DESIGN AND FABRICATION OF MULTI PURPOSE LADDER

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DESIGN AND FABRICATION OF MULTI PURPOSE LADDER

MUHAMMAD QAIDIR BIN ABDILLAH

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

> Faculty of Mechanical Engineering Universiti Malaysia Pahang

> > NOVEMBER 2008

SUPERVISOR DECLARATION

"I declare that I have read this thesis and in my opinion, this thesis is enough to fulfill the purpose for the award for the Diploma of Mechanical Engineering from the aspects of scope and quality."

Signature:Supervisor: En. Idris Bin Mat SahatDate:

STUDENT DECLARATION

I declare that this report entitled "Design *and Fabrication of Multi Purpose Ladder*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

The idea to design and fabricate a multi purpose ladder is come from a supervisor that gives a task and a title for this project. To design and fabricate this multi purpose ladder, the existing product in market must be compared first to know the latest designs that have been created. The information about current design for multi purpose ladder must be search or find from magazine, newspaper, catalog or internet. From all the information, idea to design and fabricate can be created. It includes many things about multi purpose ladder that want to be design such as portable and foldable. This because, some of the current ladder is heavy, uses a lot of space to stored and not stable.

The whole of the project involve various methods like the concept design, the designing and also the fabrication process. After the fabrication process is completed, the multi purpose ladder is tested to make sure the product is functional and achieves the objectives successfully.

Overall, this project can bring a motivation and experience, train to work under the pressure, apply knowledge that have been learned and soft skill ability like time management, planning the task, and negotiation skill to make sure this project goes smooth as plan and done at correct time.

ABSTRAK

Idea untuk merekabentuk dan menghasilkan tangga berbagai guna telah dikeluarkan oleh penyelia yang memberikan tugas. Untuk merekabentuk dan menghasilkan tangga berbagai guna ini, tangga yang telah wujud di pasaran mestilah di bandingkan dahulu untuk mengenalpasti rekabentuk yang terbaru yang telah wujud. Maklumat mengenai rekabentuk semasa untuk tangga berbagai guna perlu dicari atau didapati dari majalah, suratkhabar, katalog atau intenet. Daripada semua maklumat, idea untuk merekabentuk dan menghasilkan boleh tercipta. Ia merangkumi banyak benda mengenai tangga berbagai guna yang hendak dihasilkan seperti mudah dibawa dan boleh dilipat. Ini kerana, sesetengah tangga dipasaran adalah berat, menggunakan ruang yang banyak untuk disimpan dan tidak stabil.

Keseluruhan projek ini melibatkan pelbagai kaedah seperti konsep rekabentuk, merekabentuk dan proses penghasilan. Selepas proses penyambungan selesai, tangga berbagai guna tersebut diuji untuk memastikan product yang dihasilkan berfungsi dan memenuhi objektif.

Secara keseluruhannya, projek ini boleh memberikan motivasi dan pengalaman, melatih untuk bekerja dibawah tekanan, mengaplikasikan ilmu yang telah dipelajari dan dalam keupayaan kemahiran insaniah seperti pengurusan masa, merancang tugasan, dan kemahiran berunding untuk memastikan projek ini berjalan lancar mengikut perancangan dan siap pada waktunya.

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LIST OF SYMBOLS

- ft Feet Pounds per square inch psi Pounds lb Inch in kg Kilogram Meter т Pieces pcs Millimeter тт Ν Newton % Percent F Force Moment М σ True stress, local stress Ι Inertia
- γ Distance between center to tube

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This final year project involves designing, fabricating a functional ladder with extra new features and some analysis. This prototype could be use by the other lecturers or students in lab. As the Diploma final year, this project allocates the duration of one semester and it's focused to create the functional prototype.

1.2 PROJECT SYNOPSIS

The project title is fabricating a Multi Purpose Ladder. The project involves the survey and analysis about current design of multi purpose in current market. This ladder should be able to fold to make it easier to storage. Its also must be portable to bring it anywhere. Tests are required to be conducted and to verify the design. This project development must be concern with material strength, type of material, connection of folding and part of the structure.

1.3 PROJECT BACKGROUND

Nowadays, ladder becomes the common facilities for human. There are much type of ladder in the world wide market such as fixed ladder, extension ladder, step ladder, orchard ladder and others.

The main purpose of multi purpose ladder is to help human to do their work especially at the high place that can't be reach and help them to keep it without using a large space. Its can reduce time, increase efficiency and reduce space to store. As the result for the needed in community there are many various type of multi purpose ladder had been invented. Multi purpose ladder can foldable, portable and easy to use. It also comes in many sizes and design to make customer to choose which one is more suitable for them.

From the advantages and disadvantages of the ladder in the world wide market, one new product design will be create. This ladder can hold maximum weight 150kg, can be fold and portable.

1.4 PROBLEM STATEMENT

As we all know, ladder is one of the important thing to help human to do their job at the high place but most of it is big, hard to bring and need a lot of space to store. Furthermore, each ladder has its own use and specific use. It's limited to do other job than the specification. Some of ladder is not long lasting. To reduce this problem, one product must be created to fulfill the customer needed.

1.5 PROJECT OBJECTIVE

1.5.1 General Objective

Diploma final year project is to practice the knowledge and skill of the student that have been learned in their first and second year as a Diploma Mechanical Engineering student. It's important to born an engineer that have enough knowledge and engineering skills.

This project is important to train and increase the student capability of research, data gathering, analysis making, improving skills and then problem solving.

The project will train the student communication skills for example in presentation where they have to defend their research compare to other existing

products. They also have to deal with a lot of people to fabricate the product for example with En. Hazami Bin Che Hussain and En. Mohd Rizal Bin Mat Ali.

The project also will generate the students capability to make a good research report in thesis form or technical writing besides choosing the suitable material for their product.

This project otherwise can produce and train student to capable of doing work minimum supervision and more independent in searching.

In fabrication process, the students will learn more deeply in how to using a tool or equipment and method to fabricated the projects.

1.5.2 Specific Project Objective

The main objective of this project is:

- i. To design and fabricate a functional multi purpose ladder.
- ii. To create extra new feature, creative and innovative design.
- iii. Can hold maximum weight 150kg.
- iv. To design and fabricate the prototype of multi purpose ladder based on mechanical engineering method

1.6 PROJECT SCOPE OF WORK

This project is about design and fabricates a new product of ladder that has multi purpose. Design for this product is consider from the available product in the world wide market. Base on the advantages and disadvantages one new product will be creating to reduce the disadvantages and add more advantages facilities.

To apply all related subject like industrial design, static and dynamic in the product design and strength analysis (failure analysis).

- ii Conceptualization is to concentrate creating the product form using simple sketch.
- iii Final concept selection is to draw in 2D(AutoCAD) or 3D(SolidWork)
 often used for color studies and for testing the products feature and
 functionality.
- iv ladder must have multi purpose.

1.7 GANTT CHART

	Week														
Project Activities		1	2	3	4	5	6	7	8	9	10	11	12	13	14
literature	Plan														
review	Actual														
Idea	Plan														
Generation/Designing	Actual														
Finalized Concept	Plan														
and Selecting Material	Actual														
Fabrication	Plan														
1	Actual														
Result &	Plan														
Finding	Actual														
Discussion	Plan														
Conclusion	Actual														
Slide Preparation/	Plan														
Presentation	Actual														
Report	Plan														
writing	Actual														
Submit Report	Plan														
and Final Presentation	Actual														

Table 1.1: Gantt chart

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A ladder is a steps consisting of two parallel members connected by rungs; for climbing up or down. It is ascending stages by which somebody or something can climb the ladder. There are two types: rigid ladders that can be leaned against a vertical surface such as a wall, and rope ladders that are hung from the top. The vertical members of a rigid ladder are called beams (US) or stiles (UK). Rigid ladders are usually portable, but some types are permanently fixed to buildings.

Rigid ladders are available in many forms, such as:

- Extension ladder- fixed ladder divided into two or more lengths for more convenient storage; the lengths can be slid together for storage or slid apart to maximize the length of the ladder; a pulley system may be fitted so that the ladder can be easily extended by an operator on the ground then locked in place using the dogs and pawls
- Step ladder- hinged in the middle to form an inverted V, with stays to keep the two halves at a fixed angle
 - Platform steps- step ladder with small horizontal platform at the top
- Orchard ladder- three legged step ladder with third leg made so that it can be inserted between tree branches for fruit picking
- Telescopic ladder- stiles consist of concentric or rectangular tubing that can be slid inside each other for storage

• Hook ladder- rigid ladder with a hook at the top to grip a windowsill; used by firefighters

2.2 HISTORY OF LADDER

Ladders are ancient tools and technology. A ladder is depicted in a Mesolithic rock painting that is at least 10,000 years old, depicted in a cave in Valencia, Spain. The rock painting which shows two naked humans carrying baskets or bags that are employing a long wobbly ladder, which appears to be made out of some kind of grass, to reach a wild honeybee nest to harvest honey. Modern ladders are believed to have been conceived by Hebrews and Egyptians.

2.3 COMPARISON OF CURRENT DESIGN

In this project, seven current designs are selected to make a comparison. This comparison is specific to advantages and disadvantages for each current design from basic ladder until multi purpose ladder.

2.3.1 Fixed Ladder



Figure 2.1: Fixed Ladder

Source: Clow Group LTD

Advantages

- The price is cheap
- Durable
- Simple shape

Disadvantages

- Not adjustable high
- Cant be move
- Fix shape(cant be form into other shape)
- Fix to the wall

2.3.2 Step Ladder



Figure 2.2: Step Ladder

Source: Clow Group LTD

Advantages

- Stable to use
- Foldable to store

• Durable

Disadvantages

- Heavy to lift
- Not for high place maintenances job
- Difficult to carry
- Use a lot of space to store
- Only one side can be use(have rungs)
- Fix for one angle

2.3.3 Extension Ladder



Figure 2.3: Extension Ladder

Source: Clow Group LTD

<u>Advantages</u>

- Retractable and extendable
- Suitable for high and medium high place for maintenances job

Disadvantages

- Not stable to used
- Heavy to lift

- Difficult to carry to other place
- Must be silted to the wall to used
- Basic shape of the design

2.3.4 Multi Purpose Folding Ladder



Figure 2.4: Multi Purpose Folding Ladder

Source: Clow Group LTD

<u>Advantages</u>

- Foldable
- Stable
- Adjustable high (can be form into many shape for different high)
- Did not use a lot of space to store

Disadvantages

- Heavy
- Difficult to bring

2.3.5 Telescopic Ladder



Figure 2.5: Telescopic Ladder

Source: Clow Group LTD

<u>Advantages</u>

- Adjustable for high and medium high place for maintenances job
- Foldable
- Stable to use because the base part is more width
- Light weight (easy to lift to other place)

Disadvantages

- Large and hard to keep or stored
- Difficult to lift to other place

2.3.6 Assault Ladder

These are designed to be used by units which may need to board or assault vessels or buildings. They can be used when a full sized ladder is not required or when working in confined spaces. Suited for covert operations such as sniper placement, and vessel boarding. It was developed and designed for tubular assaults including buses and trains and for 1st story breaching. Its extra wide design gives the user greater stability, but still can fold away to be stored. It is available in standard aluminum in 6 and 8 foot lengths.



Figure 2.6: Assault Ladder

Source: Clow Group LTD

<u>Advantages</u>

- Light weight
- Easy to carry(portable)
- Foldable
- Used minimum space to stored

Disadvantages

- Expensive because it's using aluminium material
- Must be silted to the wall
- Not too stable to used

2.4 LADDER DESIGN

Ladder is design to help human. Its can be made from steel or aluminium to fulfill the customer needed. Each material have its own advantages and disadvantages.

2.4.1 Ladder Materials



Figure 2.7: Materials

MATERIAL	MODULUS OF	YIELD	DENSITY		
	ELASTICITY	STRENGHT			
	(psi)	(psi)	lb/in ³		
STEEL	30,000,000	60,000-150,000	0.285		
ALUMINIUM	10,000,000	20,000-70,000	0.100		

Aluminium	Steel
StrongLightweightCorrosion resistant	StrongEconomicalCorrosion resistant

Table 2.1: Material Properties

Steel is an alloy consisting mostly of iron, with carbon content between 0.2 and 2.04% by weight, depending on grade. Carbon is the most cost-effective alloying material for iron, but various other alloying elements are used such as manganese, chromium, vanadium, and tungsten. Carbon and other elements act as a hardening agent, preventing dislocations in the iron atom crystal lattice from sliding past one another.



Figure 2.8: Steel Bar and Steel Hollow Bar

Aluminium is a silvery white and ductile member of the boron group of chemical elements. It has the symbol **Al**; its atomic number is 13. It is not soluble in water under normal circumstances. Aluminium is too reactive chemically to occur in nature as the free metal. Instead, it is found combined in over 270 different minerals. The chief source of aluminium is bauxite ore. Aluminium is remarkable for its ability to resist corrosion (due to the phenomenon of passivation) and its low density.



Figure 2.9: Aluminium Sheets

2.5 WHEEL

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation whilst supporting a load (mass), or performing labour in machines. A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force. Common examples are found in transport applications.



Figure 2.10: Wheel

CHAPTER 3

PROJECT METHADOLOGY





Figure 3.1: Project Flow Diagram

3.2 PROJECT FLOW DESCRIPTION

From the diagram above, the project starts with literature review and research about existing product. This is about review on the advantages and disadvantages of existing ladder, features, mechanism and comparison between current ladder designs. These tasks have been done through research on the internet, books and surveys.

After gathering all the relevant information, the project start with generate of ideas. In this step, the knowledge gathered from comparison between current designs is used to make several sketches design that suitable for the project title. After several design sketched, one design will be chosen through pugh analysis (finalized concept). The selected design sketched will be transferred into solid modeling engineering drawing using Solidworks software. Then, the detail drawing will be printed to be as a guidance for fabrication process.

Then, fabrication process will take part. This process is about the fabrication of all part that have been design before according the dimension (Solidworks) using various type of manufacturing process. The manufacturing process included in the fabrication is cutting, grinding, drilling, welding and measuring. After the design is completed measuring, it will be test to make that the product is functional and safe.

From the result of the test, analysis of the result will be carried out to make sure whether the design is complete, perfect dimensional and functional. Finally, after every process is finished, all the material for the report is gathered. The report writing process will be guided by supervisor. This process also included the presentation slide making for the final presentation of the project. (The report writing is a continuous process starting from week one until the submission of draft.)

3.3 DESIGN

3.3.1 Introduction

The design of multi purpose ladder structure must be compliance to several aspects. The design consideration must done carefully to make sure the design can be fabricated and the product functioning. The aspects that need to be considered in designing the multi purpose ladder structure is:

a)	Durability	: The structure of ladder must be durability to endure
		continuous force when there is a load on the ladder.
b)	Strength	: The toughness for ladder structure is the most
		important criteria to be considered to make sure the
		product is strong enough to hold a heavy weight.
c)	Shape of ladder	: The shape of ladder is one of criteria need to be
		looked to attract the customer to buy it.
d)	Material	: Material availability is one of the challenges in the
		design consideration because of the material cost.
e)	Cost	: The cost must be in budget and reasonable. To reduce
		the cost, material from UMP mechanical lab will be
		use to complete the design.

3.3.2 Design Specification

The design specification consideration as follows:

a)	Maximum	load	150kg
u)	maximum	iouu	150Kg

- b) Maximum weight for the design is 8kg
- c) The material that will be use is hollow bar to reduce the weight.
- d) The shape must be attractive to attract the customer
- e) The design must be easy to use and easy to bring anywhere.

3.3.3 Design Selection

The design is separate into three phases. First phases is by sketched as many propose design that can be produce. Then finalize one sketched as finalize concept from all design that have been proposed. Final phases is by make a detail drawing or in the engineering drawing from the final concept.

3.3.4 Propose Design

From the review of current design, a few ideas have been create and more improvise than before. From the ideas, five sketching of the new design of multi purpose ladder are produced. All of the five designs have their own specification and different shape.

3.3.4.1 First Design



Figure 3.2: Sketching of First Design

Advantages

• Retractable and extendable

• Suitable for high place maintenances job

Disadvantages

- Not stable
- Need to silted to the wall

3.3.4.2 Second Design



Figure 3.3: Sketching of Second Design

Advantages

- Foldable
- Stable
- Adjustable (can be form into different shape for different high)

Disadvantages

- Heavy
- Difficult to bring
3.3.4.3 Third Design



Figure 3.4: Sketching of Third Design

<u>Advantages</u>

- Easy to bring
- Foldable
- Stable
- Can be converted into trolley

Disadvantages

• not for too high place maintenance job.

3.3.4.4 Fourth Design



Figure 3.5: Sketching of Fourth Design

Advantages

- Adjustable
- Foldable
- Stable

Disadvantages

• Large

3.3.5 Selecting Design

3.3.5.1 Selection Design

		CONCEPT			
Criteria		1	2	3	4
Comfortable to use		**	***	****	**
Ease to bring		*	*	****	**
Easy to move		**	***	**	*
Long life		*	**	**	*
Suitable height		*	****	****	***
Stable for climb		**	****	****	***
Adjustable height		****	****	**	**
Heavy to lift		***	***	***	**
c	Excellent	1	1	2	0
	Very Good	0	2	2	0
	Good	1	3	1	2
	Satisfied	3	1	3	4
	Not good	3	1	0	2

*= Not Good **=Satisfied ***= Good ****= Very Good *****= Excellent

Table 3.1: Metric Chart Analysis

After several design have been created, it will be compare each other. This chart is use to classify which concept of ladder have made a good point with my criteria from my objectives project. From my observation, concept 3 ladder have meet the criteria.

3.3.5.2 Engineering Drawing

After a final concept is selected, the next step is design the dimension. The design is separated into part by part and the dimensioning will be sketched first on paper.

After the dimensioning process is finish, the final concept will be drawn into 3D model (Solidwork application). Part by part will be created according to the dimension before all of the part being assembled together base on the design. All parts is converted into orthographic view to get the engineering drawing detail before the real process is started.

3.3.5.3 The Design Parts

The Design Consists of:

• Refer to Appendix A

3.3.5.4 Bill of Material

No.	Material	Size	Quantity/Length
1.	Hollow Bar	2in x 1in	1pcs/6m
2.	Hollow Bar	1in x 1in	1pcs/5m
3.	Plate	2in x 0.2in	1pcs/1.5m
4.	Wheel	-	4pcs
5.	Connection ladder(hinge)	-	2pcs
6.	Bolt	12mm	2pcs
7.	Nut	12mm	4pcs
8.	Washer	14mm	2pcs

Table 3.2: Bill of Material

3.4 FABRICATION PROCESS

3.4.1 Introduction

After designing process, fabrication process is start. This process is using the raw material and the product is created base on the dimension in the design that have been draw in 3D (Solidwork software). Many methods are used in this project such as cutting, measuring, drilling, grinding, and welding. Fabrication process is difference than manufacturing process in term of production quantity. Fabrication process is a process where only one product is need to be created rather than manufacturing process where it focus on large scale of production. This project just needs to fabricate one prototype for multi purpose ladder. In other word, the fabrication process is an experimental process in metalworking. This project is just to make prototype of product.

3.4.2 Fabricate Processes

In making the design of multi purpose ladder become a real prototype, several processes need to be used as a fabrication process which is:

- a) Cutting
 - Cutting the material into part based on the dimension needed
- b) Measuring
 - Measuring the material that have been cut into dimension needed.
- c) Grinding
 - To make the edge of the material more blunt after the cutting process.
- d) Drilling
 - Process to make holes
- e) Welding
 - Process to connect one part to another part using permanent connection
- f) Painting
 - Finishing process in fabricate the design.

3.4.3 Fabrication Method

Measure the material into the require dimensions, refer to the design. This measuring process is done by using L shape ruler, measuring tape and steel marker (Figure 3.6).

After the marking is done, cut the materials according to the dimensions by using floor cutting disc machine (Figure 3.7). Do some adjustment to the materials by using hand grinder to make sure the material is in the dimension that we needed (Figure 3.8). Make sure before the proceeding is start, wear the Personal Protective Equipment (PPE) such as goggle, glove, and safety boot.

Then, ladder frame part and support part will be mark and drill using drilling machine based on the design so both of part can be attach together next time (Figure 3.9). After drilling process is done, next process is welding process (Figure 3.10). This task is done by using MIG (Metal Inert Gas) welding and arc welding. First, the stairs part and base ladder part will be weld to the ladder frame part. Next, ladder frame part will be weld to the hinge so that the product is able to fold.

After that, the wheels take part. It also will be weld to the ladder frame part. Another part that also needs to be weld is hook part. All part will be place based on the design that has been created (Figure 3.11). Make sure before weld, every part must be accurately place in position so welding process can be done perfectly.

After welding process is done, support part will be join where it will be attach to the ladder frame part using bolt (M14), washer and nut. Role of support part is to hold the ladder at 30 degrees and 90 degrees. (Figure 3.12)

Last step need to be done is painting process. This process is started with cleaning process using sand paper to scrape off all rust and cleaning using thinner to make sure the product is really clean. Then, painting process is take part. The product will be paint with black colour and it will be paint with two layers. After painting process is done, the product will be dry under the sun (Figure 3.13).



Figure 3.6: Measuring Process



Figure 3.7: Cutting Process



Figure 3.8: Grinding Process



Figure 3.9: Drilling Process



Figure 3.10: Arc Welding Process



Figure 3.11: MIG Welding Process



Figure 3.12: Attach Bolt, Washer and Nut



Figure 3.13: Cleaning Process



Figure 3.14: Painting Process

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter is about the results and discussion of the product after the fabricated process is done. The analysis will use the fundamental of engineering analysis based on physic law such as strength of material and static. The analysis also will use theoretical and computer software such as cosmos software. Problem that also will be discuss in this chapter are the prominent problem encounter in every stage of the project.

4.2 **RESULTS**

After fabrication process is already completed, the product must be gone through the analysis process. At this stage, all data about the product is gathered. As a prototype, this process is important to classify whether the product is success or not before it enters the market.

4.2.1 Product specification

Every product must have it's own specification. In this project, the product will be classified in several categories such as colour, weight, wide and others.

Category	Specification	
Minimum height	1.2m	
Maximum height	2.45m	
Colour	Black	
Weight	10kg	
Wide	0.45m	
Other Specification	Can be fold and can be change as a	
	trolley	

Table 4.1	:Product	Specification
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4.2.2 Testing Product

Every product must be tested to make sure it functional and in good condition. This process is also important for the product whether the prototype we created is success of failure.



Figure 4.1: Testing Product (V shape)

Figure 4.2 above show that the two people are stand on the prototype to test. From there, it shows that the prototype is functional as a multi purpose ladder. Assume the total weight of man that stand on the ladder is 150kg, so each side can hold about 75kg of weight. The product can be used to make maintenances at a medium high place.



Figure 4.2: Testing Product (Straight Shape)

Figure 4.3 shows that a man is trying to climb the prototype (multi purpose ladder) to make sure each stairs part that has been weld properly to the frame part and strongly enough to be used. This product can be used to make maintenances at a high place.



Figure 4.3: Testing Product (Trolley Shape)

Figure 4.4 above shows that the product has a wheel and can be used as a trolley too. These will easiest the customer to bring the product to anywhere or lift any heavy thing to another place. This product is really difference from other current product because it can be change as trolley. These mean that this product can compete with other product in market.

4.2.3 Cosmos Express Software Results

An analysis has been done using Cosmos express software to determine the static stress analysis. Load will be applied to the product. This analysis is using 1000N as the maximum load and this load is not fix but it just assumption.

4.2.3.1 Load Information

Restraint will be applied at two structures at frame parts while load will be applied at the stair parts for 1500N.



Figure 4.4: Restraint Arrows



Figure 4.5: Load Arrows

4.2.3.2 Stress Distribution Result



Figure 4.6: Stress Result

Figure 4.6 above show that the stress is applied to the product. The center of the stair parts receive a highest load and become green colour. Blue colour show the surfaces receive a minimum effect because of the load.

4.2.3.3 Deformed Shape Result



Figure 4.7: Deformed Result

Figure 4.7 shows how the product will form after load is applied. The product is bending at the center of the stair parts.

4.2.3.4 Displacement Result



Figure 4.8: Displacement Result

Figure 4.8 shows that the displacement of the product is at the center of stair parts and the part is become red colour because it received the higher load.

4.3 DISCUSSION

4.3.1 Mild Steel

4.3.1.1 Overview

- Steels are the most important engineering materials, and cover a wide range of alloys based on iron and carbon. The strength of iron-carbon alloys, particularly after heat treatment, has been exploited for thousands of years (since the "Iron Age"). Modern steels and ferrous alloys have mostly been developed since the Industrial Revolution.
- Mild steel contains 0.1-0.2% Carbon. They are cheap, strong steels used for construction, transport and packaging.
- All steels have a high density and a high Young's modulus. The strength of mild steel is improved by cold working. It is inherently very tough.
- Mild steel rusts easily, and must be protected by painting, galvanizing or other coatings.

4.3.1.2 Design Issues

Design strengths:

- High strength-to-weight ratio
- High stiffness-to-weight ratio
- Good strength with high toughness
- High stiffness
- Very cheap
- Easy to shape
- Easy to weld
- Easy to recycle

Design weaknesses:

- High density
- Poor electrical and thermal conductivity

4.3.1.3 Environmental issues

- Steel production uses a lot of energy, but less than most metals.
- Steel is easily recycled as it is usually magnetic it is easily sorted from mixed waste.

4.3.2 Aluminium

4.3.2.1 Overview

Aluminium is a lightweight, reasonably cheap metal widely used for packaging and transport. It has only been widely available and used for the last 60 years.

- Raw aluminium has low strength and high ductility (ideal for foil). Strength is increased by alloying, for example with Silicon (Si), Magnesium (Mg), Cuprum (Cu), Zink (Zn), and heat treatment. Some alloys are cast, others are used for wrought products.
- Aluminium is quite reactive, but protects itself very effectively with a thin oxide layer. The surface can be "anodised", to resist corrosion and to give decorative effects.

4.3.2.2 Design Issues

Design strengths:

- High strength-to-weight ratio
- High stiffness-to-weight ratio
- High electrical and thermal conductivity
- Easy to shape
- Easy to recycle

Design weaknesses:

• Difficult to arc weld

4.3.2.3 Environmental issues

- Aluminium production uses lots of energy
- Aluminium is easily recycled this only uses 1% of the energy needed to produce the metal.
- Aluminium use is growing rapidl

4.3.3 Bending of Bar

The most concept that we need to consider is bending, in particular bending of the hollow bar. In engineering mechanics, bending (also known as flexure) characterizes the behavior of a structural element subjected to an external load applied perpendicular to the axis of the element. A structural element subjected to bending is known as a beam.



Figure 4.9: Free Body Diagram

We are concern with the stress and deflection resulting from bending of the bar. When a bar is subjected to a pure bending moment as shown in the figure below, it is observed that axial lines bend to form circumferential lines and transverse lines remain straight and become radial lines.



Figure 4.10: Moment Diagram

In the process of bending there are axial line that do not extend or contract. The surface described by the set of lines that do not extend or contract is called the neutral surface. Lines on one side of the neutral surface extend and on the other contract since the arc length is smaller on one side and larger on the other side of the neutral surface. The figure shows the neutral surface in both the initial and the bent configuration.



Figure 4.11: Moment Diagram (Specific)

From this relation we can calculate the expression for stress as a function of the bending moment by substituting in the expression for axial stress, this relation for the radius of curvature. This gives



Figure 4.12: Maximum and Minimum Normal Stress Diagram

As can be seen in the figure, the maximum and minimum normal stresses occur in the material that is furthest away from the neutral surface (either at the top or bottom of the bar depending on the actual direction of the moment).M is moment, y is the distance from center of the tube and I is the inertia.

4.4 Problem

4.4.1 Literature Review Problems

The problem encountered during research for literature review is about the current product did not tell specification and dimensions of the design. This will make comparison process for current product is difficult. The other problem is about limited resources about the project that relevant and suitable material such as books, magazines and newspaper.

4.4.2 Design Problems

The problems are about decision for dimensioning the final concept of the project. The dimension must be suitable and reasonable as a prototype.

Another problem encountered during design process is about material. This because, we need to order or buy some of the material if the material we want used is out of stock.

4.4.3 Fabrication Process Problems

At this stage, the main problem is to make sure this project is done based on time in Gantt chart. To avoid delayed for this project, some of the material need to be buy by our own self.

Another problem is the design can not be redesign because there is no time to fix the weakness of the product.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

Final chapter for this report will be discussing about the conclusion and recommendation of the product. Basically, the entire project can be divided into 4 stages which are concept review in current market, drawing, fabrication and testing the product. The drawings are divided into two categories, which are sketching and designing. The selected design or concept sketched is transfer to solid modeling and engineering drawing using Solidwork software. This multi purpose ladder is fabricate and produce using all necessary manufacturing process such as cutting(using Floor Cutter Disc), measuring, drilling, grinding, and welding(using Metal Inert Gas and Arc welding). This project is really challenging to complete.

Many problems encountered in every task of this project. Students need to be creative on solving the problems that students encounter during progress of the project. This multi purpose ladder is tested to gather the information whether this product is functional or not.

This mutlit purpose ladder is different from other product in current market because it can be used as a trolley.

5.2 **RECOMMENDATIONS**

Several recommendations that I would like to express for the more improvement to the future work:

- i) Material :Many types of material can be used in fabricating a multi purpose ladder. The most important thing should be considered to choose material is strength, durability, and toughness. Mild steel hollow bar that has been used for this project may not suitable because it too heavy for multi purpose ladder. Other suitable material that can be use is aluminium alloy or stainless steel because of weight, durability, does not rust and it's toughness.
- ii) Market :This product should be made as a product for marketing stage because there not many ladders can be change into trolley.
- iii) Time :Give more time for student to done the final year project. This is because the application tools for fabricating process are too limited.
 Furthermore the students have class to attend.
- Iv) Budget :The budget must be prepared earlier and specific to make sure there is no budget problem

5.3 CONCLUSION

For the conclusion, all objectives for this project is successfully achieve.

- The product can be fold because of the hinge
- Its also easy to bring because the product is attach with wheel
- The product can be used to do maintenance at a high and medium high place.
- The product is multi function because it can be change into trolley and can carry other thing

Although there is some problem and the fabrication process is started late, the project is still can be done on time. The most important thing to make sure this project can be done on time is based on project management. After the fabrication process is finish, the product will be test as prototype whether it functional or not.

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APPENDIX A

DESIGN PARTS



Ladder Frame



Stairs Part



Base Ladder Part



Support Part



Hook Part



Hinge



Bolt



Nut



Wheel

APPENDIX B

PART OF ASSEMBLY



APPENDIX C



ORTHOGRAPHIC VIEW

APPENDIX D

COMPLETED PRODUCT

