DESIGN AND FABRICATE KNEE WALKER FOR MALAYSIAN ELDERLY AND DISABLE PEOPLE

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ABSTRACT

This thesis is about designing and fabrication of the Knee Walker. The Knee Walker is one of the walking aid for elderly and disable people. The knee walker is a mobility assistance device used by people who have suffered an injury or who are recovering from surgery that has temporarily left them without full use of one of their legs. To achieve the objective of the project, the knee walker must be design for the users that have problem with their injury below the knee that could be Achilles tendon injury, a fracture of foot or ankle and gout problem.

The knee walker should be fabricated using welding process and other laboratory process such as drilling process, grinding process and cutting process. This project flow is start from gathered the information, design a concept then fabricated the project. Before the fabricated start all the information are gathered from the source such as internet, book and journal. It is important to know the basic about the knee walker to know about it advantages and disadvantages of the product from other walking aid. The fabrication process must follow step by step to ensure the result fabricated is lightly as the design. The result of fabrication is slightly as the finalized design. From the result obtain also significantly reduce the cost and time to market, and improve product reliability and customer confidence.

ABSTRAK

Tesis ini tentang proses mereka bentuk pengerak lutut. Pengerak lutut amatlah salah satu bantuan untuk berjalan untuk orang tua dan orang kurang upaya. Pengerak lutut adalah satu dari alat dari bantuan yang menbantu yang digunakan oleh orang tua atau orang yg baru pulih dari pembedahan. Untuk mencapai objektif projek ini pengerak lutut haruslah direka mengikut kesesuaian pengguna yang mengalami kecedaraan Achilles tendon, kepatahan kaki atau buku lali serta gout.

Pengerak lutut ini direka bentuk mengunakan proses seperti kimpalan sertaproses lain seperti pemotongan, pencanaian serta mengerudi. Aliran projek bermula dari mengumpul data, mereka konsep serta membentuk projek tersebut. Sebelum projek ini direka segala maklumat dikumpulkan dari berbagai sumber seperti dari intenet, buku serta jurnal. Ini sangat penting untuk mengetahui segala maklumat asas produk tersebut supaya segala kelebihan dan kekurangan ini dapat diatasi dari produk bantuan jalan yang lain. Proses mereka hendaklah mengikut segala langkah demi langkah untuk mendapat keputusan yang seperti diinginankan. Daripada keputusan yang diperolehi terdapat beberapa keputusan ketara yang berubah seprti kos yang dapat dikurangkan dan masa untuk memasarkan juga singkat. Ianya juga meningkatkan kebolehpercayaan keyakinan penguna untuk memilikinya.

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LIST OF SYMBOL

ε	Total strain, Bandwidth parameter
$\sum$	Total Summation
σ	True stress, Local stress
E	Young's Modulus
F	Total Force acting
A	Total Area

LIST OF ABBREVIATIONS

DC	Direct Current
AC	Alternating Current
GMAW	Gas Metal Arc Welding
FCAW	Flux Core Arc Welding
GTAW	Gas Tungsten Arc Welding
SAW	Submerged Arc Welding
MIG	Metal Inert Gas
TIG	Tungsten Inert Gas

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Recently, knee walker is an alternative product that has been produced to help elderly and disable people to walk without any help from others. This device can help them to walk instead of uses wheelchair or crutches and that devices become more friendly and easy to use. Furthermore, the device is unique and gives more advantages to the user to improve their life personality.

The need of this device is extremely important because when we glance into this common life most of the people live independently. As a matter of fact, the winner will be the one who that run together with the current situations. In this world, we have to deal with the many different types of people and sometimes not all the people can help us, so with the help of this device we not need any assistance. All of these now come in virtual medium.

Therefore, for normal it is not the main problems to get use with it, but for the elderly and disable people they have to survive in order to full fill the requirement of this life. This problems are become the main point that give an ideas to invent the product of knee walker. Moreover to develop this product some development process must be done such as product planning, identifying customer needs, product specifications, generate concept and concept selections. The development process can be achieved when some different functional area work in team to do the activities and solve the problems.

1.2 BACKGROUND

There are several different types of mobility devices that someone who has a leg injury might use. Some of these devices have been in use for centuries. A knee walker is a device that is used to provide mobility support to someone recovering from an injury or procedure on the foot, knee, or hip of one leg. Similar to a scooter, the user places one leg on the device and uses the other leg to propel the device forward. Steering is accomplished by turning the handlebars and using handbrakes if the device is equipped with these items. Compared to other devices, this rehabilitation device is generally easier to use. Moving up or down hills with this device can be challenging as the user will be fighting gravity in both directions. Moving downhill can be quick and pleasant with a quality walker that features good steering and handbrakes, but moving uphill will be a challenge with any walker and steeper hills should be avoided if possible.

1.3 OBJECTIVE

They are several objective of this project that need to be achieved:

1. To improve the function and characteristics of the knee walker.
2. To help the person to have a product that is easy to store and bring. It also portable.
3. To reduce the energy consumption for elderly and disable person who have difficulties to walk.

1.4 SCOPE

They are several scope of this project:

1. This knee walker is suitable for the elderly and disable person.
2. To fabricate the product that portable and can bring to anywhere.
3. The knee walker can be detached parts by parts and can be assemble easil

1.5 PROBLEM STATEMENT

Human are born with different condition not all of them are given completed part of body for example the disable people and the elderly that have health problem. Besides, they also want to run their lives like normal people. Furthermore, the live is affect by the problem that occurred to them. They also have their right to feel the same like normal people to get deal with current environment. What the inventors need to do is try to design usable device that can help the elderly and disable people to be on running like normal people.

Several of these elderly and disable can be effectively deal with by using conventional devices most are already familiar with a wheelchair to help someone that cannot walk a hearing aid to help the hard of hearing ,or even something as simple as a magnifying glass to enlarge the fine print for someone that has vision problem.

For the last few decades, scientists and engineers have developed special devices for the disabled that have greatly advanced the conventional ones that already exist. Almost all of these current devices would not exist without the incorporation of computers and computer technologic.

Since today they are many alternative ways are created for the person that have a problem from their knee until the knuckle and their parts of leg. So scientist and engineer have work to created many mobility devices to help them to walk without any assistance. But in this world that need every one to life in their own foot the product need to be improve from the product that already in the market.

Such as the characteristic and the function need to be highly improve and can be used in the different situations that always can help the person that use it. For an example the characteristics that been improved such as the weight, function, design and others.

1.6 GANTT CHART

		Week													
Activity		2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature review	Plan														
	Actual														
Sketching and designing	Plan														
	Actual														
Material listing and preparation	Plan														
	Actual														
Fabrication process	Plan														
	Actual														
Mid semester presentation	Plan														
	Actual														
Analysis and testing	Plan														
	Actual														
Final presentation	Plan														
	Actual														
Thesis writing and submission	Plan														
	Actual														

Figure 1.1: Gantt Chart

Notes:

	Plan
	Actual

Based on the Gantt Chart from figure 1.1, this project started with the literature review on the 2nd week until the 3rd week. On this time, all the information about the knee walker needs to find out from internet, books and other resources such as journal. Then from this week the example and concept can be identified.

On the 3rd week until 4th week, the sketching process is been made. All the information gather from the literature review give the idea to decide the concept of the product in order to fulfil the customer need. After the concept is decided, the concept will be design using SolidWork based on the dimension.

The project continues with the material listing and preparation process. It took two weeks in order to decide the suitable material that can been used in the project according to availability in the store. The material used need to be given enough strength to support the load from human body but light to be easier the product been used and moves.

After get all the material from the store and buy from hardware outside, the fabrication process took place from 6th week until 13th week. On this fabrication process, it will start by measuring the material to desire dimension according to the dimension in the drawing. Then it will follow by cutting the material, welding all the parts into the specified parts, drilling and grinding. After all it finishes, the finishing process is done to complete the fabrication process. After it done, the product need to be testing and the result must be used to make sure it suitable for been use.

There are two parts of presentation which is on 8th week and 14th week. On the 8th week, the mid semester presentation been held, where the student need to present the progress on the project. On the 14th week, student need to present and explain about the work done for the project and do the simulation in front of panels.

Report writing took about six week to complete starting from 8th week until 15th week. On this report, all the information should be include starting from the literature review until the result and discussion. The final report must be submitted on 15th week of study.

1.7 FLOW CHART

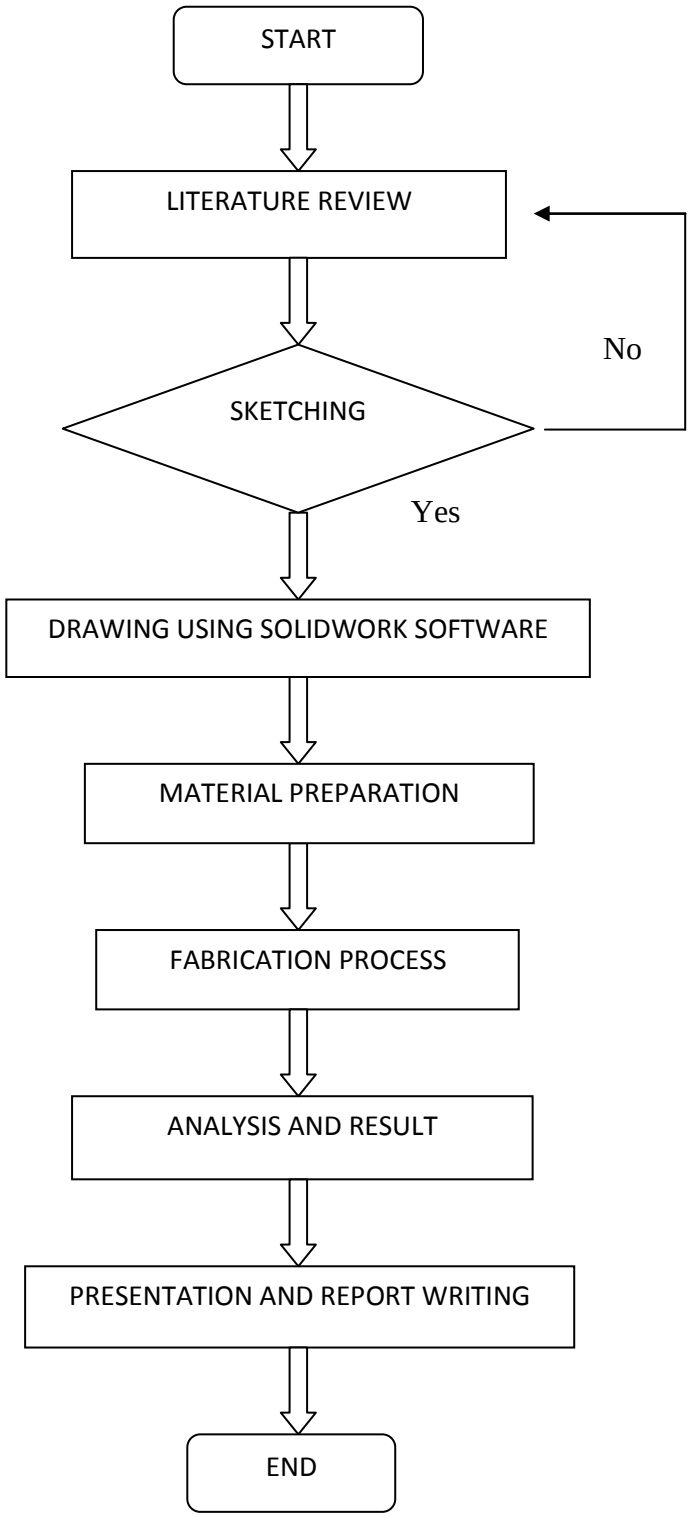

Figure 1.2: Flow Chart

Figure 1.2 show a flow diagram of the project. It started with literature review where all the information about the product is collected. The sources are from relevant article in the internet, book and other resources. From the literature review all the users need for the knee walker are gather and will try to improve the characteristic.

After getting all the information, the idea to generate the concept can be put in the design. Then, the character of the walker will improve. Sketch at least three concepts and then decide which concept is most suitable for the user. If the concept is not suitable, all the information need to be gather again. After decide which concept is best for the user the concept need to be draw into the software application such as Solidwork. The drawing should consist of 2D and 3D.

After that the process follow is material listing and preparation. Purpose of this process is to determined which material is suitable for the product. The material should give enough strength and lightweight so that is more users friendly. After that, also need to list the component and purchase if necessary.

Then the fabrication process will start. The process is consist few of manufacturing process depend on the product. The process including measuring, cutting, welding, drilling and grinding. Then after all the process is done, the product will assemble and then finalized. After that, the product need to be test and simulate. The product need to be analysis to see how it can support the load from the human body and user friendly so the product can be improve.

Finally, after getting the result, the preparation of presentation and writing report need to be prepare. Both should have entire process of the project including introduction, literature review, methodology and other. The report should be submitted at the end of the semester.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, it will discuss about the product that already have in the market. From the product the idea will be generated to form one other product that will improve from the older product. Besides that, this chapter also discuss about the machining process used in build the product. The measurement for the product is based on anthropometric data for Malaysian people. The anthropometric data will be used to measure the height of Malaysian for the suitability with the product to make it more users friendly.

In order to come out with the sufficient design, some review should be made so the idea of characteristic can be determined and the requirement of the need for this product suitable with the current situation. In this chapter, the review is based on the existing products and also the ergonomic consideration to walking purpose. In this chapter, I will review about the products in details. The products in the market and the product that will improve the function and it characteristics.

Reviewing the existing product can bring out the idea generation on how to design and define the characteristics of product. The idea can be gathered from the concept such as usable features, material used, design shapes that invented which can be relate to product that will be designed.

2.2 PRODUCT REVIEW

They are many types of knee walker in the market. There have same purpose that is to make people that have problem with their knee to walk in easy ways. The design of knee walker must be done carefully so the design can be fabricated and functioning. There aspects that must be considered in the designing the Knee walker is:

a. Ergonomic: Knee Walker must be user friendly as easy to be use, assemble and bring
   to everywhere.
b. Strength: It is the second of important criteria in designing the easy assembled knee
   walker. This is because the knee walker is used for the person that
   has the health problem.
c. Material: An available material is one of the aspects that must be considered. The chosen depend on the usage.
d. Cost: The cost of whole system must been not exceed the budget given and it also reasonable.
e. Environment: The Knee walker is suitable for used in all places such as home, park and etc.
f. Measurement: The measurement of the Knee Walker is suitable for Malaysian people height.

2.2.1 Product A

Roller Aid Knee Walker with Swivelling Front Wheels

Figure 2.1: Product A

(Source: http://www.allegromedical.com/walkers-c516/rolleraid-p216973.html)

The design shows in figure 2.1 is the walker that already has in the market. The walker is made from lightweight aluminium for it body frame. The height for the seat can be adjustable from 4’10 to 6’4. The walker also has a high stability to be use for the person that has the knee problem.

Table 2.1: Characteristic of product A

Advantages	Easily adjustable for heights from 4'10" to 6'4", Lightweight, Wide flat free tires give extra stability, Easy folding mechanism makes transporting unit a breeze, Adjustable tiller & knee pad to accommodate different user heights.
Disadvantages	Have to have good knees, Need to take up thin rugs, Cannot negotiate staircase
Material	Body frame: Aluminium Cushion: Foam
Price	RM 595

2.2.2 Product B

Weil Knee Walker

Figure 2.2: Product B

(Source: http://www.activeforever.com/p-1951-weil-knee-walker.aspx)

The walker show in figure 2.2 is the other design that also already in the market. The chassis of the 2nd design is different from the 1st design. It has three unique wheel design for a better turn control. The size of the walker also smaller and it fits through any standard doorways. It also accommodates all the people height. The paint of the

walker is three coated paint for better durability so users not worried about the colour that been varnished at the environment.

Table 2.2: Characteristic of product B

Advantages	Large storage basket, Thicker padded seat for comfortable, Locking handle brake, handle and seat adjustable, made from strong but durable for long term use.
Disadvantages	Cannot be use in small place like toilet, Cannot negotiate staircase, Need to have good knee because pressure concern at the knee.
Material	Body frame: Alloy steel Cushion: memory foam
Price	RM 399

2.2.3 Product C

Forward Mobility Voyager Seated Scooter Knee Walker

Figure 2.3: Concept 3

(Source: http://www.kneewalkershop.com/voyager-rolling-leg-knee-walker-scooter-caddy-with-seat.html/)

The picture show in figure 2.3 is the 3rd design of the knee walker that already in the market. The design is different from other two walkers because the chassis is more slightly like scooter. It has a comfortable seat with shock absorbing suspension. It gives more comfortable to the user to use the walker.

Table 2.3: Characteristic of product C

Advantages	Folds compactly for easy storage & transport, Works for left or right legs without adjustment, Stability to pass through many surface, Handgrip , footrests and seat can easily be clean, Lightweight
Disadvantages	Need to have good knee, Unsafe, Cannot negotiate staircase
Material	Body frame: Stainless steel
Price	RM 409

2.3 FABRICATION PROCESS

There is several processes that involving in this project. It includes welding, drilling, grinding and cutting process.

2.3.1 Welding

Welding is a fabrication or sculptural process that joins materials, usually metal 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 (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the workpieces to form a bond between them, without melting the workpieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space. Welding is a potentially hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense.

Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, and/or slag.

Gas metal arc welding (GMAW), also known as metal inert gas or MIG welding, is a semi-automatic or automatic process that uses a continuous wire feed as an electrode and an inert or semi-inert gas mixture to protect the weld from contamination. Since the electrode is continuous, welding speeds are greater for GMAW than for SMAW. A related process, flux-cored arc welding (FCAW), uses similar equipment but uses wire consisting of a steel electrode surrounding a powder fill material. This cored wire is more expensive than the standard solid wire and can generate fumes and/or slag, but it permits even higher welding speed and greater metal penetration.

Gas tungsten arc welding (GTAW), or tungsten inert gas (TIG) welding, is a manual welding process that uses a nonconsumable tungsten electrode, an inert or semi-inert gas mixture, and a separate filler material. Especially useful for welding thin materials, this method is characterized by a stable arc and high quality welds, but it requires significant operator skill and can only be accomplished at relatively low speeds. GTAW can be used on nearly all weldable metals, though it is most often applied to stainless steel and light metals. It is often used when quality welds are extremely important, such as in bicycle, aircraft and naval applications. A related process, plasma

arc welding, also uses a tungsten electrode but uses plasma gas to make the arc. The arc is more concentrated than the GTAW arc, making transverse control more critical and thus generally restricting the technique to a mechanized process. Because of its stable current, the method can be used on a wider range of material thicknesses than can the GTAW process and it is much faster. It can be applied to all of the same materials as GTAW except magnesium, and automated welding of stainless steel is one important application of the process. A variation of the process is plasma cutting, an efficient steel cutting process.

Submerged arc welding (SAW) is a high-productivity welding method in which the arc is struck beneath a covering layer of flux. This increases arc quality, since contaminants in the atmosphere are blocked by the flux. The slag that forms on the weld generally comes off by itself, and combined with the use of a continuous wire feed, the weld deposition rate is high. Working conditions are much improved over other arc welding processes, since the flux hides the arc and almost no smoke is produced. The process is commonly used in industry, especially for large products and in the manufacture of welded pressure vessels. Other arc welding processes include atomic hydrogen welding, electroslag welding, electrogas welding, and stud arc welding.

2.3.2 Cutting

Cutting is a collection of processes wherein material is brought to a specified geometry by removing excess material using various kinds of tooling to leave a finished part that meets specifications. The net result of cutting is two products, the waste or excess material, and the finished part. If this were a discussion of woodworking, the waste would be sawdust and excess wood. In cutting metals the waste is chips or swarf and excess metal. These processes can be divided into chip producing cutting, generally known as machining. Burning or cutting with an oxyfuel torch is a welding process not machining. There are also miscellaneous specialty processes such as chemical milling.

Cutting is nearly fully represented by:

- Chip producing processes most commonly known as machining
- Burning, a set of processes which cut by oxidizing a kerf to separate pieces of metal
- Specialty processes

Drilling a hole in a metal part is the most common example of a chip producing process. Using an oxy-fuel cutting torch to separate a plate of steel into smaller pieces is an example of burning. Chemical milling is an example of a specialty process that removes excess material by the use of etching chemicals and masking chemicals.
There are many technologies available to cut metal, including:

- Manual technologies: saw, chisel, shear or snips
- Machine technologies: turning, milling, drilling, grinding, sawing
- Welding/burning technologies: burning by laser, oxy-fuel burning, and plasma
- Erosion technologies:by water jet or electric discharge.

Cutting fluid or coolant is used where there is significant friction and heat at the cutting interface between a cutter such as a drill or an end mill and the workpiece. Coolant is generally introduced by a spray across the face of the tool and workpiece to decrease friction and temperature at the cutting tool/workpiece interface to prevent excessive tool wear. In practice there are many methods of delivering coolant.

2.3.3 Grinding

Grinding uses an abrasive process to remove material from the workpiece. A grinding machine is a machine tool used for producing very fine finishes, making very

light cuts, or high precision forms using an abrasive wheel as the cutting device. This wheel can be made up of various sizes and types of stones, diamonds or inorganic materials. The simplest grinder is a bench grinder or a hand-held angle grinder, for deburring parts or cutting metal with a zip-disc.

Grinders have increased in size and complexity with advances in time and technology. From the old days of a manual toolroom grinder sharpening endmills for a production shop, to today's 30000 RPM CNC auto-loading manufacturing cell producing jet turbines, grinding processes vary greatly. Grinders need to be very rigid machines to produce the required finish. Some grinders are even used to produce glass scales for positioning CNC machine axis. The common rule is the machines used to produce scales be 10 times more accurate than the machines the parts are produced for.

In the past grinders were used for finishing operations only because of limitations of tooling. Modern grinding wheel materials and the use of industrial diamonds or other man-made coatings (cubic boron nitride) on wheel forms have allowed grinders to achieve excellent results in production environments instead of being relegated to the back of the shop. Modern technology has advanced grinding operations to include CNC controls, high material removal rates with high precision, lending itself well to aerospace applications and high volume production runs of precision components.

2.3.4 Drilling

Drilling is the most common machining process whereby the operation involves making ground hole in the metallic and nonmetallic. Approximately 75% of all metal cutting process is of the drilling operation. Drills usually have a high length to a diameter ratio that is capable of producing deep hole. However due to flexibility, necessary precaution need to be taken to maintain accuracy and prevent drill from breaking. Drilled hole can be either through holes or blind holes. A through hole is made when a drill exits the opposite side of the work, in blind hole the drill do not exit the

workpiece. During the operation, chip that produces within the workpiece must exit through the flute to the outside of the tool. As the chip is formed and extracted towards the surface, it will generated friction. Friction subsequently heat is also generated when the drill bit touch the workpiece during the hole making process. Therefore, chip disposal and cutting fluids are among the most important element that need to be consider during this process. Normally, holes produced by drilling is bigger than the drill diameter and depending on its applications, the drill holes will subjected to the other operation such as reaming or honing to better surface finish and dimensional accuracy.

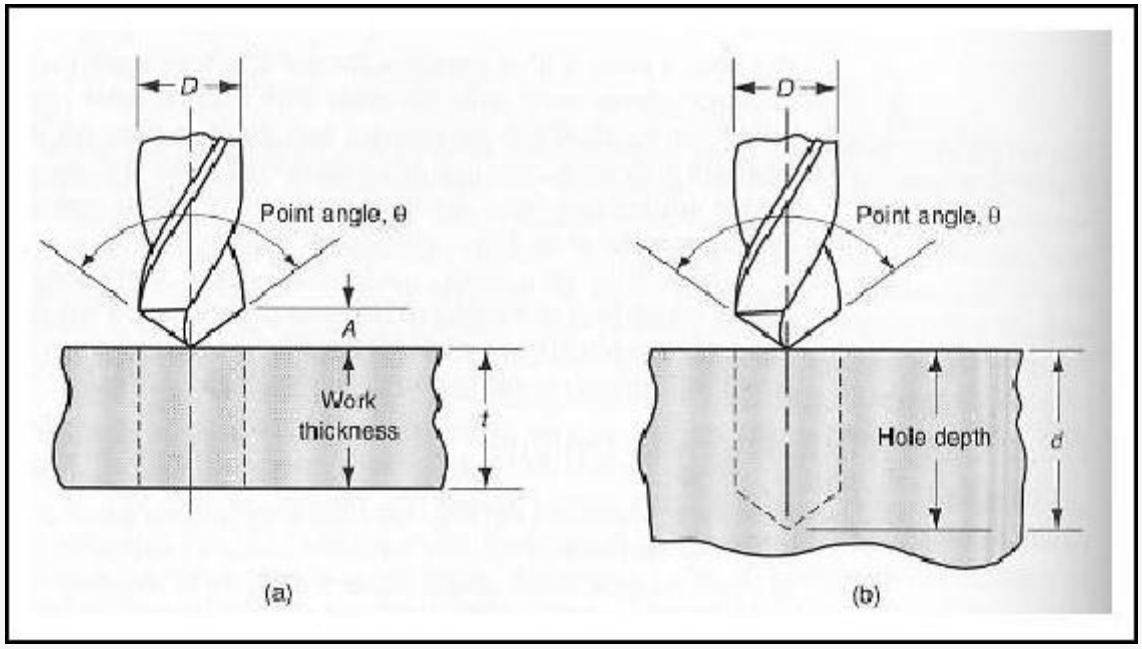

Figure 2.4: Two holes types: (a) through hole and (b) blind hole

The figure 2.4 show the two types of drilling hole. The first picture is through hole and the second picture is blind hole. The two type of hole is different from each other. The through holes been drilling until the hole penetrating. The other types is drill the hole not exceed the workpiece.

There are also several apparatus needed during drilling operation:

i. Drilling machine
ii. Center punch
iii. Hammer
iv. Center drill
v. Coolant
vi. Vernier caliper
vii. Two flute drill set
    - Center drill
    - Countersink drill
    - Counter bore drill
    - Drill various diameter

2.4 ANTROPOMETRIC DATA

Anthropometry is the measure of wo/man (anthro=man, pometry=measure). The study of anthropometry is the study of human body measurements to assist in understanding human physical variations and aid in anthropological classification.Anthropometric history is a term coined in 1989 by John Komlos to refer to the study of the history of human height, focusing on explaining secular trends, cycles of various lengths and cross sectional patterns by changes in the. The systematic study of human physical stature reaches back into the 18th century (Tanner, 1981). By the 1830s, Adolphe Quetelet and René Villermé recognized that biological outcomes were influenced by both the natural and the socio-economic environment (Villermé, 1829, Quetelet, 1842). However, until French historians of the Annales School began to explore the socio-economic correlates of human height in the 1960s, the topic interested primarily scholars of sister disciplines such as anthropology, auxology, or even military history (Emmanuel Le Roy Ladurie, Bernageau, and Pasquet, 1969).

The true expansion of the use of anthropometrics in the social sciences began in the mid-1970s among cliometricians who were interested in measuring living standards in the past primarily in order to understand better hitherto hidden effects of economic development on the growth of the human organism. Anthropometric history uses physical stature as an indicator of well-being to complement conventional indicators of living standards by the biological standard of living (Baten, 2000; Craig and Weiss, 1998; Cuff, 2005; Steckel, 1995; Sunder, 2004; Woitek, 2003).

Nevertheless, this is not to say that height itself has a direct benefit on economic success or an increased standard of living. Rod Usher's "A Tall Story For Our Time" shows that one's tallness is a product of favorable living conditions. Thus, growth in human height within a designated area could well be an accurate measurement of economic growth and development there.The anthropometric data is different between the locations of people. The height and weight of Europe people is not same as height and weight of Asia people. All the body parts measurement also not same for all of people in this world. This anthropometric data is important in design a product for human so it became suitable at the people of the area.

Table 3. Relationship between Body Mass Index (BMI) category and gender (n=230)

Gender	BMI Category				Total
	Underweight (Below 18.5)	Normal (18.5-24.9)	Overweight (25.0-29.9)	Obesity (30.0 and over)	
Male	5	60	51	13	129
	3.9%	46.5%	39.5%	10.1%	100.0%
Female	7	33	34	27	101
	6.9%	32.7%	33.7%	26.7%	100.0%
Total	12	93	85	40	230
	5.2%	40.4%	37.0%	17.4%	100.0%

x^2=13.260, df=3, p=0.004

Table 4. Chi-square analysis of BMI Category between Malay and Non-Malay (n=230)

Ethnicity groups	BMI Category				Total
	Underweight (Below 18.5)	Normal (18.5-24.9)	Overweight (25.0-29.9)	Obesity (30.0 and over)	
Malay	7	62	66	39	174
	4.0%	35.7%	37.9%	22.4%	100.0%
Non-Malay	5	31	19	1	56
	8.9%	55.4%	33.9%	1.8%	100.0%
Total	12	93	85	40	230
	5.2%	40.4%	36.9%	17.5%	100.0%

x^2=16.580, df=3, p=0.001 Cramer's V =. 268

Figure 2.5: BMI for Malaysian people

The table in figure 2.5 show the anthropometric data for the relationship between Body Mass Index (BMI), category and gender. It show the different of BMI between Malay and Non Malay. The figure show also the different of the BMI between man and women. This is important to design of product because from the data the product will develop according to the anthropometric data of people.

2.5 ANALYSIS EXPLANATION

For this project several of analysis is been used to analysis the product after is finish to be fabricated. The analysis such as stress analysis, deformation analysis and displacement analysis. All the analysis is using software to created it.

2.5.1 Stress

Stress analysis is used to determine the stress in materials and the structure subjected to static or dynamics forces or load. The aim of this analysis is usually to determine whether the structure is safely withstanding the specified forces. This is to achieved when determine stress for applied forces is less than the ultimate tensile and so on. The load that been applied is 1000N as the forces. The load is just an assumption of weight capacity from human body to the product.

Stress is the measure of the average amount forces that exerted per unit area. It is the measure of the intensity of the total internal forces acting within a body across the imaginary internal surfaces, as the reaction to external applied forces and body forces. It was introduced into the theory of elasticity by Cauchy around 1822. Stress is a concept that is based on the concept of continuum. In general stress can be expressed as:

Stress, $\sigma = \frac{F}{A}$

Where:

- σ is the average stress, also called engineering or nominal stress
- F is the force that acting
- A is the area of the force acting

2.5.3 Displacement

Displacement is the vector that specified the position of the point or a particle in the reference to a previous position, or to the origin of the chosen coordinate system. When the reference point is the origin, this is better to as a position.

A displacement vector is simplified represent of motion. Namely, it indicates both the length and direction of hypothetical motion along a straight line from the reference point to actual point. A motion along the curved line cannot be represent by a single displacement vector, and may be described as a sequence of a very small displacement. On the other hand, a distance is typically defined as scalar quantity and can be used to indicate both the length of displacement (minimum distance) and the length of a curved path (travelled distance), but not the direction of motion.

When the reference point is a previous position, the displacement vector is difference between the final and the initial position. The difference is divided by the time needed to perform the motion, defines as the average velocity of the point or particle.

2.5.3 Deformation

Deformation is a change in the shape or size of an object due to an applied force. This can be a result of tensile (pulling) forces, compressive (pushing) forces, shear, bending or torsion (twisting). Deformation often describe in terms of strain.

As deformation occurs, internal inter-molecular force arise which oppose the applied force. If the applied force is not too large these force may be sufficient to completely resist the applied force, allowing the object to assume a new equilibrium state and to return to its original state when the load is removed. A large applied force may lead to a permanent deformation of the object or even to its structural failure.

- Elastic deformation

This type of deformation is reversible. Once the force are no longer applied, the object returns to its original shape. Elastic deformation is governed by Hooke's Law which states:

$$\sigma = E\,\varepsilon$$

Where σ is the applied stress, E is a material constant called Young's modulus, and ε is the resulting strain. This relationship only applies in the elastic range and indicates that the slope of the stress vs. strain curve can be used to find Young's modulus. Engineers often use this calculation in tensile tests. The elastic range ends when the material reaches its yield strength. At this point plastic deformation begins.

- Plastic deformation

This type of deformation is not reversible. However, an object in the plastic deformation, which is reversible, when the force is release, so the object will return part way to its original shape.

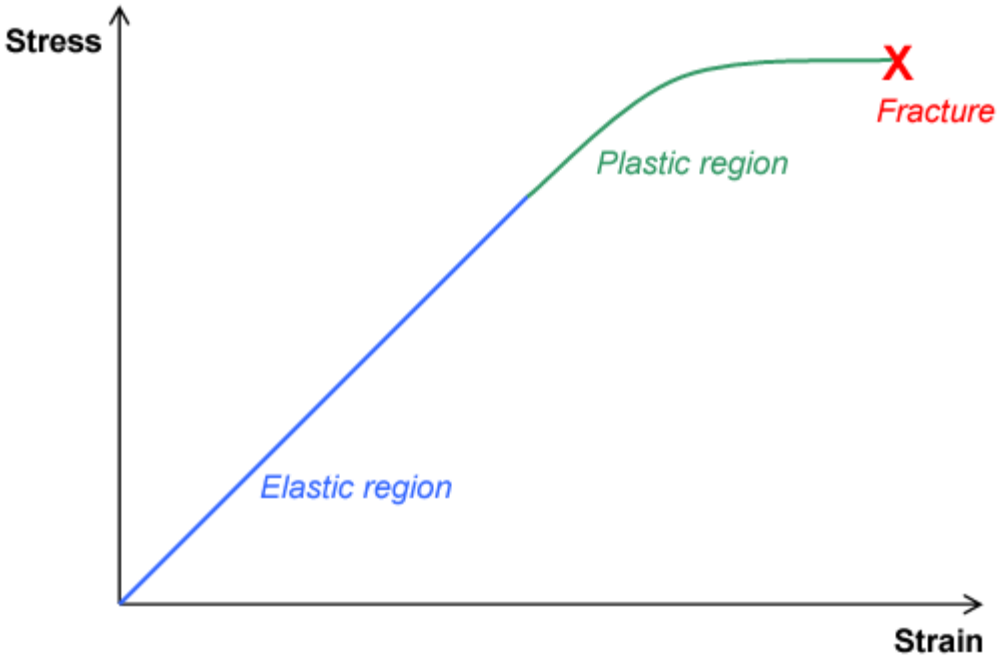

Figure 2.6: Stress-strain graph

The figures 2.6 show the stress-strain graph. It shows the region elastic deformation and plastics deformation. The deformations happen before the fracture.

Under tensile stress plastic deformation is characterized by strain hardening region and a necking region and finally, fracture (also called rupture). During strain hardening the material becomes stronger though the movement of atomic dislocations. The necking phase is indicated by a reduction in cross-sectional area of specimen. Necking begins after the Ultimate Strength is reached. During necking, the material can no longer withstand the maximum stress and the strain in the specimen rapidly increases. Plastic deformation ends with the fracture of the material.