UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: DESIGN AND FABRICATE MULTIPURPOSE PORTABLE DESK

SESI PENGAJIAN: 2008/2009

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DESIGN AND FABRICATE MULTIPURPOSE PORTABLE DESK

MUHAMMAD ZULFADLI BIN CHE ZAKARIA

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

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

NOVEMBER 2008

SUPERVISOR DECLARATION

I hereby declare that I have read this project report and in my opinion this project report is sufficient in term of scope and quality for the award of the Diploma of Mechanical Engineering.

Signature : ……..

Name of Supervisor : EN JAMILUDDIN BIN JAAFAR

Position :

Date :

STUDENT DECLERATION

I declare that this project entitled "Design And Fabricate Multipurpose Portable Desk" is the result of my own idea except as state in the reference. The project has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

Signature : ……..

Student Name : MUHAMMAD ZULFADLI BIN CHE ZAKARIA

Date : ……..

DEDICATION

Firstly thanks to my beloved parent Che Zakaria Bin Mohamad and Tuan Ruzema Binti Tuan Yusoff and also my family without whom lifetime effect, my persuit of higher, education would not have been possible and I would not have chance to study in a mechanical course.

Also I wish to express my sincere appreciation to my supervisor, En Jamiluddin Bin Jaafar and mechanical staff because of the guidance without whose wise suggestions, helpful guidance and direct assistance, if could have neither got off the guard nor even been completed.

A special thanks to all my friends and other who help me finish this project on time. Their views and tips are useful to me. Finally to individuals who has involved neither directly nor indirectly in succession of this thesis. Indeed I could never adequately express my indebtedness to all of them. Thank you.

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor En Jamiluddin Bin Jaafar for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this project possible. He has always impressed me with his outstanding professional conduct, his strong conviction for engineering, and his belief that a Diploma program is only a start of a life-long learning experience. I am truly grateful for his progressive vision about my training in engineering, his tolerance of my naive mistakes, and his commitment to my future career.

My sincere thanks go to all my lab mates and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals.

ABSTRACT

The study of manufacturing was very important in order to carry out this project to ensure that the student understand on what are needed to do. This project is about designing and fabricate “Multipurpose Portable Desk” to help people easy to bring anywhere. This project involves the process of designing the table by using considering some of factor such as shape and ergonomic for people to use. After the design is complete, it was transformed to real product where the design is used as a guideline. This project also required to ensure the safety for indeed of publishing. Methods and process involve in this project for instance joining using welding, rivet, shearing, bending and drilling. This project is mainly about generating a new concept of multipurpose and portable desk that would make easy to bring anywhere and more function. After all process had been done, this desk may help us to understand the fabrication and designing process that involved in this project.

ABSTRAK

Pembelajaran mengenai pembuatan adalah penting untuk menjalankan projek ini bagi memastikan pelajar memahami tentang perkara yang perlu dilakukan. Projek ini adalah mengenai merekabentuk dan membuat meja serbeguna bagi memberi kemudahan kepada pengguna untuk membawa kemana-mana sahaja. Projek ini melibatkan proses reka meja tersebut berdasarkan bentuk dan ergonomik bagi memudahkan pengguna untuk menggunakannya. Selepas proses ini siap, meja tersebut dihasilkan berdasarkan reka bentuk yang telah dibuat. Projek ini juga melibatkan cirri-ciri keselamatan bagi pengguna untuk tujuan pemasaran. Kaedah dan proses yang terlibat dalam projek ini bagi penyambungan segera menggunakan proses mengimpal, rivet, memotong besi, pembengkokak dan menebuk lubang. Projek ini sebenarnya melibatkan proses menjana konsep baru dalam menghasilkan meja mudah alih dan mempunyai banyak fungsi. Selepas semua projek ini siap, meja mudah alih ini akan membantu kita tentang pemahaman proses merekabentuk dan penghasilan yang terlibat dalam projek ini.

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CHAPTER 1

INTRODUCTION

1.1: Project Title

My project title is design and fabricate multi-purpose portable desk. The fabrication of the table is concern to strength, durability, and more function. New concepts require improving portable multipurpose function such as easy to use.

1.2: Project synopsis

This project is design and fabricates a Multipurpose Portable Desk. The project involved the design and fabrication. This desk can be adjusts to different heights and angles and folds away too. Multi-purpose Portable Desk instantly turns a chair or sofa into an eating, entertainment or work center. The desk must be sturdy and portable so it can use for flat for eating, writing, and doing paperwork.

Skill requirement during making this project is AutoCAD, mechanical design, welding and basic machining such as shearing machine, bending machine and drill machine.

1.3: Project Background

At this moment desk in market have various type, specification, and shape. Table used as place to put anything on them. Beside that table can used to study and making many works such as writing note, make assignment, and can do the drawing.

As we know, desk is large, difficult to move and sometime not using friendly. In order to solve this problem, the desk that I design is considering all of current weakness. This desk design is more compact, user friendly due to we can adjust the height and angle, portable and multipurpose.

1.4: Project Objective

Project objective divide by two. It is general objective and specific objective for the title of project.

1.4.1: General Objective

The objective of diploma final year project is to practice the knowledge and skill in problem solving using academic research, in order to become a good engineer that have been enough knowledge and skill.

This project also important to train and increase student capability in research, analysis and problem solving. These projects also educate the student in communication like in presentation and educate them to define their research in presentation.

This also can produce and train student to capable of doing work with minimal supervisory and more independent in searching, detailing and expanding the knowledge and experiences.

The other objective is generating student that have capability to make a good research report thesis form or technical writing.

1.4.2: Specific Project Objective

The main objective of this project is:

i. To design and fabricate a multipurpose portable desk.
ii. Fabricate desk can be adjust to different height, angle and can fold.
iii. To design a desk that is suitable to it application.
iv. Introduce and fabricate new concept of desk.
v. Fabricate the desk with minimize the manufacturing cost.

1.5: Problem Statements

Basically this project is base on these problem statements:

- Existing desk in the market only has limited function.
- Many desks right now fit for their height and angle.
- Difficult to change the place because the desk not portable or can't be fold.

1.6: Project Scope

- Literature review
  - Consideration on the multipurpose and portable of the desk.

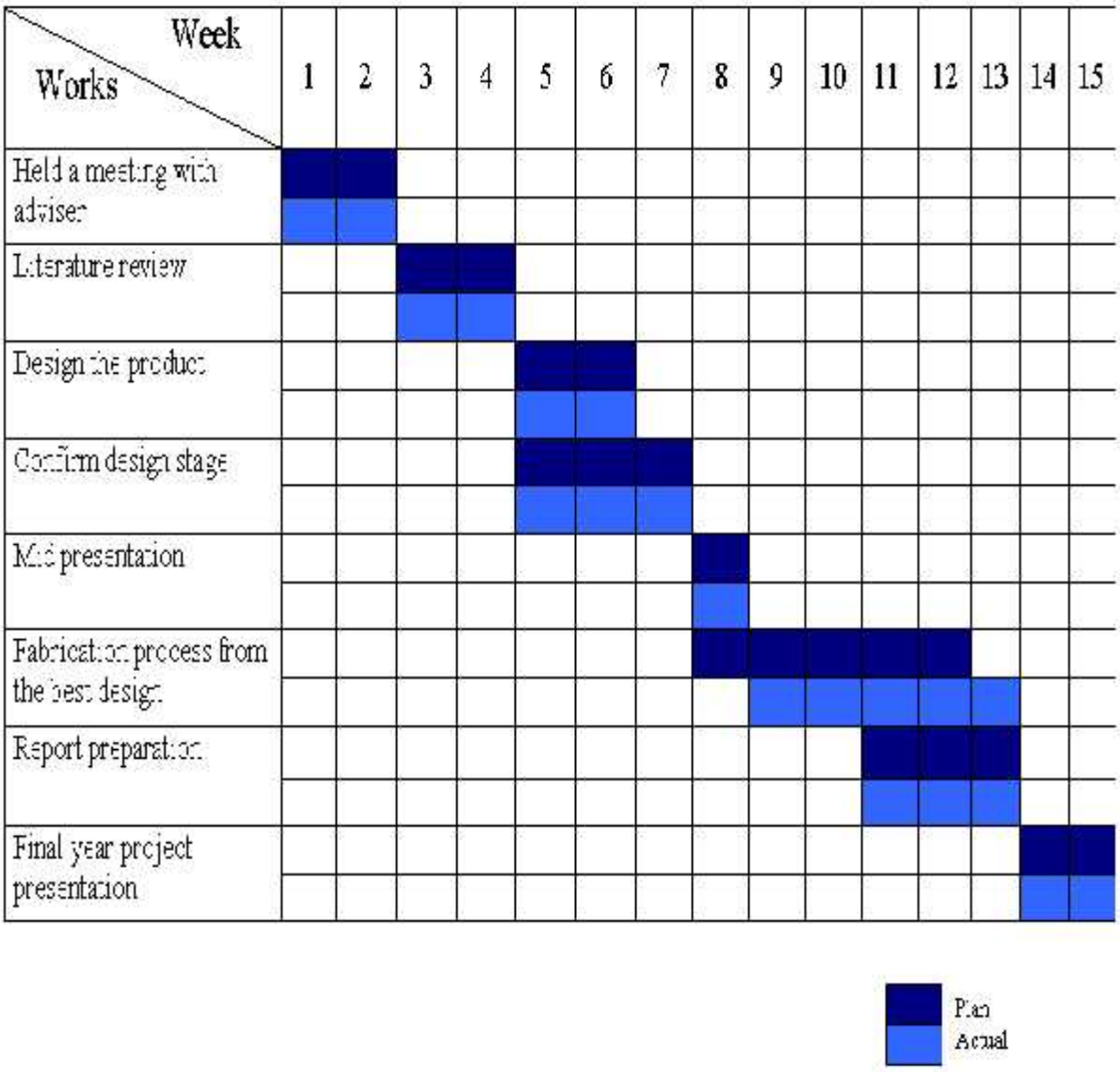
- Design product
  - Sketching and CAD drawing
  - Mechanical design application

- Fabrication product
  - Process involving basic machining and joining.

- Test and evaluation
  - Aspect to consideration:
    Strength, safety, ergonomic
  - No error from fabrication

1.7: Project Gantt Chart

Table 1.1: Project gantt chart



CHAPTER 2

LITERATURE REVIEW

2.1: Introduction

Table used as place to put anything on it. Beside that table can be used to writing, study and making many work such as doing drawing, making homework and others. We already know many table have a big size and difficult to move at other place and bring it. So many designs right now become fordable table that have more easy to use, can fold, move to other place and bring it. Foldable table is thing that can fold from large to become a small size such as briefcase, box and others. Fordable table is the most interesting to people used to camping, picnic because easy to bring it. Many products at the market have different specification, shape and type when manufacture by different manufacturing company. Research review about fordable table is to get data to make a new concept of foldable table.

2.2: Review Current Product

2.2.1: Winsome Folding Computer Desk

Figure 2.1: Winsome Folding Computer Desk

Product Information

This computer desk is perfect for smaller spaces. Crafted of solid beech wood with a Honey Pine finish and classic Mission styling, it features a pull-out keyboard tray and folds up when not in use. Other coordinating shelves and desks are available separately.

Product Features

- Keyboard tray
- Solid beech wood
- Fold up

2.2.2: Carolina Cottage

Figure 2.2: Carolina Cottage

Product Information

This unique folding desk comes in a beautiful chestnut finish and carved, turned legs. The simple, traditional design is great for any room.

Product Features

- Turned leg.
- Chestnut finish.
- Can fold it.

.

2.2.3: Easy Fold portable computer desk

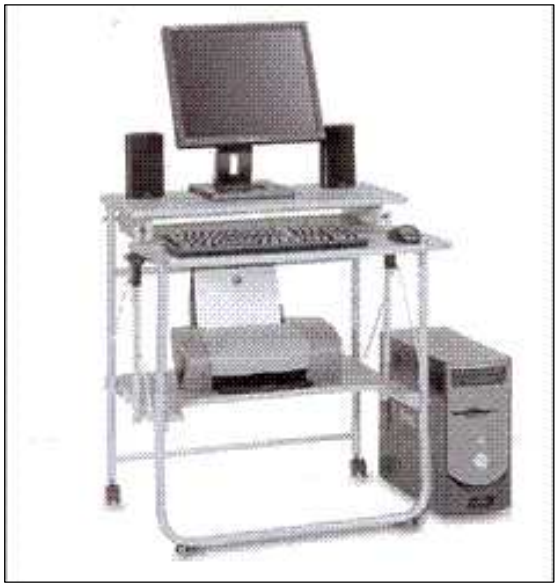


Figure 2.3: Easy Fold portable computer desk

Product Information

Foldable desk provides an added work area in the home or office while taking up little floor and storage space. This stylish desk features a highly functional design with a durable metal frame and laminate shelves for holding a monitor, keyboard, and printer. Dual single-touch lock/release clamps allow for easy setup or storage, making it the perfect laptop, bill paying, or study desk. Also includes rear casters for convenient mobility.

Product Features

- Durable metal frame.
- Dual single-touch lock.
- Rear casters.

.

2.3: Basic Parts

The basic parts of table are dividing by three parts are :

i. Surface Table : Usually this made from wood. For new technology surface table using sheet metal, plastic and aluminum that joined with bolt and nut, rivet and welding with steel frame and leg steel.

ii. Arm : Arm is function to lock leg table and make table become stable. Usually arm shape like a small rectangular bar or sheet metal. It is join with surface table and leg table.

iii. Leg Table : This part using steel because it has good strength to up heavy loaded that place on the surface table. It is joining with frame surface table or directly with surface table.

CHAPTER3

METHODOLOGY

3.1 Introduction

This chapter will cover all the process when doing this project. From the literature review, searching information, sketch the design, fabrication and until write a final report. This chapter also includes all the steps and project planning during making this project.

3.2 Project Flow Chart

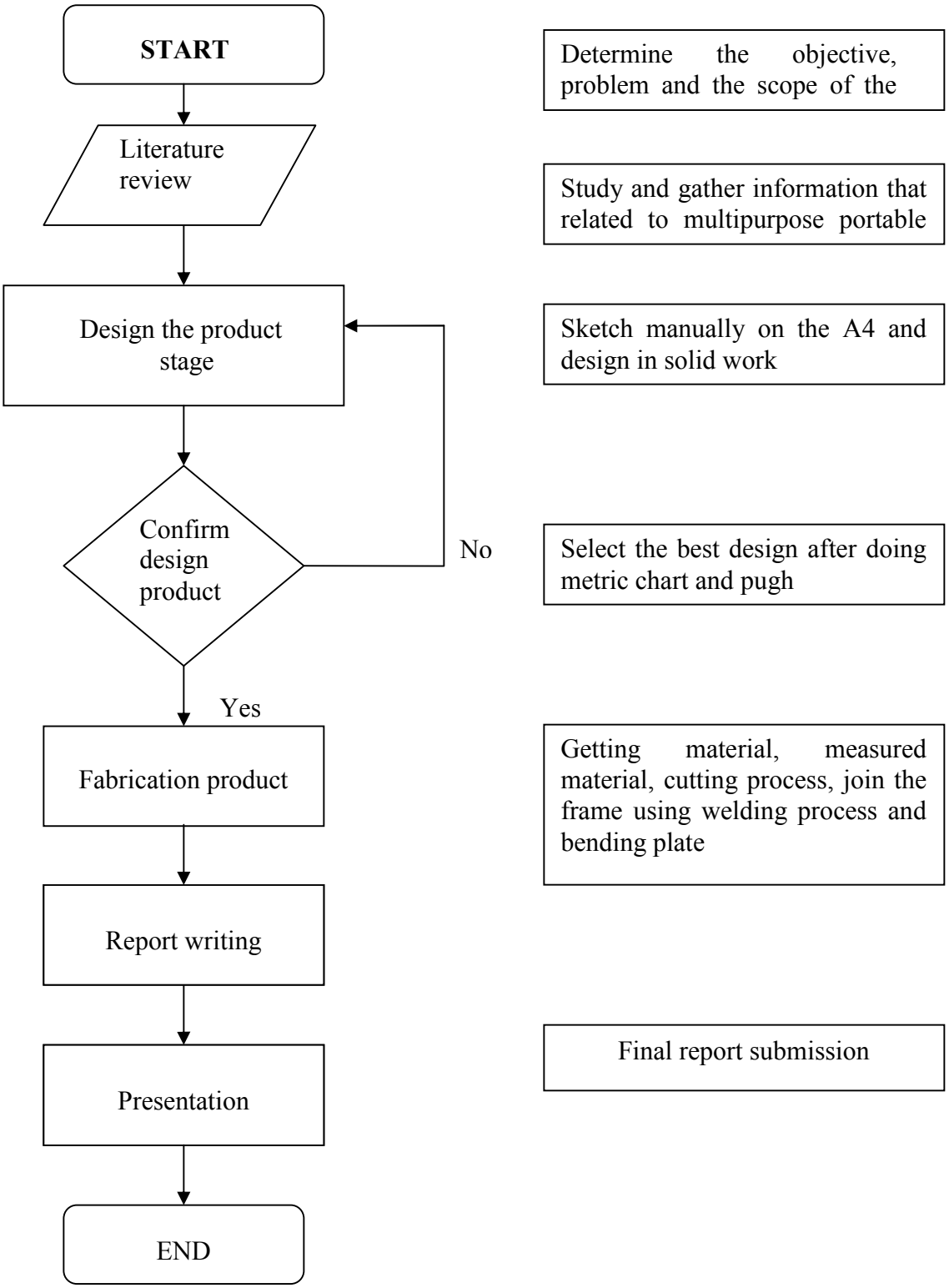


Figure 3.1: Project flow chart

For the diagram, the project starts with literature review and research about the title. This consist a review of the concept and type of multipurpose table using in the market. These tasks have been done through research on the internet, books and other sources.

After collected all the information, the project get through to design process. In this step, the knowledge of mechanical design use to make a sketch design that suitable for the project. After 4 designs sketched design selections have been made and one design have been chosen. The selected design sketched then transfers to solid work. The material and dimension needed for this table must list down and calculated to give ergonomic shape.

After needed material is list, acquisition step take places. There are only a few material needed to buy such as hinge, hold and other finishing product. Some of material is well prepare by the faculty laboratory such as sheet metal and circle hollow steel.

The next step is fabrication process. The finished drawing and sketching is used as a reference by following the measurement and the type of material needed. The fabrication process that involved is shearing, cutting, welding, drilling and other. After every process was finish, the parts are check to make sure that the output of the process obeys the product requirement.

If all the product had been processed, the parts are joined together to produce full-scale multipurpose table. Here come testing and evaluation process. The table will be test to see if it fulfill the requirement such as easy to bring anywhere, stability, strength, and functional table. The finish product will be compared with the report to make sure that there is no mistake on both project and report.

After the product and report had been approved by the supervisor, the report is rearranged and prints out. The final presentation also been prepare.

3.3: Design

The design must be compliance to several aspects. The design must consideration to done carefully so it can be fabricated easy and all part are all functioning. Some off the aspect are:

i. Strength : This is important because it support structure of the table.

ii. Ergonomic : Foldable table must be user friendly as easy to use and bring anywhere.

iii. Cost : Cost is one of exist in objective. The cost of whole system must been not exceed from budget given and also reasonable.

iv. Material : Available of material is one of aspects that have been considered. The material can be used depend on their purpose.

3.4: Drawing

The drawing is dividing into two categories which are:

i. Sketching: All the ideas are sketched on the paper first to ensure that ideas selection can be made after the selected design choose.

ii. Solid work: The sketching design is transfer to solid modeling by using solid work.

3.5: Sketching and Drawing Selection

From the existing idea, only 4 sketching that had been chosen to be considered.

3.5.1: Concept 1

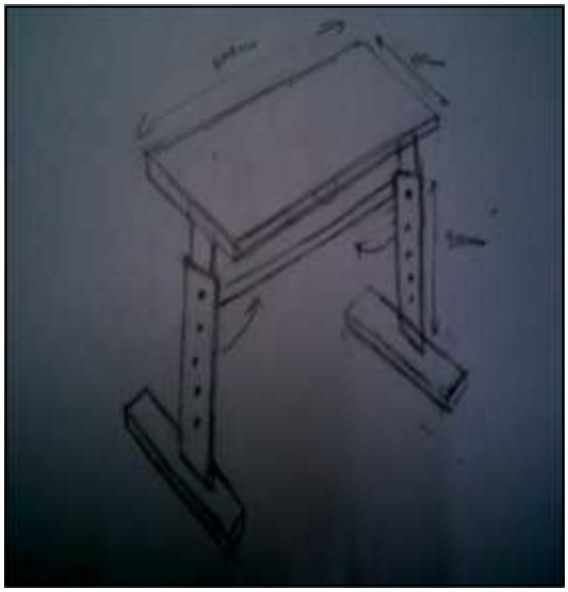


Figure 3.2: Concept 1

3.5.2: Concept 2

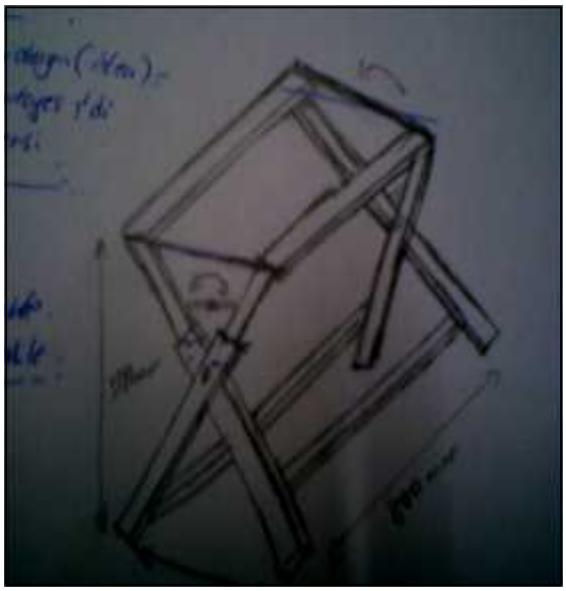


Figure 3.3: Concept 2

3.5.3: Concept 3

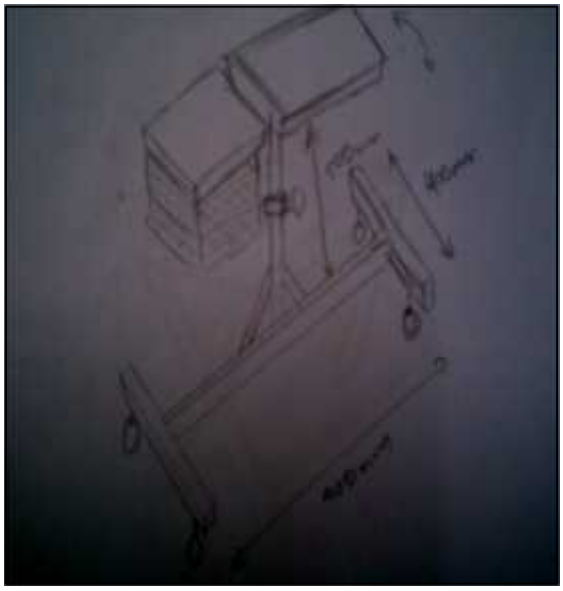


Figure 3.4: Concept 3

3.5.3: Concept 4 (Selection Product)

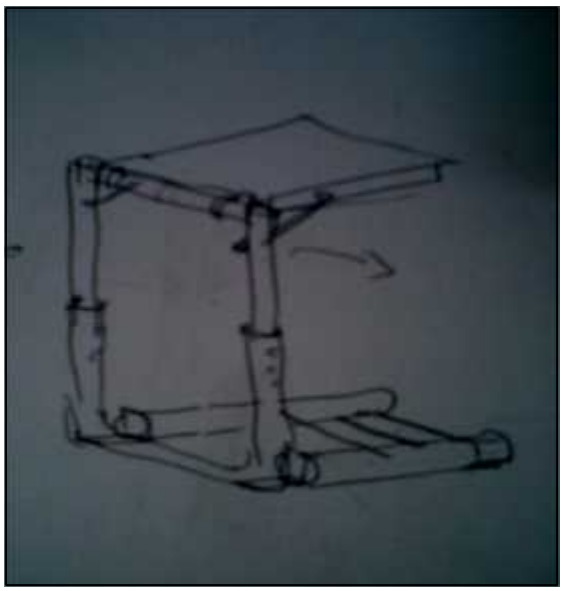


Figure 3.5: Concept 4

Comparison of the concept

Table 3.2: Comparison concept

Concept	Advantage	Disadvantage
Concept 1	• Easy to fabricate • Can adjust the height • Frame can fold • Can hold by hand	• Can't adjust the angle • Just frame can fold
Concept 2	• Can adjust the height • Easy to bring it • Angle desk can adjust	• Desk can't fold • Difficult to fabricate • Chair can't put inside • Not suitable for leg
Concept 3	• Suitable for leg • Easy to fabricate • Can adjust the height • Use wheel	• Can't adjust the angle • Can't fold it • Desk not portable • Chair can't put inside
Concept 4	• Frame can fold • Can adjust the height • Can hold by hand • Angle desk can adjust	• Difficult to fabricate • Can't support large force

3.6: Metrics Chart

Table 3.3: Metric chart

	criteria	concept 1	concept 2	concept 3	concept 4
1	Easy to handling	***	**	***	****
2	Easy to manufacturing	***	****	**	***
3	Easy to use	***	****	**	***
4	Easy to keep	**	**	****	****
5	Shape	***	****	**	***
6	Stability	***	***	**	***
7	Quantity of Material	***	***	**	****
8	Weight	***	**	***	***
9	Function	***	***	**	****
10	Strength	****	***	***	***
11	Capability	****	***	**	****
12	Fold	****	***	**	****
		38	36	29	42

*	Very poor
**	Poor
***	Medium
****	Good
*****	Very good

From the metric chart above, criteria or characteristic for fabricated a new product are important thing to be considered. 11 criteria have been chosen to consider. According to metric chart, the selection concept based on how many star there get it. So concept 4 will be chosen to fabricate.

3.7: Pugh

Table 3.4: Pugh

	Concept Variants				
Selection Criteria	Concept 1	Concept 2	Concept 3	Concept 4	Product
Easy to handling	(+)	(-)	0	(+)	0
Easy to use	0	(+)	0	(+)	0
Easy to keep	0	(+)	(-)	0	0
Capability	(+)	(-)	0	0	0
Strength	(+)	0	(-)	0	0
Manufacturing	(+)	(-)	0	(+)	0
Shapes	0	(+)	(-)	(-)	0
Weight	0	(+)	(-)	(+)	0
Fold	(-)	(-)	(+)	(+)	0
Function	(+)	(-)	0	(+)	0
Pluses	5	4	1	6	
Sames	5	1	5	3	
Minuses	1	6	4	1	
Net	4	-2	-3	5	
Rank	2	3	3	1	
Continues	NO	NO	NO	YES	

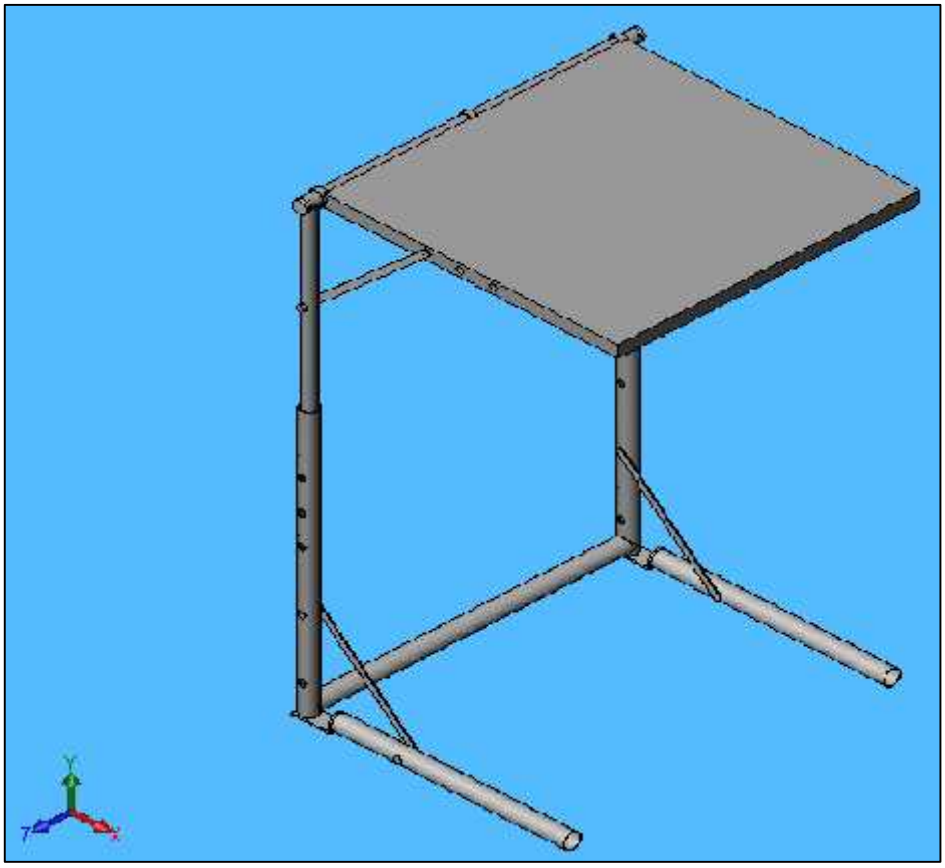


Figure 3.6: Overall view of the design

3.8: Design Specification

Design specification is based on drawing and sketching selection, after generate and evaluated the best concept selection. This concept is the best design that can be fabricated. Below table is the detail product design specification of this concept:

No	Parts	Type of material	Dimension (mm)	Quantity	Remarks
1	Top frame	Tube (hollow steel) Ø 20mm	500 x 20	1	
2	Side frame (top)	Tube (hollow steel) Ø 20mm	450 x 20	2	
3	Side frame (bottom)	Tube (hollow steel) Ø 25mm	459 x 25	2	
4	Bottom frame	Tube (hollow steel) Ø 25mm	450 x 25	1	
5	Base	Tube (hollow steel) Ø 25mm	350 x 25	2	
6	Plate	Sheet metal (steel) thickness 1.5mm	454 x 450	1	
7	Hinge (small)	Steel	Standard	4	

Table 3.5: Design specification

3.9: Fabrication Process

These processes are about using material selection and make the product base on the design and by followed by the dimension. Many methods can be used to fabricate a product such as cutting, bending, drilling and many more. Fabrication processes it means that it only make a one product. As a precaution during fabrication process, must wearing personal protect equipment (PPE).

Figure 3.7: Personal Protect Equipment

3.10: Process Involve

To fabricate this product there are using too many process. Some of the processes that involve are:

i.) Getting material:

First step in fabrication of this product, there must have the material. This material can get at mechanical laboratory. For the multipurpose and portable desk it was using hollow bar steel and sheet metal.

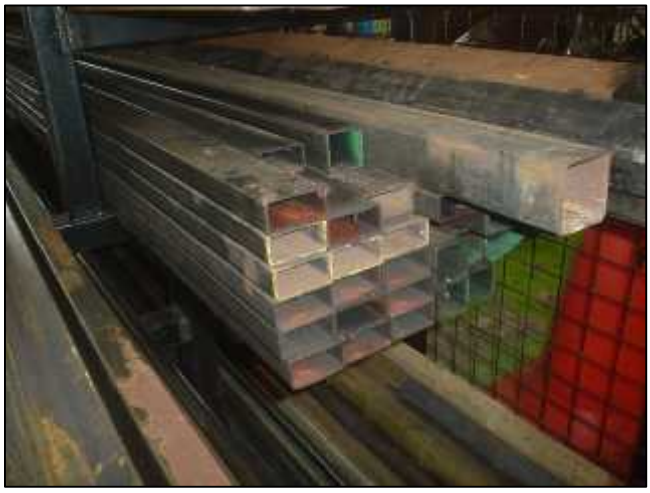


Figure 3.8: Material

ii.) Measuring and marking

The next step is measuring and making the material like figure below. The dimensions must follow from drawing. The equipment used in this process is measuring tape and maker.

Figure 3.9: Measuring and marking

iii.) Cutting material

After finish measuring and marking all material based on the dimension it can be cut by using floor cutter disc.

Figure 3.10: Floor cutter disc

iv.) Bending process

This processes for making a base of the table. Bending machine was used for making the shape smoothly and no shape edge.

Figure 3.11: Bending process

v.) Drilling

Drilling process to make the hole for bolt and rivet. The size of tool must suitable with the dimension of hole.

Figure 3.12: Drilling process

vi.) Joining

This process is to joining all the part together according to the drawing by using the arc welding and metal inner gases. The joining parts are base, frame and arm.

Figure 3.13: Welding process

vii.) Grinding Process

After cutting and welding process, the chip from work piece must be remove using hand grinder. It is to make sure the surface is smooth.

Figure 3.14: Grinding process

3.11: Process Procedure

Step 1: Get the material from mechanical laboratory because all the material is prepared by faculty. After that measure and marking the material based on the drawing dimension. The material of this product is hollow bar steel for the frame and sheet metal steel for base of the table.

Step 2: Used floor cutter disc for cut the material such as hollow bar steel. Safety measure when using floor cutter disc is must wearing the goggle and glove because it is too dangerous. For cutting the plate it must using shearing machine to get the specific size.

Step 3: After that, bending machine was used for make the shape of plate. Bending machine used for making the shape smoothly and no shape edge.

Step 4: To make a hole at above and below frame, drilling machine was used. The drill bit is Ø 5.5mm for rivet.

Step 5: Arc welding and metal inner gas welding was used for joining the frame. All of parts were weld together according on the method joining drawing.

Step 6: After finishing weld, the entire weld place were then grinded to make sure that the entire joint surface was smooth from any spatters or sharp edge. Must wearing goggle and glove while doing this process because the chip can enter the eye during grinding process.

Step 7: The last step is finishing process. Spray all the part with the gold and black colour.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter is focus on the result and analysis about the product. After done all fabrication process the product would through testing process where the data would be taken and then analysis process by using Solidwork plus the Cosmos software where could determine the strength and ductility of product when it perform. From the cosmos software we can get data about strength and ductility the material of this product. After that the discussion would took place which is come out from the result in testing process and all matter about the product such as it specification including it weight and dimension.

4.2 Results after finishing

Figure 4.1: Complete multipurpose portable desk (side view)

Figure 4.2: Complete multipurpose portable desk

Figure 4.3: Desk easy to bring anywhere

Figure 4.4: Desk can be fold

4.3 Product Specification

For the product specification, there are a lot of factor that consider. The product is classify to several categories such as weight, colour , wide, height and other else. The product specification is like below. Below is the result for product specification which is:

Table 4.1: Product specification

Category	Result
Dimension	505mm x 442.5mm x 753mm
Colour	Black plus Gold (2K)
Overall weight	It was 4 kg
Height	Can adjust into 3 stages.
Maximum forces can be loud	30 kg
Convenience	- Desk can be fold - The height can be adjust - Easy to bring anywhere

4.4 Discussion

Discussion is dividing into two. Firstly is a discussion about types of defect on the final product. Second is discussion about the problem in progress start with literature review until finish this project.

4.4.1 Type of defeated

After fabrication done, there is some defect happen on this product. This defect happens because lacks of skill to operate a machine such as when handling welding machine. Although these problems happen, its can gives an experience to avoid the same mistaken repeat again at the future. There are some of defect happen on the product bellow:

4.4.1.1 Bead

Figure below is shown a defect happen on joining part. The bead is not trim well after finish welding process. The electrode use in this welding is not suitable for this material. Insufficient experience to handle also caused of the bead.

Figure 4.5: Bead defect

4.4.1.2 Gap

Figure below is shown a gap happen in this part. This happen because not using a turret punch machine before this part was bending by bending machine. During fabrication the turret punch machine have problem. It takes time to repair because the cost is too high and difficult to get the spare part.

Figure 4.6: Gap defect

4.4.2 Problem in progress

Many problems occur in progress when design and fabrication of this product. Some of the problem is like below:

i.) Literature review problems

The problem is about the difficultly to get the data and design the product. It takes long time on the design stage. This because the design outcome must be follows with the objective of this project. Raw material also the problem encountered during this step because some of the material used not available at Mechanical Lab. So the material must be order first.

ii.) Fabrication Problems

Problem during this stage is very critical that make the actual progress not follow project planning schedule. First, the problem is late to get the material that we order it. So the fabrication stage not follows the Gantt chart. The material not available is hollow bar steel. This material using for fabricate the frame of this multipurpose portable desk.

The problems also come during fabrication process. Punch machine is can't be use because the machine have problem. To repair this machine takes long time because the cost to high and spare part not easy to get it. So the solution is cutting manually before the part is using with bending machine. The other problem is hand grinding and floor disc cutter only have two. This project have a problem when to welding because gas for MIG welding was finish and forced wait for several day to get new gas for MIG welding.

4.5 Product analysis

When the object put on the desk, there have forces that acted on the arm at the frame. We need to determine and study the effect on that because to make sure the table can support how much force can be acted at this arm. To study the effect whether design would fail to perform well or it would damage when demonstration is held. By using Solidwork Cosmos analysis software, it would help us to study the stresses that acted on design and determine the condition of design such as crack and bending at part of design. Basically this process is very important because for engineer or designer who intend to fabricate and designing new product, the analysis should be held because it directly help us a lot of benefit such as got reduce cost and know the design capable off. Arm the only part we analysis because this part is support the force when the object pun on this desk.

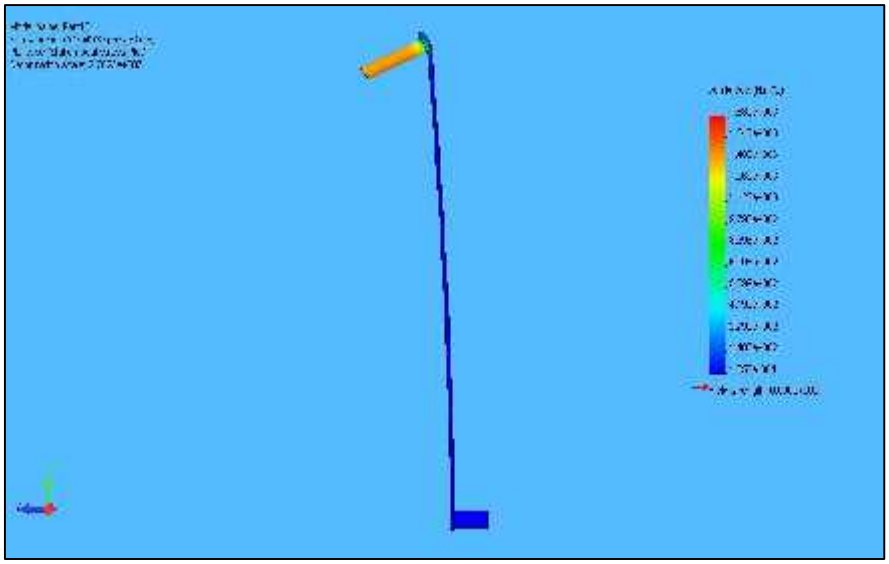


Figure 4.7: Result analysis (Arm)

After using the cosmos software, this is the result we get. The maximum force this arm can support is 30 kg. If the force acted more than 30 kg, deformations happen into this arm like the figure above.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Introduction

For this chapter it present about the conclusion and recommendation for this project. The most important things for this chapter are about the problems encountered during the whole project carried out. The problem are included the process planning that have been done. The entire problems during doing this project make the student more creative and think how to solve this problem. This chapter also discusses about the conclusion of the project and also contains recommendation for the future work. This is good because for the future it can make some improvement on this project.

5.1 Conclusion

The conclusion can be make for this project "Design and Fabricate Multipurpose Portable Desk" is successfully achieves the objectives. This project was done around fourteen week included the report, almost all the step such as literature review, design, fabrication process. Although fabrication stage not follow with the planning and Gantt chart but this project can finish on the time.

5.2 Recommendation

Several recommendations to express for myself and the faculty for future final year project are:

i.) Supervisor must explaining to student more detail all about the task for this final project. So the student can get representation how to doing during finish this project.

ii.) The planning schedule and Gantt chart of the project must be done before the project started. The flow chart also important to guidance the student step by step during does this project.

iii.) The faculty must prepared all the familiar material using by the student during the final year project such as hollow bar steel and square hollow steel. So student should not be order the material because when order this, it taken too much time to get the material.

iv.) The involvement of the student must be observed more efficient.

v.) More time given to the project, it include statement the final year student should more focus on final year project, this could make the result of the project finish on time and have better result.

vi.) The budget must be prepared earlier to make sure no budget problem not occur during material buying process.

5.3 Future work

Future planning for the multipurpose portable desk is to make sure all the function have in this product is achieved. This desk must be more comfortable for the people when using this desk. This project can be used by the student to gain the knowledge and understanding of mechanical process when to make new product. It also could helpful student in the study of process machining such as shearing machine, bending machine, drilling machine, cutting machine, welding and all equipment in mechanical lab.

To be efficient, the upgrade should involve to this product. For example change the using material into stainless steel. This material is more light and good in their strength. Aside those it also can reduce the heavy of this desk. So it can easy to bring anywhere because this desk is lighter. If the upgrade can be done it make good strength, more comfortable, life longer and more attractive. In the future the desk must more ergonomic, light, more function or useful and good from before.

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APPENDIX A

3D Drawing Multipurpose Portable Desk

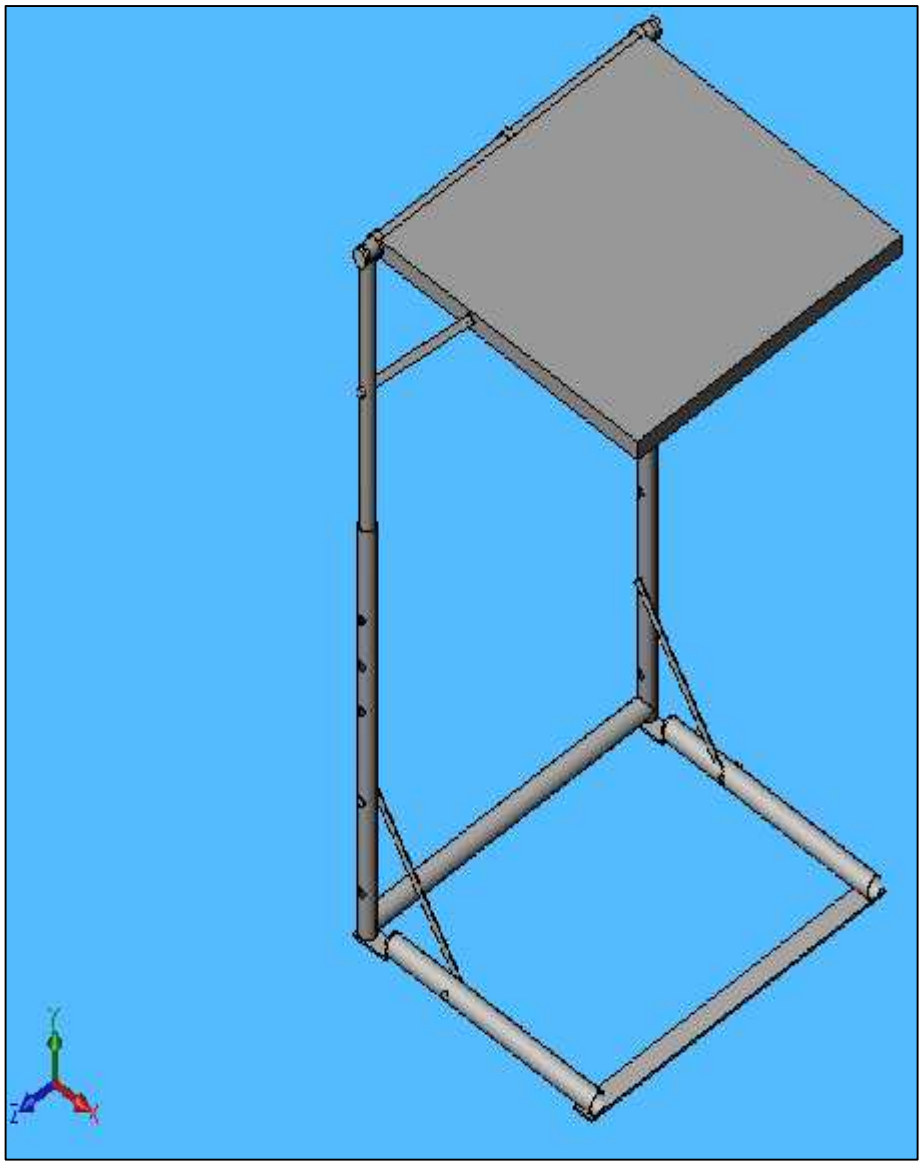

Figure A1: Isometric view

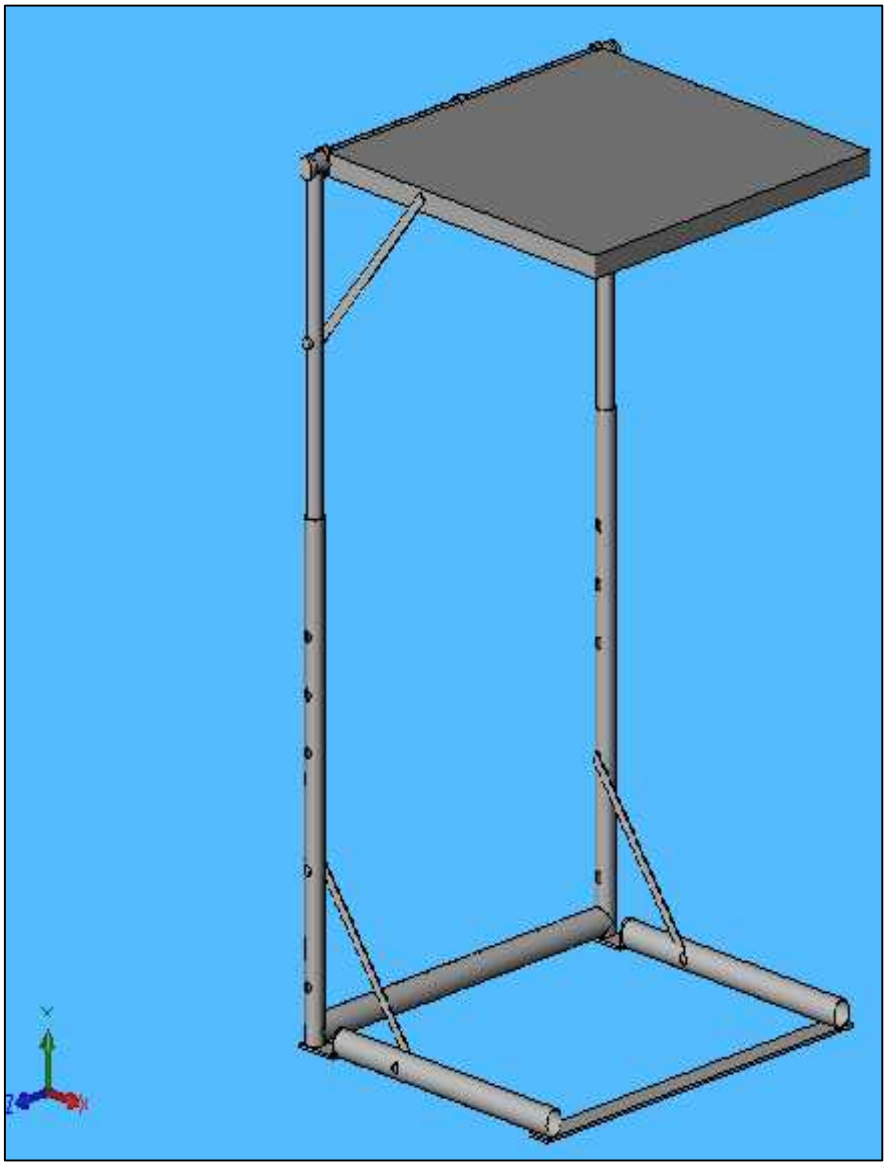

Figure A2: Dimetric view

APPENDIX B

2D Drawing Multipurpose Portable Desk

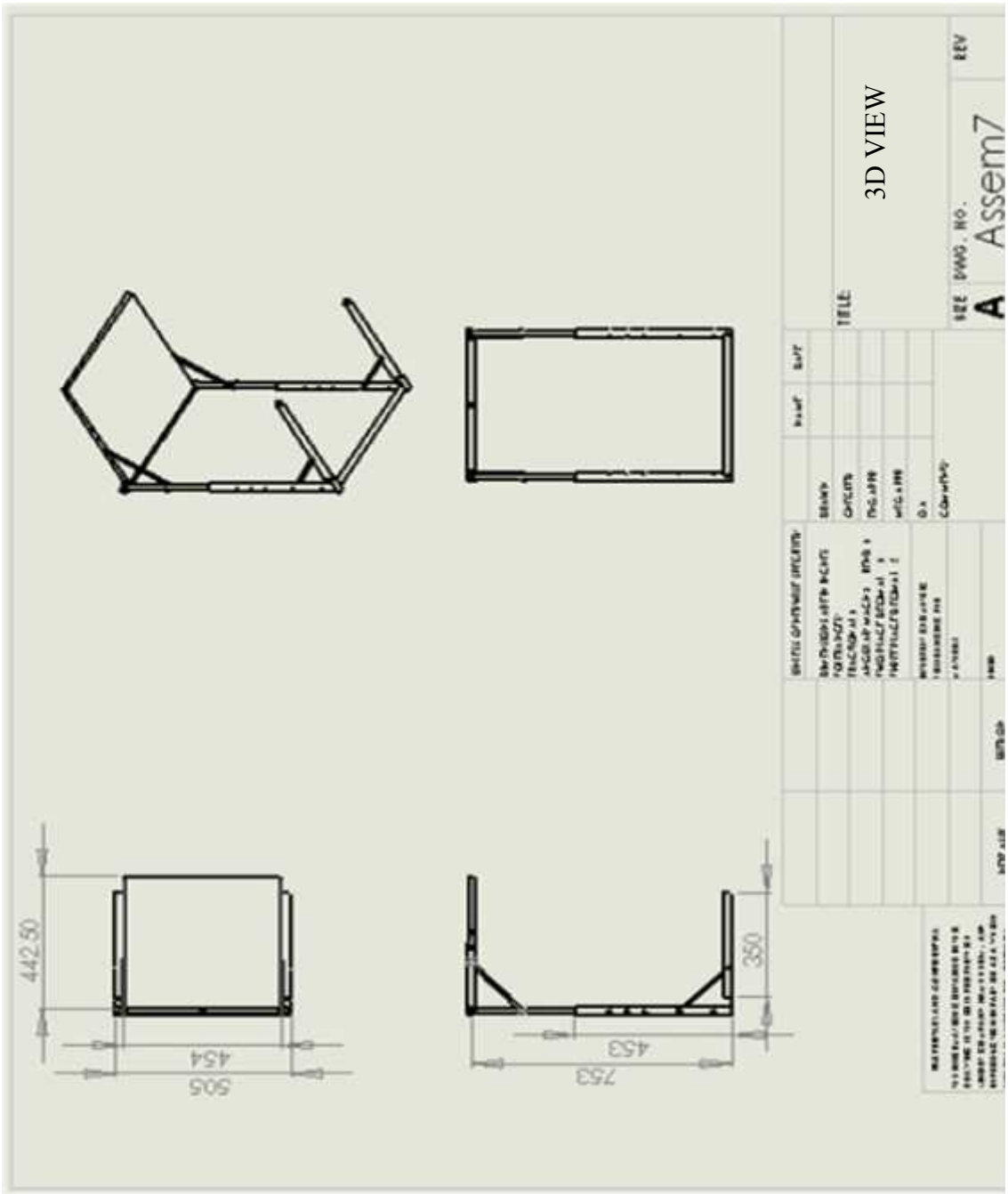

Figure B1: 2D Drawing

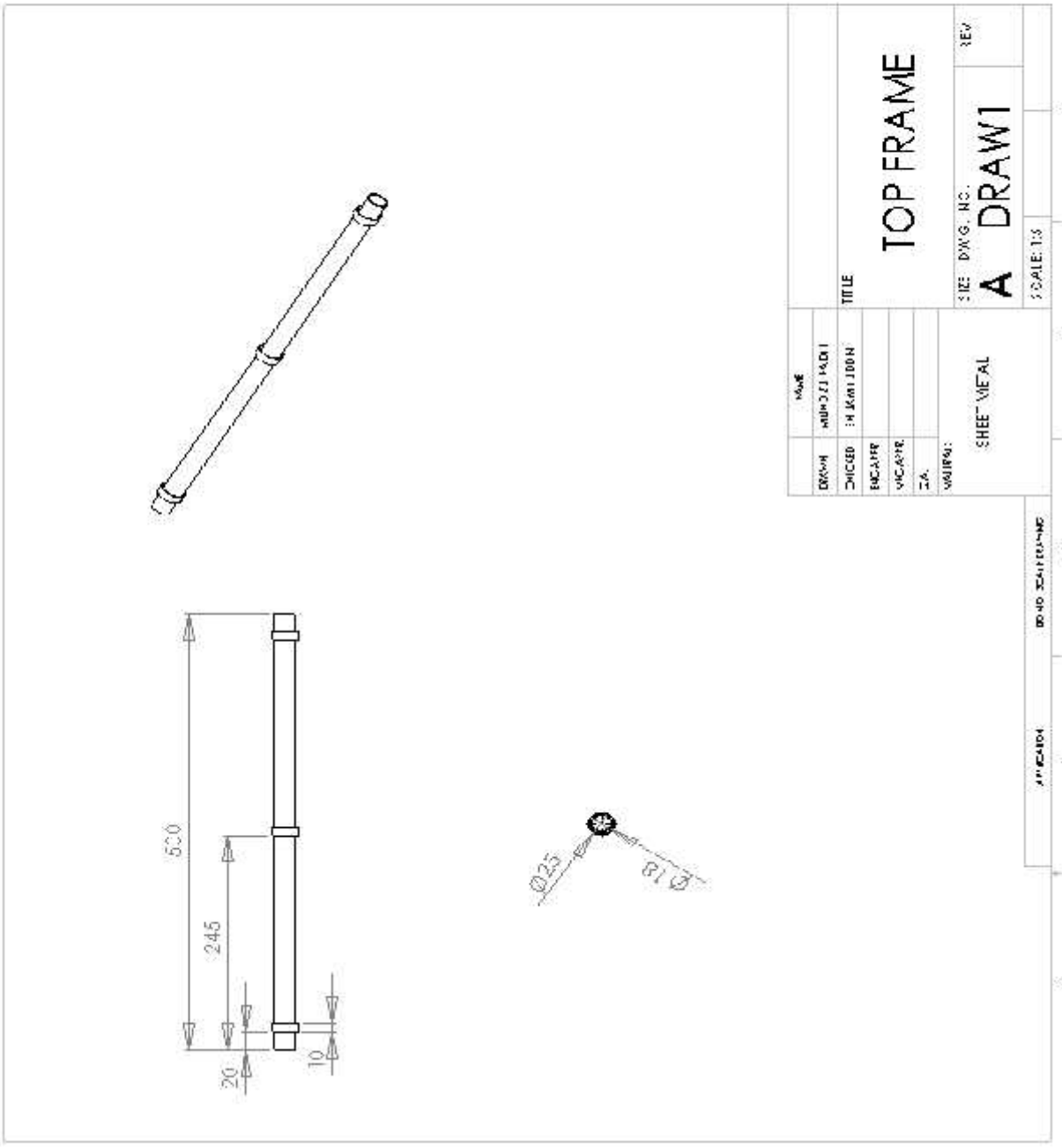

Figure B2: Top Frame

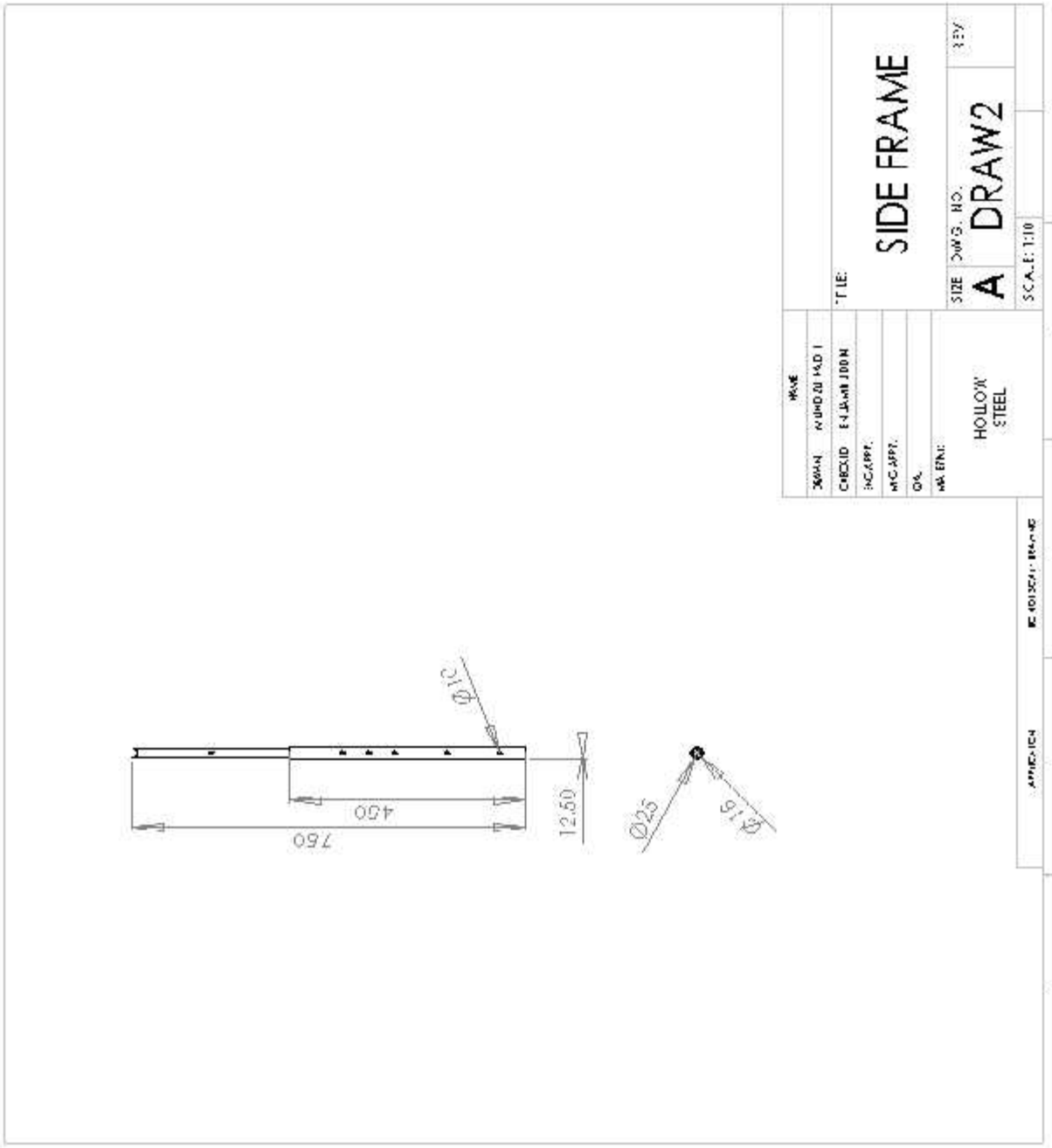

Figure B3: Side Frame

Figure B4: Plate

APPENDIX C

Figure and List of Machine

Figure C1: Bending Machine

Figure C2: Shearing Machine

Figure C3: Apparatus MIG Welding Machine

Figure C4: Floor Disc Cutter

Figure C5: Portable Hand Drill

Figure C6: Grinding Machine