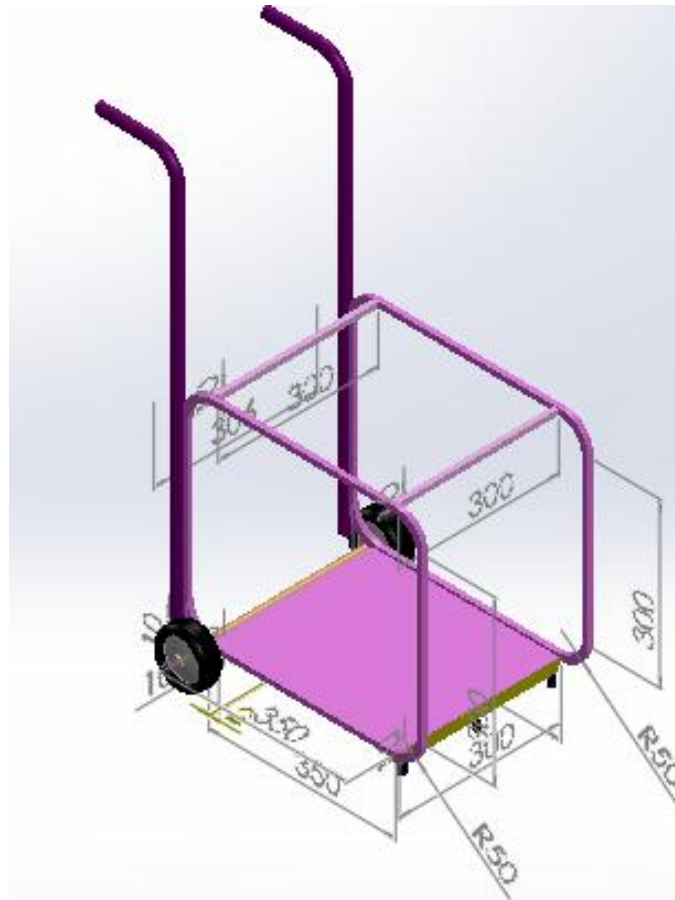


**Figure 3.8:** Part 4



**Figure 3.9 :** Part 5

### 3.6.2 Assembly



**Figure 3.10** : Project design after assemble

## **3.7 FABRICATION METHOD**

### **3.7.1 Selection of material**

In this project, the hollow bar and the hollow square has use to make the body of the trolley, sheet metal as the base of the pump, rubber retainer as the stand of the pump trolley, and the wheel to make the trolley is moveable.

**Table 3.2** : List of the material

<b>Part (mm)</b>	<b>Material</b>	<b>Dimension</b>
Body 12.2	Hollow Bar	1100 × R
25.4	Hollow square	300 × 25.4×
Base of Pump ×350×1	Mild steel sheet metal	300
Hander of Trolley R12.2	Hollow Bar	1000 ×
Wheel 20	Black rubber	R30 ×
Stand	Rubber stopper / retainer	R10 × 20
Throttle R2.54×70	Rubber	

From the table 3.1, the body of pump trolley made by hollow bar and hollow square. This material chosen is to make more strengthen to pump trolley. Moreover, this material would save a lot of cost as buying materials from outside shop wouldn't be necessary. The hander of trolley make by hollow bar material because the hollow bar easy to bend to get the design needed for pump trolley. The stand material is from rubber stopper, this material is as the stand to make the trolley stabilize when the pump is working, It also has grip at the smooth surface. The material of throttle also from the rubber, it has function to provide grip at the user hand.

### 3.7.2 Measuring and Marking

The measuring tape used to measure the material used for the project. It is important to measure first joining the material or to move to next process. This is to prevent material waste. The fabrication process start with measuring and marking the material into the dimension needed according to the design. The measuring and marking process is done by using steel ruler, measuring tape, L-shape ruler and steel marker.

### 3.7.3 Cutting Process

After the measuring and marking process the next process is cutting process. Cutting process is a process to separate a material into two portions through an application of an acutely directed force. To cut the steel hollow bar and steel hollow square the electrical grinding machine was used. The type of the cutting disc to cut steel hollow bar n hollow square are Metal High Speed Cut Off and the size is 12” .This type of disc is special for cut the steel hollow bar and hollow square.



**Figure 3.11** : Electrical Grinding Machine



### 3.7.4 Shearing Process

Shearing is a metal fabricating process used to cut metal material. Shear machine is used because it can cut the sheet metal precisely and nicely. The shear machine was used to cut sheet metal has the thickness 2mm to get the part of base to put pump on trolley..



**Figure 3.12 :** Shear Machine

### 3.7.5 Bending Process

Bending is a metal working process that leads to metal forming process on metal. The bended metal will experienced plastic deformation which cannot be roll back. The profile bending machine was used to bend the steel hollow bar to make the body of product and the holder of the pump trolley. It make manual to get the angle 90° for the part holder and body of the pump trolley.



**Figure 3.13** Profile Bending Machine

### 3.7.6 Welding Process

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the workpieces and adding a filler material to form a pool of molten material that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. The MIG welding machine was used to joint the hollow bar and the hollow square to make the main body of the pump trolley. The voltage used for the joint is 70-80 v. Above than this range can cause the material melt and the steel will have hole. This can decrease the durability of the main part. Safety tools and wear for welding in shown in appendix C.



**Figure 3.14** : MIG Welding Machine

### 3.7.7 Drilling Process

Drilling is a process of making holes on the workpiece. Drilling process can be done using hand drill and drill press depending on suitability. Drill points come in different sizes that allow us to drill the workpiece using different drill points for different sizes. Drill press is used to make hole on the sheet metal and hand drill was used to make hole at the hollow square. The hole that make is used for tie nut and bolt at the base of the pump and pump/ The size of the hole is 8mm.



**Figure 3.15 :** Hand Drill



**Figure 3.16 :** Press Drill Machine

### 3.7.8 Grinding Process

Grinding is an abrasive machining process that uses grinding wheels as the cutting tool. The hand grinder was used to help to achieve workpiece function by removing some excess material. The disc that was used for this process is the 5" Aluminum Oxide Fiber Disc.



**Figure 3.12** : Hand Grinder Machine

### 3.7.9 FINISHING

Finishing process is the final process of fabrication. During finishing process, the fabricated product is sprayed to make the product more attractive. The spray paint used is Anchor Spray Paint. The colour type is 63 undercoat silver. The spray is done twice. The first spray round is to coat the product with silver colour, and the second spray round is to finish up the product with silver colour overall.

## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

#### **4.1 INTRODUCTION**

This chapter will covers about the result of this project. The result of project includes final Solidwork design, final product, and discussion about pump trolley. Discussion will focused on the problem occurred during this project is held.

## 4.2 FINAL PRODUCT



**Figure 4.1** : Front view of fabricated product

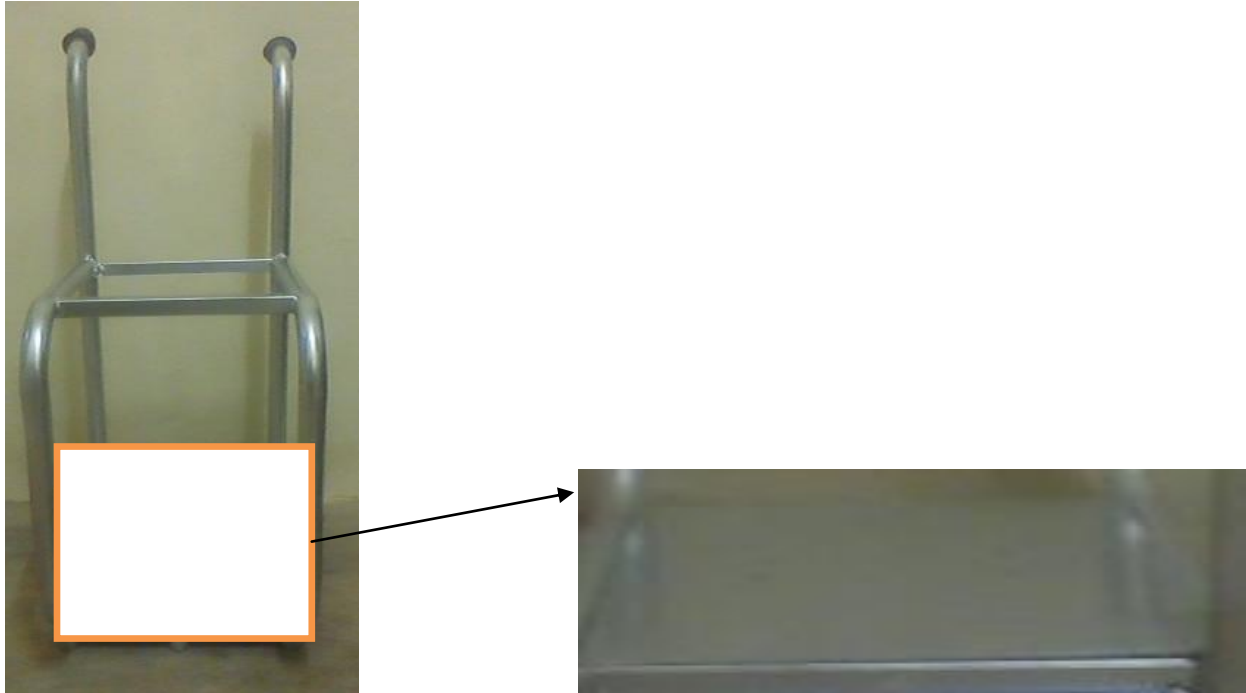


**Figure 4.2** : Side view of fabricated product



## 4.3 DISCUSSION

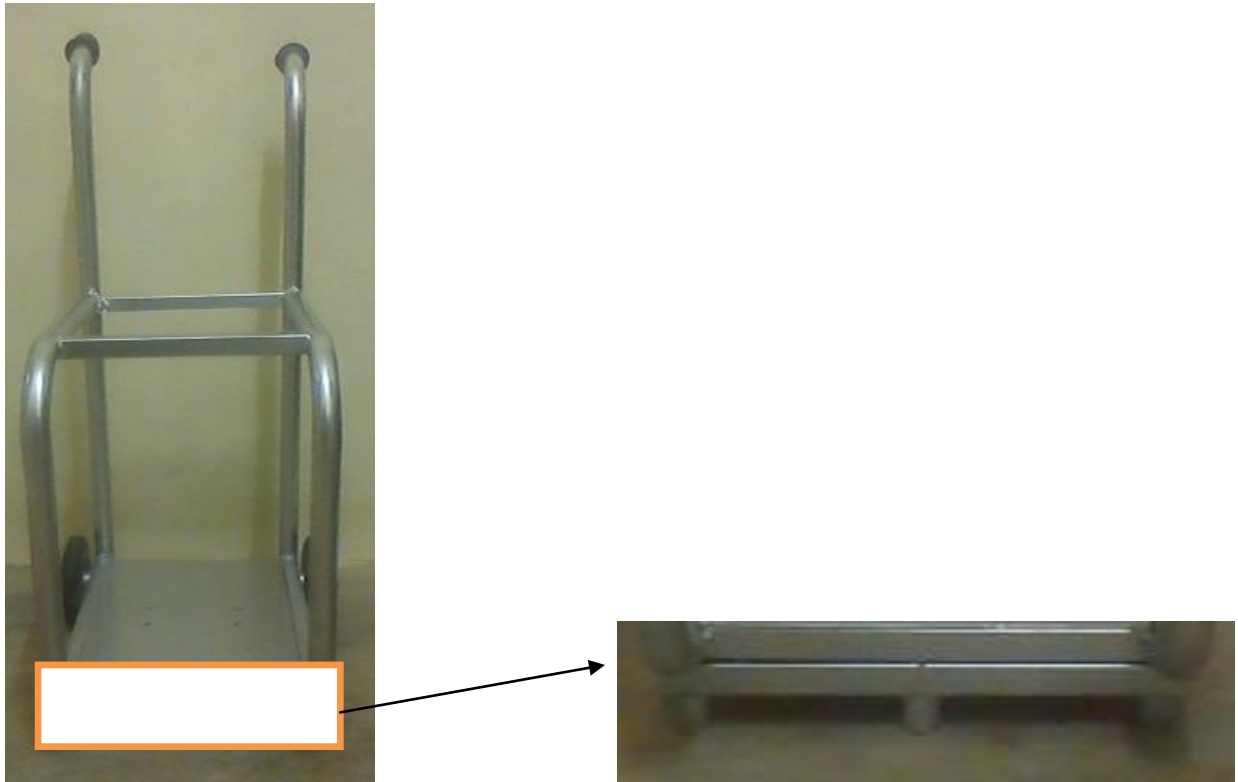
### 4.3.1 Sheet Metal



**Figure 4.3** : Sheet metal from fabricated product

Sheet metal that has dimension  $300 \text{ mm} \times 350 \text{ mm} \times 1 \text{ mm}$  was fabricated for the function as the base of the pump. The sheet metal weld to the body of the pump trolley. The pump was fastened together with the nuts to make the pump is not move when the pump is working.

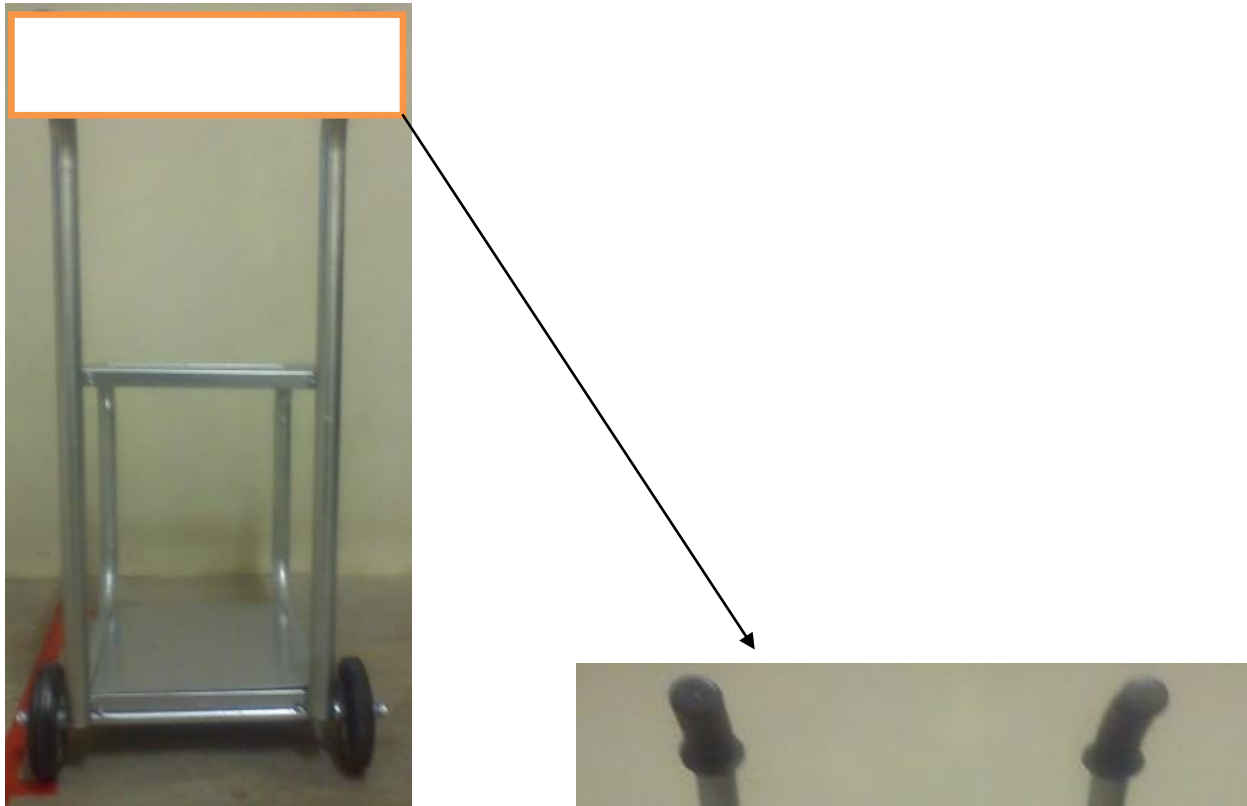
### 4.3.2 Rubber Stopper



**Figure 4.4 :** Rubber stopper from fabricated product

The rubber stopper from the material black rubber was located at the front the pump to make the pump trolley stabilize when the pump is working, The rubber stopper was fastened with the screw to make the body of the trolley and rubber stopper is tied together.

### 4.3.3 Rubber Throttle



**Figure 4.5 :** Rubber throttle from fabricated product

The rubber throttle that has the dimension  $R\ 2.54\text{mm} \times 70\ \text{mm}$  was located at the handle pump trolley. The function of the rubber throttle to provide the grip at the hands when the users use the pump trolley. The rubber throttle was tied with the handle with use the rubber gum.

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1 CONCLUSION**

In conclusion, this project that has achieved the objectives of this design and fabricated the pump trolley that is portable and easy to store, easy to operate, it is extensive for warehouse and workshop and has stability when the pump is working. The best design was chosen and fabricated within the time limit given. The designing process required skills that have been learned in the subject Engineering Drawing and Solidworks. The fabrication process also required many skills that have been learned in previous mechanical laboratory such as material measuring, marking, cutting, bending, welding and grinding. This project provides the experience to develop the skills and the way to operate the machine or software to complete this project. Besides that, the problem-solving skill was also learned during the designing and fabrication process for completing this project. This project acts as a motivator in facing the challenges as a professional engineer in this globalized era.

#### **5.2 RECOMMENDATION**

First of all, for the recommendation for this project is to add four wheels at the pump trolley so that the wheels can be adjustable to move or to be static. The function of the 4 wheels can make it easier to move the pump and when the wheels can be adjustable to lock when the trolley does not move it can make it more stable to pump trolley.

Beside that, the design of the pump trolley should change to get more interesting and more function. This product also will add the hydraulic system to up and the lower the body of trolley to easier take the pump from the land to the trolley.

So, after this product have all the item will added like in recommendation the market demand of this product will increase.

### **5.3 PROBLEM ENCOUNTERED**

During designing and fabrication process for this project many obstacles were faced. Firstly was lack of the knowledge about pump trolley. The lack of exposure in this field caused problem as the information of pump trolley was hard to attain either from internet or the library. The next problem that faced was lack knowledge about profile bending machine but after the helping of the staff in Mechanical Laboratory, this problem was resolved

## REFERENCES

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## APPENDIX A

## Gantt Chart

WEEK TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DATA COLLECTION	Blue	Blue												
	Purple	Purple												
INTERPRETING DATA		Blue												
		Purple												
PROJECT SKETCHING			Blue											
			Purple	Purple										
PROJECT DRAWING			Blue	Blue	Blue	Blue								
			Purple	Purple	Purple									
MATERIAL SELECTION							Blue	Blue						
							Purple	Purple						
PROJECT FABRICATION								Blue	Blue	Blue	Blue	Blue	Blue	
								Purple	Purple	Purple	Purple	Purple	Purple	
PART ASSEMBLY													Blue	
													Purple	
DESIGN TESTING													Blue	
													Purple	
FINISHING													Blue	
													Purple	
SLIDE PREPARATION						Blue	Blue						Blue	
						Purple	Purple						Purple	
REPORT												Blue	Blue	Blue
												Purple	Purple	

**APPENDIX B**

**Figure of Safety Tools / Wears**



Gloves



Welding Shield



## APPENDIX C

## DRAWING

D1 shows 2D drawing for final design.

