



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of Linear Positioning Table for Drilling Machine

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Bachelors of Engineering Technology Process) (Hons.)

اونيورسيتي تيكنيكل مليسيا ملاك

by
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABDUL FATTAH BIN ABD RAHIM

B071310645

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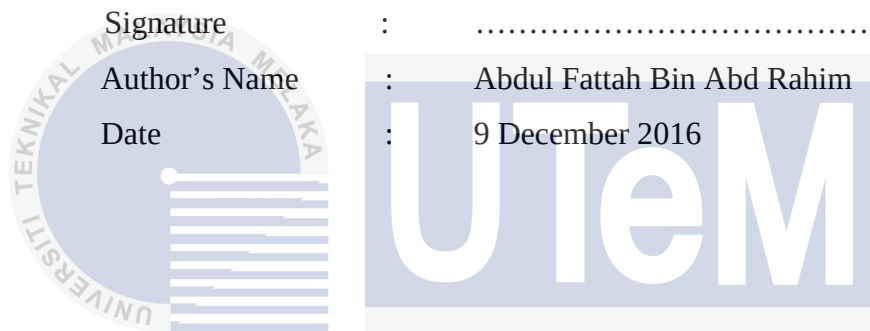
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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process And Technology) with Honours. The member of the supervisory is as follow:



ABSTRAK

Operasi penggerudian adalah satu operasi yang menghasilkan lubang dengan membawa pemotong berputar menyentuh dengan bahan kerja. Operasi penggerudian biasa dilakukan dalam mesin gerudi tekan namun beberapa masa di kilang atau mesin bubut. Mesin gerudi datang di dalam pelbagai bentuk dengan yang paling biasa digunakan sebagai model bangku-atas, model rantai berdiri, model magnet dan model jejarian. Setiap model mempunyai perbezaan dari yang lain, kebanyakannya dari segi keperluan kuasa, keupayaan, kemampuan dan mudah alih. Memegang bahagian-bahagian yang hendak digerudi adalah salah satu masalah utama yang dihadapi oleh pelajar. Jika bahan yang mempunyai banyak lubang yang hendak digerudi, maka prosedur yang diterima pakai adalah menandakan dengan menumbuk pusat, menetapkan pada mesin (Drill Press Machine), dan tahan bahan kerja. Ini akan memakan masa dan mungkin berbahaya kerana pelajar perlu memegang bahan itu sendiri sepanjang proses penggerudian. Projek ini membentangkan inovatif meja kedudukan linear untuk memudahkan operator semasa proses penggerudian. Selain itu, sistem pengapitan juga akan disediakan yang menyediakan ketegaran yang lebih baik dan kurang pergerakan bahan kerja semasa proses penggerudian. Seseengah pengapit togol adalah tetap di atas meja untuk selamat memegang jawatan sebagai sebahagian daripada bergerak sepanjang kitaran pemesinan. Tambahan pula, projek ini juga akan memberi tumpuan kepada bagaimana untuk membuat proses penggerudian boleh dilakukan dalam satu pengapitan tunggal. Reka bentuk mudah dan ekonomi adalah dicadangkan untuk membangunkan projek ini yang dijangka akan menunjukkan masa yang hebat penjimatan dalam pengeluaran. Terdapat linear lain yang serupa jadual digunakan gelongsor, tetapi perbezaan utama ialah dalam tujuan yang dimaksudkan. Tiada jadual linear yang sedia ada telah direka untuk digunakan pada mesin gerudi akhbar. Linear meja X-Y dibentangkan di dalam tesis ini mempunyai ruang kerja yang jauh lebih besar.

ABSTRACT

Drilling operation is an operation which producing holes by bringing a rotating cutter into contact with the workpiece. Drilling operation commonly done in drill press however some of the time on mills or lathes. Drill presses come in several forms with the most commonly used ones being the bench-top model, the floor-standing model, the magnetic model and the radial model. Each model has its differences from the other, mostly in terms of power requirements, capacity, affordability and portability. Holding parts to be drilled is one of major problems faced by the students. If the material has many holes to be drilled, then the procedures adopted is marking out with a center punch, setting on machine (Drill Press Machine), and hold the workpiece. This will be time consuming and might be dangerous as the students need to hold the material themselves throughout the drilling process. This project presents an innovative linear positioning table to ease operator during drilling process. In addition, clamping system also will be provided which provides better rigidity and less movement of the workpiece during drilling process. Some toggle clamps are fixed on the table to securely hold the position of the part from moving throughout the machining cycle. Furthermore, this project also will be focused on how to make the drilling process can be done in one single clamping. A simple and economic design is proposed to develop this project which expected will shows a great time saving in the production. There are other similar linear sliding tables in use, but the main differences being in the intended purposes. None of the existing linear tables were designed for the use at drill press machine. The linear X-Y table presented in this thesis has a considerably larger workspace.

DEDICATION

I dedicate this thesis to my great family, who never stop giving off themselves in countless ways. For their endless love, support and encouragement that keep me moving forward. I also dedicate this thesis to all my dearest relatives, lecturers, and friends as without whom none of my success would be possible.



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In the name of Allah, the Most Merciful, the Most Compassionate all praise be to Allah, the Lord of the worlds and praise be upon Muhammad His servant and messenger, I would like to take this time to thank my supervisor or research advisor Dr. Norfariza Binti Ab Wahab for the opportunity to undertake this research project. She has provided me with endless amounts of support and guidance throughout the entire project. I would like to also thank Mr. Azimin, technician in the machine shop. Along with the machining of all of the components for the project, Mr. Azimin has been tremendous in helping with any design or assembly issues that I came across throughout this research project. Mr. Azimin's years of experience saved me countless hours in potential design flaws and mistakes. With the guidance and help from these two individuals my research experience has been nothing short of amazing. The effort and time of Dr. Norfariza and Mr. Azimin is much appreciated and greatly valued.

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CHAPTER 1

INTRODUCTION

1.1 Clamping System

A fastening device or can be known as clamp is used to grip objects securely to limits movement through the application of inward pressure. During high speed cutting process, clamping is very essential. The workpiece that are going to be machined must be clamp securely and tightly to get high precision and accurate results. However the main purpose of clamping is to hold the position of the object against the locators firmly throughout the machining cycle. The system can be described as follows:

- i. The clamp should not deformed the part or damage it.
- ii. The clamp should allow rapid loading and unloading of parts and be fast-acting.
- iii. The clamp must have enough strength to restrict its movement and hold the parts.

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1.1.1 Positioning

The positioning of the clamp should be as follows:

- i. Clamps must contact the work all the time throughout machining at its most rigid point.
- ii. To prevent force of the clamping from bending the part.
- iii. The part must be supported if the workpiece is clamped at a point where the force could bend the part.

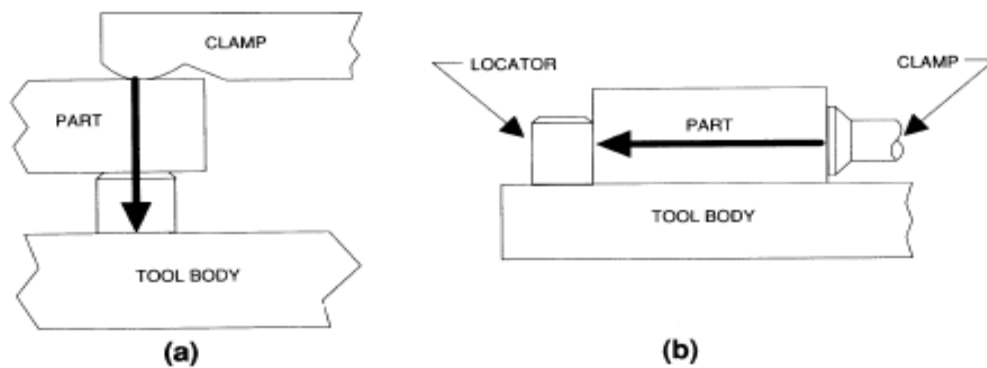


Figure 1.1 Illustration of Positioning in Clamping

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1.1.2 Tool Force

Tool force is caused by resistance of the workpiece being cut or sheared by the tool. Clamps are also positioned so they do not interfere with the operation of the tool or machine so that the operator can do the machining easily and safely. Most of the force is in a downward direction against the base of the tool and must be resisted cause the part to revolve around the drill axis.

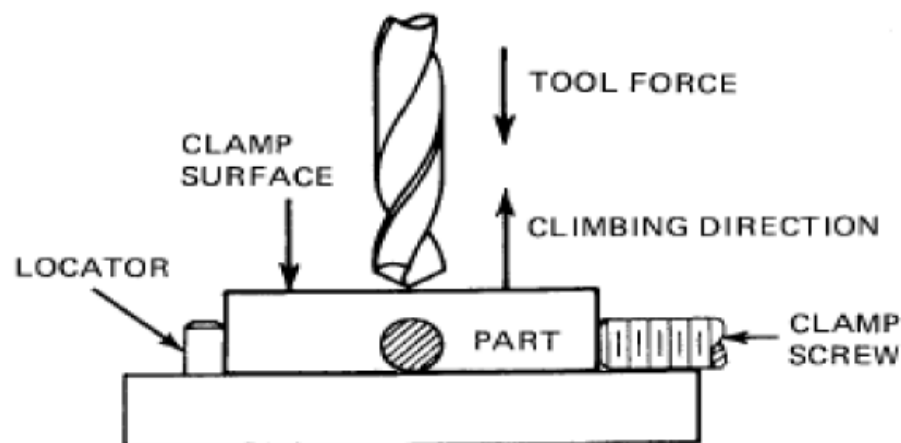


Figure 1.2 Illustration of Tool Force

1.1.3 Clamping Force

Force of clamping or can be called as clamping force is a force needed to hold a part against the locators. Thus, clamping prevents the part from shifting or being pulled from the jig or fixture during the machining operation. In addition, primary cutting forces should be directed to locators or supports rather than the clamps. The clamps should not be designed or required to resist cutting forces. Furthermore, clamping force should be sufficient to resist operation forces to keep part in position.

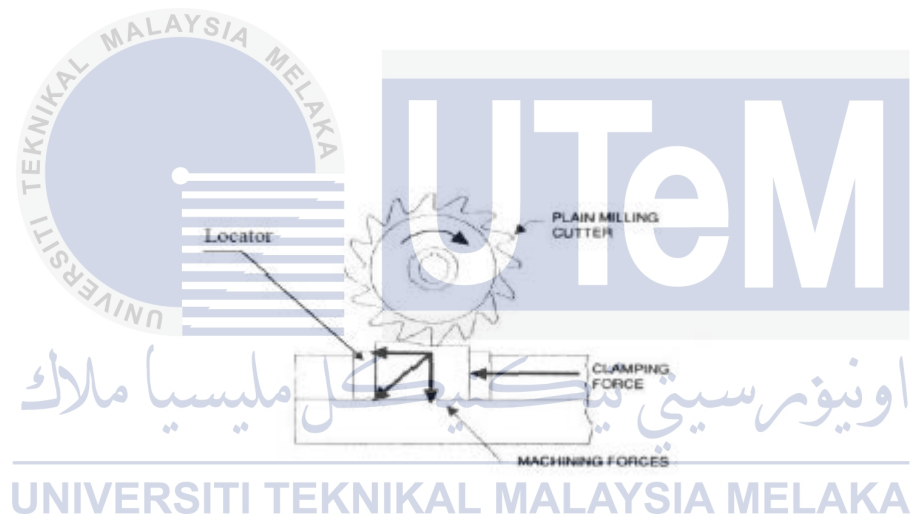


Figure 1.3 Illustration of clamping force

1.1.4 Types of Clamps

There are a few types of clamps which have their own characteristic and advantages which are:

1) Screw Clamps

It is most widely used mechanism in all kinds of fixtures.

Advantages:

- i. Simple structure
- ii. Large force increasing ratio
- iii. Reliable self-locking property

Disadvantages

- i. Slow operation speed which limits its applications in mass production and automated production.

2) Lever or Strap Clamps

- i. Strap clamps are used in almost every area of jig and fixture design and construction
- ii. The fulcrum is positioned so that the clamp bar is parallel to the base of the tool at all times.
- iii. Because of the slight differences in part thickness, this is not always possible.
- iv. To make up for these differences, spherical washers or nuts are used.

3) Power Clamping

- i. Power-activated clamps are an alternative to manually operated clamping devices.
- ii. Power clamping systems normally operate under hydraulic power or pneumatic power
- iii. Pneumatic or hydraulic use two types of cylinders:
 - Single-action cylinder
 - Double-action cylinder

Advantages

- i. Better control clamping pressures
- ii. Less wear on moving parts of the clamp
- iii. Faster operating cycles.

Disadvantages

- i. Costly

- ii. Easily offset by increased production speeds and higher efficiency.

4) Non-mechanical Clamping

Non-mechanical clamping is a workholding devices used to hold parts by means other than direct mechanical contact. Thus, it cannot be held with other devices due to the size, shape, or configuration of the fixtured parts. Furthermore, clamping forces must be applied evenly across the entire part to minimize any possible workpiece distortion. There are two principal forms of Non-Mechanical Clamping:

- i. magnetic clamping
- ii. vacuum clamping

Magnetic chucks are most often used to hold ferrous metals or workpieces made from other magnetic materials. While vacuum clamping are another style of chuck used to clamp difficult parts. While these chucks can hold almost any type of nonporous material, they are typically used for nonmagnetic materials or for parts that must be clamped uniformly. Vacuum clamping generally generated by a vacuum pump that draws out the air between the chuck face and the workpiece.

1.2 Problem Statement

- i. The current drilling machine being used by the students has no clamping device yet.
- ii. Less safety measure for that particular drilling machine.
- iii. Work piece that have a lot of part to be drilled need to be clamped many times.

1.3 Objective

The objective of this project is to design and also develop a clamping device for drilling machine. The specific research tasks to fulfill the objectives of this thesis are summarized as follows:

- i. To design a linear positioning table for drilling machines (ALZSTAR 30/S).
- ii. To select the best material for the linear table.
- iii. To develop a linear positioning table for drilling machine (ALZSTAR 30/S)
- iv. To evaluate the complete product by using surface roughness testing.



1.4 Project Scope

This project will only cover on:

- i. Design of the linear table for drilling machines is based on Drill Press Machine (ALZSTAR 30)
- ii. Materials that will be selected to develop this project are mild steel and aluminum.
- iii. Development of the linear positioning for drilling machine by using all machines that available at the laboratory.
- iv. The result of surface roughness testing will be used to evaluate the product.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Machining Process

Any of methods in which undesirable material is cut to get a desired size and shape with astounding surfaces and exact measurements with adequate tolerances can be called as machining process. As of now the material removal process also can be known as subtractive manufacturing, contrasts to process of material addition, which also can be called as additive manufacturing. In metal cutting, the temperature measurement of cutting tool is being influenced by cutting factors, especially in continuous cutting operation. Since the life of the cutting tool material strongly depends upon cutting temperature, it is important to predict heat generation in tool with reliable techniques (Gosai & Bhavsar, 2016).

Machining is not only involved in manufacture of metal products, in addition, it can be utilized on other materials, for example, wood and ceramic. These days, machining is done by using computers to do all the operation and advancement mills, lathes and other cutting machine which is known as Computer Numerical Control (CNC).



Figure 2.1 Example of Computer Numerical Control (CNC) Machine

(Kalpakjian, 2005) stated that machining process, included grinding, cutting, and other non-mechanical chips-less processes, are appealing or even vital for the accompanying major cause:

- i. Approximate dimensional tolerances, surface roughness or surface finish may be required than are accessible by powder metallurgy, casting, forming, and other forming processes.
- ii. Materials geometries may be excessively intricate or costly to be manufactured by other processes.

2.1.1 Conventional Machining Process

In conventional machining, the capability of the cutting tool is used to pressure the material pass the yield point to begin the process of material removal. Material of the cutting tool is required to be harder than material of the workpiece. The advents of hard and strong materials for aerospace industry causing the process of material removal by conventional ways become very in addition to time consuming. This is due to material removal rate diminishes with harder workpiece.

(Kharagpur, n.d.) Stated that the major attributes of conventional machining includes of:

- i. At room temperature, work-piece is softer than cutting tools moreover under certain of machining condition.
- ii. Commonly, certainly seen chip formation by shear deformation.
- iii. Material happens as a result of cutting forces – energy may be named mechanical.

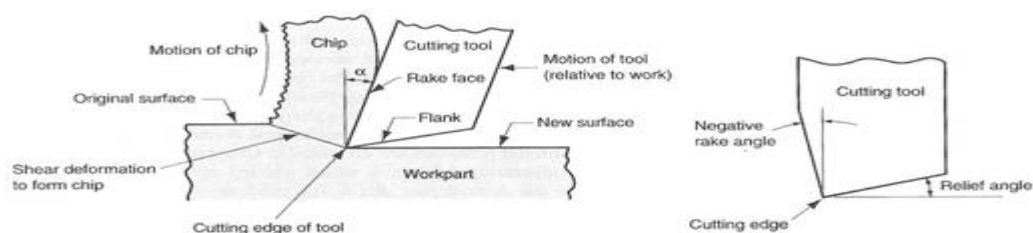


Figure 2.2 Machining Theory

Contact machining or conventional machining generally includes using an implement made of a harder material to change over the shape of a work piece. By using conventional way to machine hard and strong materials, can causes increased demand of energy and time and consequently increment in costs; and in a few cases, conventional machining won't be sensible. Conventional machining moreover costs with respect to tool wear and in loss of quality in product owing to induced residual stresses during manufacture. With consistently growing demand for manufactured goods of metals and hard alloys, for instance, titanium has slanted toward non-conventional machining strategies. Conventional machining can be described as a procedure using mechanical (motion) energy while non-conventional machining uses different types of energy. A few case of conventional machining procedure are turning, drilling, milling, grinding and slotting.

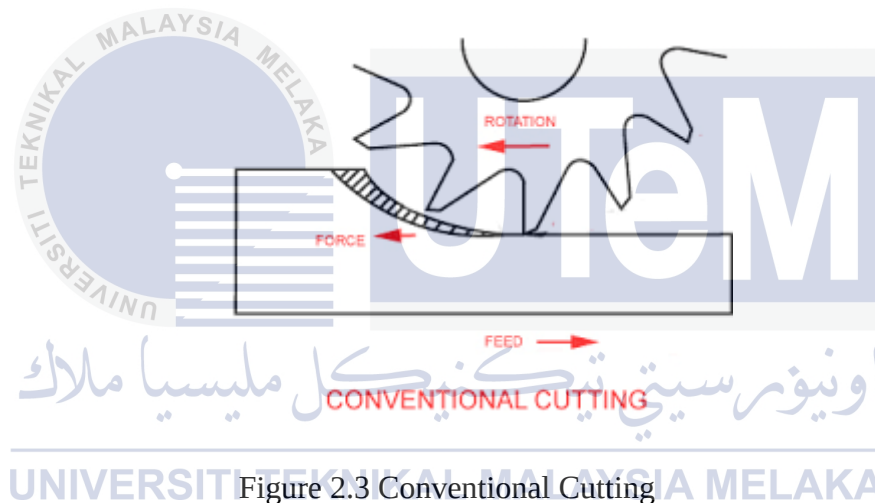


Figure 2.3 Conventional Cutting

2.1.2 Non-Conventional Machining Process

In order to realize the manufacturing/machining demands thrived by newer, hard and difficult-to-machine materials being utilized in the present day industries, an assortment of non-traditional machining processes has been developed over the past few decades. These processes are capable of generating intricate and complex shapes with high degree of accuracy, close dimensional tolerance and better surface finish (Prasad & Chakraborty, 2015).

Non-conventional machining process generally large ought to be utilized when:

1. The hardness and strength of work-piece materials are high, ordinarily > 400 HB.
2. The material is too brittle makes it impossible to be machined without harm to the part, typically the case of highly treated alloys, glass, ceramics and powder metallurgy parts.
3. The work-piece excessively adaptable or slender, making it impossible to withstand forces involved in machining or grinding, or the parts difficult to clamp in fixtures and work holding devices.
4. Special surface finish and dimensional tolerance necessities that cannot be acquired by other manufacturing process or are uneconomical.
5. Requirement for complex shapes, which cannot be machined by conventional processes at all or cannot easily be machined.
6. During processing, the temperature rises and residual stresses developed in the work-piece are not acceptable.



Figure 2.4 Example product of non-conventional machining

Non-conventional machining can be categorized by principle form of energy:

1. Mechanical processes – energy of mechanical in some form different from the action of a conventional cutting tool; disintegration of the work piece material is run of the mill.
2. Electrical processes - electrochemical energy to remove material.
3. Thermal energy processes – thermal power regularly completed to a little partition of the work surface, causing material removal through vaporization and/or combination; thermal energy is created by change of electrical energy.
4. Chemical machining processes - most materials are vulnerable against chemical attack by method for specific acids or different etchants; chemicals specifically remove material from portion of the work-piece, at the same different portions of the workpiece are secured.

Thus, classification of non-conventional machining processes is completed relying upon the nature of power used for material removal (Kharagpur, n.d.). The wide classification is given as follows:

1) Mechanical Processes:

- I. Abrasive Water Jet Machining (AWJM)
- II. Water jet Machining (WJM)

2) Electro-thermal Processes:

- i. Electron Beam Machining (EBM)
- ii. Electro-discharge Machining (EDM)
- iii. Laser Jet Machining (LJM)

3) Chemical Processes:

- i. Photochemical Milling (PCM)
- ii. Chemical Milling (CHM)

4) Electrochemical Processes:

- i. Electrochemical Grinding (ECG)
- ii. Electro Jet Drilling (EJD)
- iii. Electrochemical Machining (ECM)

2.2 Machining Operation

There are three principle of machining process which can be named as drilling, turning, and milling. Case of different operations are shaping, boring, and sawing. These operations can be categorized as miscellaneous operations.

- i. Milling operations will be operations in which unwanted materials is removed from the surface of workpiece by turning the cutting tool.
- ii. Turning operations will be an operation where cutting tool (single point) is moved linearly while the workpiece rotate. Lathe machine is the principle machine tool used as a part of turning.
- iii. Drilling operations will be operations in which rotating cutter with cutting edges at the lower furthest point into contact with the work piece to produce holes. Commonly done in drill presses anyway some of the time on mills or lathes.

A raw material required machining to create a finished product by removing unwanted material. When a workpiece that meets the particular set out for it by engineering drawing, it can call as finish product. For example, a workpiece might be required to have a particular diameter. Lathe that can be used to make that diameter by turning the workpiece then a cutting tool cut the material, creating a round surface follow the dimension given and surface finish. Holes can be made by using a drill. Various operations can be used for different sorts of material removal. A significant number of these same operations are used as a part of carpentry.

Recently, advanced machining process including waterjet machining, electrochemical machining and laser cut is used to shape material workpiece. Additionally, the obvious issues related to right dimensions, there are the issues of fulfilling the correct finish or surface smoothness on the workpiece. The poor surface finish found on the machined surface of a work piece may be caused by wrong clamping method or a dull tool.

2.2.1 Milling

Milling is a machining process in which unwanted materials are cut by using a milling cutter. This process involves various machines and operations, either the workpieces are large or not. It is one of the most familiar or commonly used processes in industry used today for machining parts to get the acquired dimensions. (Od, 1988) expresses that although rough, these machines helped in keeping up precision and consistency while copying parts that couldn't be made with the utilization of a file. Milling process is a common classical removal process used on production of parts in many metal based industries such as automobile, aerospace, and else. The performance of the milling process is affected by the cutting force and the rigidity of the cutting process. Cutting force exists during cutting process in any machine tool application (Jamaludin et al., 2016).

Milling machine is one of the most versatile conventional machine tools with a wide range of metal cutting capability. A lot of complex operations can be carried using a milling machine. The milling cutter is a rotary cutting tool, commonly with various cutting points. Cutting action is carried out by feeding the workpiece against the rotating cutter. Thus, the spindle speed, the table feed, the depth of cut, and the rotating direction of the cutter become the main parameters of the process. Good results can only be achieved with correct setting of these parameters. Advancements and enhancements of the milling machine and parts continued, which brought about the manufacturing of heavier arbors and high speed steel and carbide cutters (Od, 1988).



Figure 2.5 Milling Process

The milling operation cuts unwanted material by performing many little cuts. A cutter with a lot of teeth is used for this process and then it is rotated at high speed. The material or workpiece is advanced to the cutter slowly. When the workpiece advances through the cutter, the speed is called feed rate. Usually it is measured in length of material over full revolution of the cutter.



Figure 2.6 Example of Milling Cutter

2.2.2 Turning

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In metal cutting industries, machining types, especially turning operation is very basic type of machining (Gosai & Bhavsar, 2016). Turning is a machining process which removes unwanted material by using a non-rotary tool bit that moves linearly while the workpiece is turned or rotates. It requires a turning machine, usually a lathe machine. Turning is used to make rotational, normally axis-symmetric, parts that have numerous features, for example, grooves, holes, threads, tapers, and even shaped surfaces. Because of the high tolerances and surface finishes that turning can offer, it is perfect for adding precision rotational components to a part whose basic shape has already been formed.

Turning process can be done manually, in a conventional form of lathe, which a significant part of the time requires consistent supervision by the operator, or by using a robotized machine. Today the most broadly recognized type of such automation is computer

numerical control, otherwise called CNC. (CNC likewise generally utilized with a wide range of sorts of machining other than turning).

In turning, a bit of generally rigid material (for instance plastic, metal, wood, or stone) is rotated and a cutting tool is navigated along 1, 2, or 3 axes of motion to create precise diameters and depths. Turning can be either on the outside of the cylinder or inside (generally called boring) to deliver tubular components to various geometries. Albeit now altogether uncommon, early lathes could even be used to deliver complex geometric figures, even the dispassionate solids; despite the way that subsequent to the coming of CNC it has been able to astonish to use non-robotized tool path control therefore.

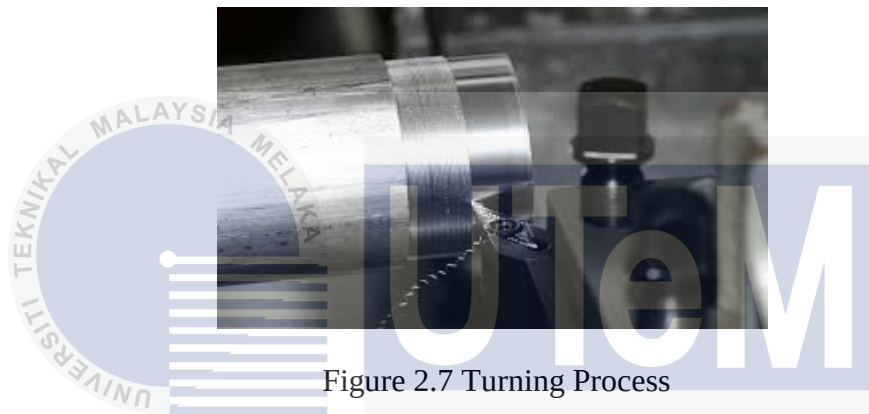


Figure 2.7 Turning Process

The conventional roughing cycles in turning, where a cut-ting tool performs constant depth of cut, can be adapted and extended with the cycles when the tool cuts with variable depth of cut (Sadílková, Poruba, Sadílek, Dubsk, & Cam, 2016). The turning process are conventionally done on a lathe, thought to be the oldest machine tools, and can be off our unmistakable sorts, for instance, taper turning, straight turning, and profiling. Those sorts of turning processes can deliver different shape of material, for instance conical, straight or grooved workpiece. Generally, turning utilizes basic single point cutting tool. Every group of workpiece materials has a perfect arrangement of tools angles which have been made as the times passed by.



Figure 2.8 Lathe Machine

2.2.3 Drilling

Drilling is a machining process that uses a drill tool to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotational cutting tool, often multipoint. The bit is squeezed against the work piece and turned at rates from hundreds to a large number of revolutions per minute. This forces the cutting edge against the workpiece, cutting off chips from the hole as it is drilled. Uncommonly, special formed bits can cut holes of non-round cross-section; a square cross-section is possible.



Figure 2.9 Drilling Process

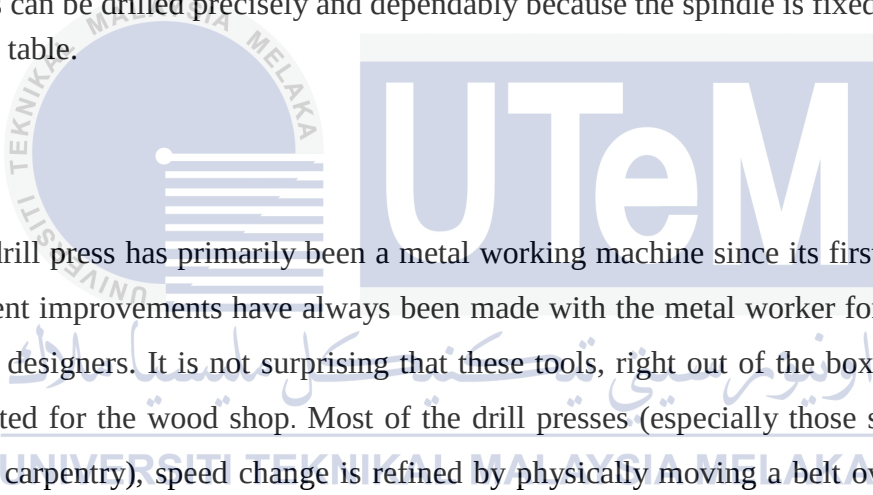
Drilling processes are extensively used as a part of aviation, airplane, and automotive. Although strategies of metal cutting have improved in the industry of manufacturing, like electron beam machining, ultrasonic machining and waterjet machining, conventional drilling is still the most common machining forms (Kurt, 2008; Bagci, 2008). Drilling is the most basic conventional machining operation that is used for creating cavities or holes for the assembly of different parts. At production stage, during drilling operations, an uncut portion of material comes out along circumference of hole. This deposition of material at entry and exit of hole is called burr (Thakre & Soni, 2016). In the most recent couple of years, environment issues had constrained the advancement of cutting fluids of low natural effect so as to minimize the usage of cutting fluid. In this way, some researchers have been exploring the option strategies like dry machining or minimum quantity of lubricant (Kelly, 2002; Cotteral, 2002).

2.3 Drill Press

A drill press (generally called a bench drill, pedestal drill or pillar drill) is a fixed style of drilling machine that may be mounted on a stand or can be dashed to the floor or workbench.

Drill press has a few of points of interest compared to hand-held drill:

- i. To drill the workpiece or material, less effort or energy is needed because drill press uses rack and pinion system which gives the operator mechanical advantage.
- ii. Clamps or vises are fixed on the table to securely hold the position of the part from moving throughout the machining cycle.
- iii. Holes can be drilled precisely and dependably because the spindle is fixed with respect to the table.



The drill press has primarily been a metal working machine since its first incarnation, and subsequent improvements have always been made with the metal worker foremost in the minds of the designers. It is not surprising that these tools, right out of the box, are still not ideally outfitted for the wood shop. Most of the drill presses (especially those suggested for home use or carpentry), speed change is refined by physically moving a belt over a stepped pulley arrangement. Some drill presses add a third stepped pulley to get more number of available speeds. No matter what the size of the machine, all drill presses work in basically the same way. A motor mounted at the back of the machine drives a pulley that's connected to a spindle that turns the bit. Stepped pulleys allow bit speed to be adjusted to suit the material: slower speeds for large-diameter bits and higher speeds for small-diameter bits. A greater number of speeds allow more precise adjustments.

Chuck quality is very important as the chuck quality varies from machine to machine. Look for a chuck that operates smoothly over its whole range of adjustment. Consider any available information on run out in the spindle and chuck assembly which refers to how much a bit will run out of true as it turns.

2.3.1 The Size of Drill Press

When looking to acquire a drilling machine, two important things that everyone should take into accounts which are unit's swing and the stroke. The measure of a drill press is determined by the distance from the column to the drill which can be known as the throat depth. The size of a drill press is two time the throat depth. This type of measurement is known as Swing. The stroke likewise can be referred to as quill stroke decides how deep one can drill. It is the capacity of the drill press. Basically, taking after will be the elements that could be considered for the time being as determining how big a drill press may be:

- i. Biggest hole drilled through the device.
- ii. Distance between worktable and the spindle.
- iii. Distance between column and the spindle.
- iv. Biggest workpiece that may be center drilled.

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Throat Depth

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People usually size of a drill press by considering the length between the column and chuck. This length is known as throat depth. The size of the drill press is twice the throat depth. This type of measurement is known as Swing.

Stroke

The stroke decides how deep one can drill. It is the capacity of the drill press. Basically the depth of cut that can be achieved by the drill press can be called as stroke.

2.3.2 Characteristic Constructional Features of Drill Press

Every model of a drill press has its variations in its construction as an adaption for its use. However, all of them still has some common features. These features or parts have their individual functions.

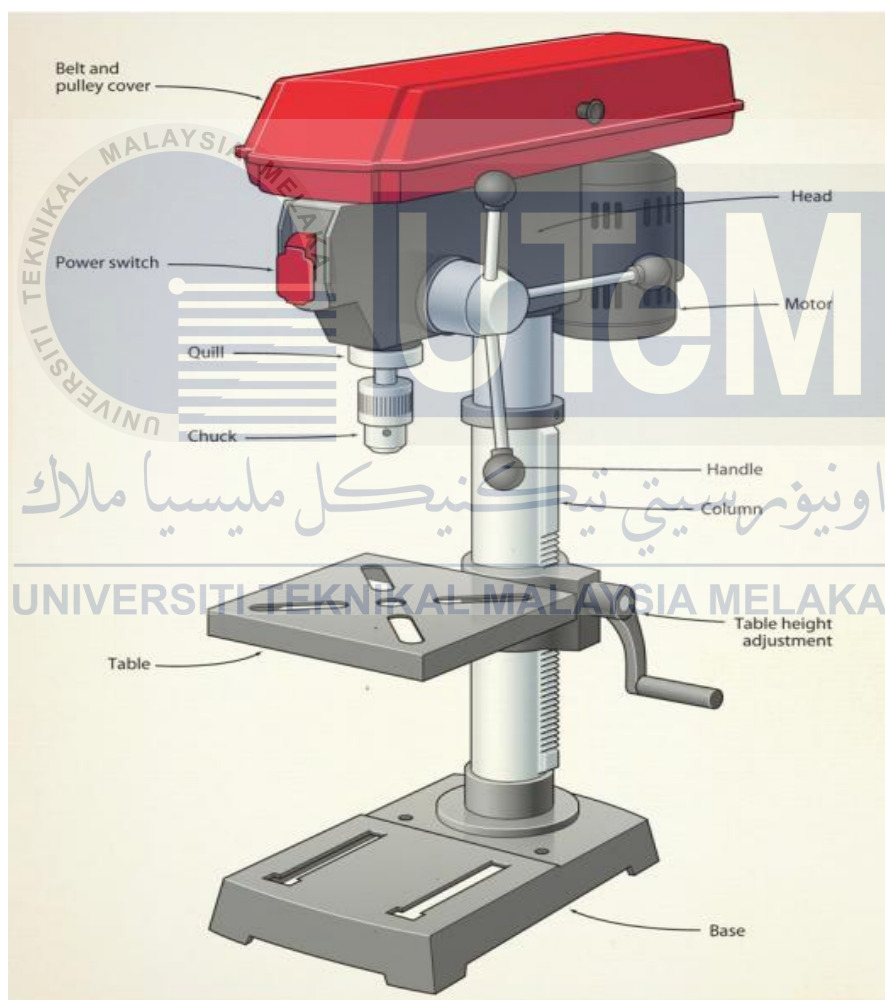


Figure 2.10 Parts of Drill Press

[<https://www.canadianwoodworking.com/tools/bench-top-drill-press>]

Following are the common features that can be found in drill presses:

1. Base:

The base holds the whole machine up and as such, it determines the accuracy of the drill press. When the base is mounted properly either on the floor or on a table, it minimizes vibration. This is especially so in the floor-standing model.



Figure 2.11 Drill Press Base

[<http://www.atm-workshop.com/radial-drill.html>]

2. Spindle:

The spindle is a part that rotates when drilling operation is performed using drill press. It holds the cutting tool. Thus, spindle is crucial part of the drill press.



Figure 2.12 Spindle

[<http://drillpresselect.com/important-basics-to-know-about-drill-press-constructional-features/>]

3. Quill:

The quill often called as sleeve. It keeps the spindle secure while it rotates. It either can be raised or lowered in case of vertically mounted drill press. It contains bearings which help to transfer the drive from motor to concentrically mounted spindle.

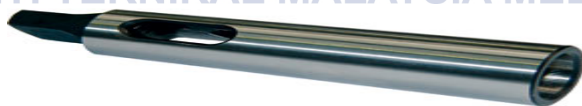


Figure 2.13 A Quill

[<http://drillpresselect.com/important-basics-to-know-about-drill-press-constructional-features/>]

4. Column or pillar:

The pillar is a very stable column that supports the sleeve and spindle of the drill. It is almost always circular and made of solid material. It determines the height of the drill press. Commonly, the work table is attached to the column. It is solid and built cylindrical. Column is supported by the base of the drill press.



Figure 2.14 Column of Drill Press

[<http://supporting-paa.wikispaces.com/Drill+Press>]

5. Head:

The head comprises of the sleeve, electric motor and spindle. The head is important because electric motor is located here. It is attached to the column so it can be moved up and down in order to vary the depth of cutting as desired.

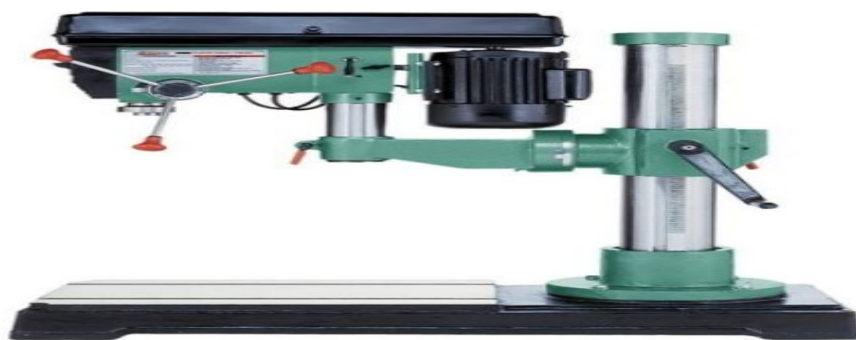


Figure 2.15 Head of Drill Press

[<http://drillpresselect.com/important-basics-to-know-about-drill-press-constructural-features/>]

6. Worktable:

The worktable is portable, thus it can be correctly adjusted to match the size or tilt of items being worked on as well as height realignment for the convenience of the user. It can be tilted either vertically or horizontally. A majority of work tables have slots for holding work accessories. Besides, it contains spaces to allow possessing fixtures and clamping from the workpiece. Some models give plywood with the worktable.

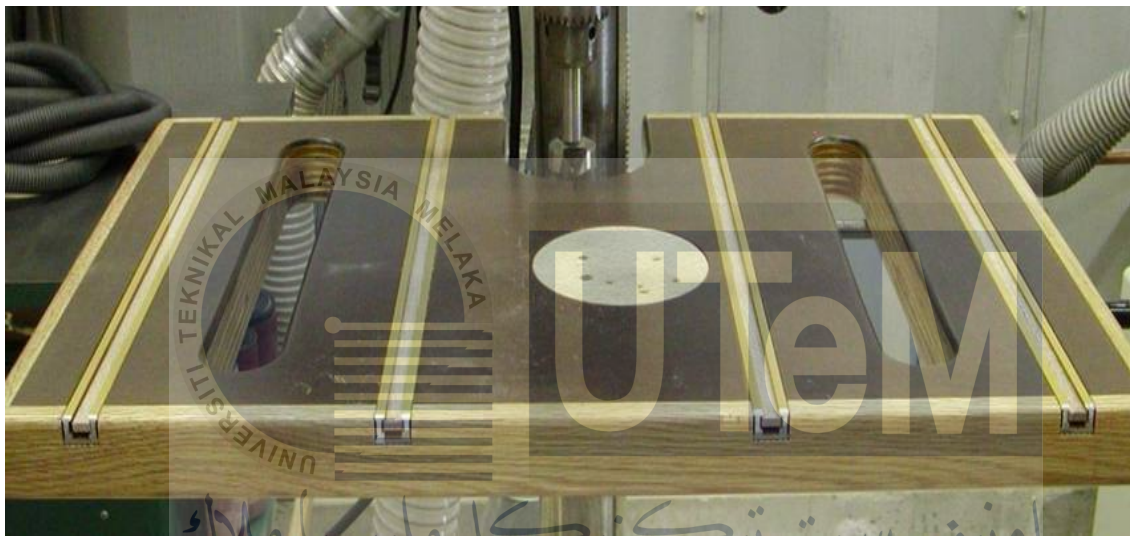


Figure 2.16 The Worktable

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[http://woodgears.ca/reader/walters/drillpress_table.html]

2.4 Drill Press Safety

While not looked at by many among the more threatening machines in the shop, a drill press can bite the hand that feeds it still. The principal hazard is from grabbing and climbing. When drilling material, always ensure that it's held right down to prevent it from moving. Not merely will you wrap up with a cleaner hole, you'll prevent these dangerous situations. A drill little bit can grab the materials if the section is strike because of it that is harder than the others. Once the bit is locks into the material, and the power of the motor must go somewhere else. What usually happens is the fact that immediately, the piece is ripped from the hand of the operator and commences spinning at the same speed as the bit. In case the part is small it will spin readily before machine is switched off; a more substantial piece will spin until a part of it hits the column.

When drilling thin stock, climbing is a particular hazard, with metal especially. When by using a twist drill to drill thin stock or a piece of metal, as the bit starts breaking out the other side, the ragged edges of the hole will catch on the edges of the bit and the material will wind its way from the table or more the space of the bit. Should this happen with a piece of metal, it can easily progress the little bit and be an unguarded content spinning saw blade. Whenever using thin metal on the drill press, wear gloves and use a hold-down always.

Following are some of the safety guidelines when using a drill press:

- i. Make sure that your face shield or safety glasses are in place before you start the drill press.
- ii. Always wear an approved shop cap to contain long hair and keep your head up well away from all moving parts of the drill press.
- iii. Clamp the work securely to the table before starting the machine. Attempting to hold the work under the drill with one hand can result in serious and painful injuries.
- iv. Make sure that drills are run at proper speed and feed. Forcing or trying to feed to quickly can cause drill to break or splinter with the chance of serious injuries.
- v. If work should slip from the clamp, never attempt to stop it with the hands.
- vi. Never reach around or in back of any rotating drill.
- vii. If the drill sticks I the work, stop the motor and rotate the drill by hand to free it from the work.

2.5 Effect of Cutting Parameters

Cutting parameters such as feed rate, depth of cut and cutting speeds are the variables that influence the cutting force characteristics (Jamaludin et al., 2016). There are three important process parameters in the cutting process that are depth of cut, speed and feed. These parameters will affect the surface roughness of the workpiece. The surface roughness might also be affected by other factors such as condition of the cutting tool and also condition of the machine used, but the three parameters is the main parameters that need to be careful of.(Dr. C. J. Rao, 2013).

Feed rate has critical impact both on cutting power and also surface roughness. Depth of cut impacts cutting forces however has an irrelevant impact on surface roughness. The cooperation of feed and depth of cut and the connection of all the three cutting parameters have huge impact on cutting forces, while, none of the collaboration impacts are having critical impact at surface roughness delivered.

The cutting parameters affecting tool chatter are shown in Figure below in turning are:

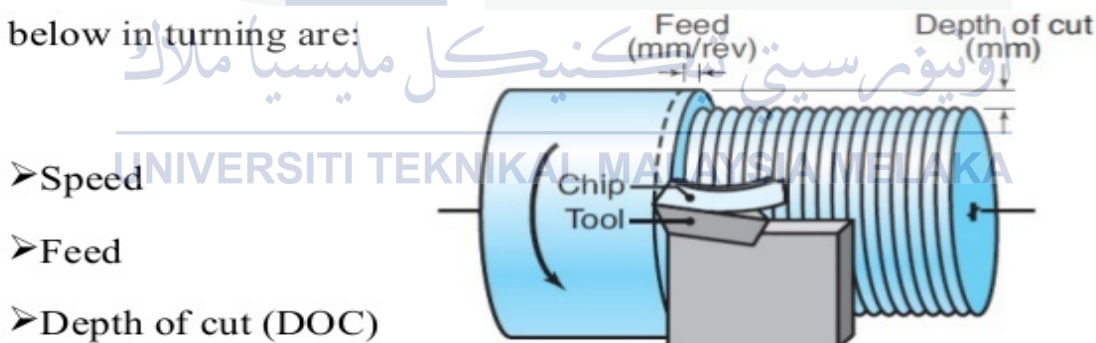


Figure 2.17 Cutting parameters

[<http://www.slideshare.net/devanshuy2/project-report-on-simulink-analysis-of-tool-chatter-vibration-on-lathe>]

2.5.1 Cutting Speed

Exit burrs produced during various machining processes degrade the product quality and functionality of different parts of assembly. It is essential to select the optimum tool geometry and process parameters for minimizing the burr formation during machining (Thakre & Soni, 2016). Cutting speed is a speed of material moves past the cutting edge of the tool, irrespective of the machining operation used. Besides, cutting speeds are calculated based on the cutting conditions exist. For example, metal removal rate, full and constant flow of cutting fluid, rigidity of the machine and tooling setup, continuity of cut, and condition of material. There are three factors that can affect the calculation of cutting speed which is:

- i. The material being machined
- ii. The material of the cutter
- iii. The economical life of the cutter

2.5.2 Feed Rate

Feed rate is the velocity at which the cutter is fed, that is advanced against the work-piece. The unit is in units of distance per time. There are three ways the feed can be express which is:

- i. Feed per Tooth
It is the distance traveled by the work-piece between engagements by the two successive teeth.
- ii. Feed per Revolution
It is a time of the travel of work-piece in one revolution of milling cutter.
- iii. Feed per Unit of Time
It is the distance advances by the work-piece in unit time. Feed also can be expressed as feed/minute or feed/sec.

2.5.3 Depth of Cut

Depth of cut in milling operation is the distance of the cutting tool penetrates into the work-piece. The depth of cut influences to the preparing speed. At the point when the cutting profundity is huge, the handling speed turns out to be brisk and the surface temperature turns out to be high. At that point, the surface roughness of the work-piece will be change. It better to start machining with small cutting depth if suitable cutting depth is unknown (Gorbachov, Petrenko, & Thangavadivelu, 2015).

2.6 Surface Roughness

The terms surface roughness and surface finish are utilized broadly as a part of industry and are by and large used to measure the smoothness of a surface finish. In 1947, the American Standard B46.1-1947 "Surface texture" characterized a large number of the ideas of surface metrology and wording which dominated past principles. . The pattern of the surface which different from the normal surface is known as surface texture. It may result from waviness, lay and flaws and may be repetitive or random (Tseng et al 2016). Real surface is that the real surface of associate object is that the peripheral skin that separates it from the encompassing medium. This surface invariably assimilates structural deviations that area unit classified as kind errors, waviness, and surface roughness. Roughness consists of the finer irregularities of the surface texture sometimes together with those irregularities that result from the inherent action of the assembly method. These are considered to incorporate cross food marks and different inconsistencies inside of the breaking points of the unpleasantness examining length.

Alternatives for surface roughness estimation are basically delimited by the exactness required in the outcome. For instance, surface roughness could be surveyed by eye and touch, by contrasting a test with a standard specimen, however this is not estimation: it is subjective. Touch affectability and visual determination restrict the viability of these evaluations to components that are a couple of microns high and wide, at as far as possible. Surface geology

estimations, at an accuracy building level, are isolated for the most part into the size of the elements that are inspected.

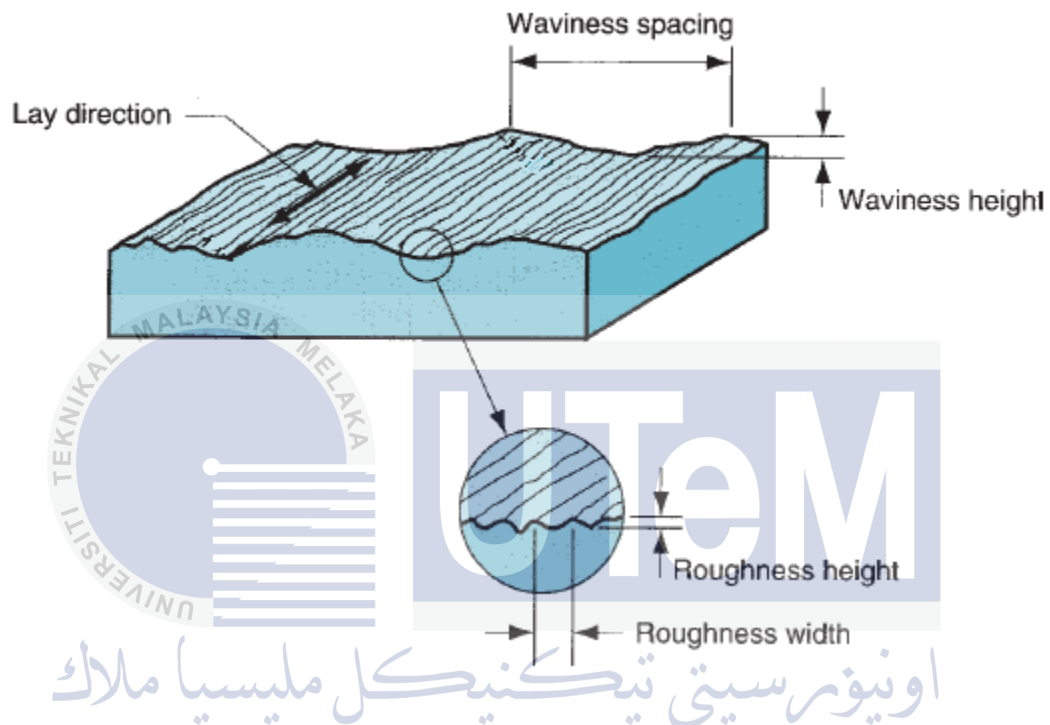


Figure 2.18: Surface Characteristic

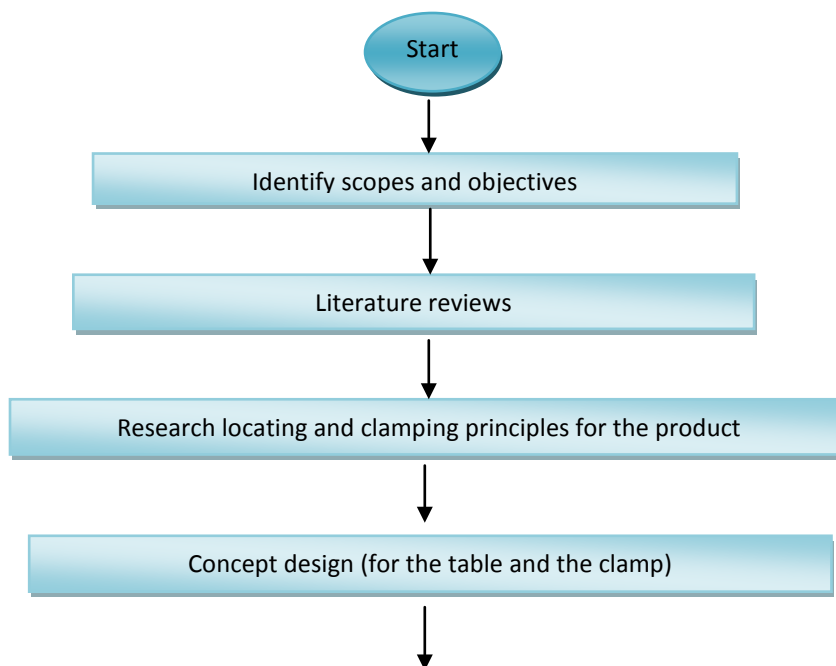
[<http://www.arknovin.com/en/quality-control/surface-quality/surface-roughness.html>]

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss in detail about the process that will be conducted to make the linear XY table and also experimental method that will be conducted to test this project. This chapter will be divided into four parts. The first part is design of linear table where this part explains on how the design of this product is acquired. Second part is material solution of design where the material selection to make the product. Third part is development of linear table where the process to make it is explained in detail. The last part is on evaluation of the product. Two testing will be conducted to evaluate the product. Overall, the process is based on System Development Life Cycle (SDLC) as shown in Figure 3.1



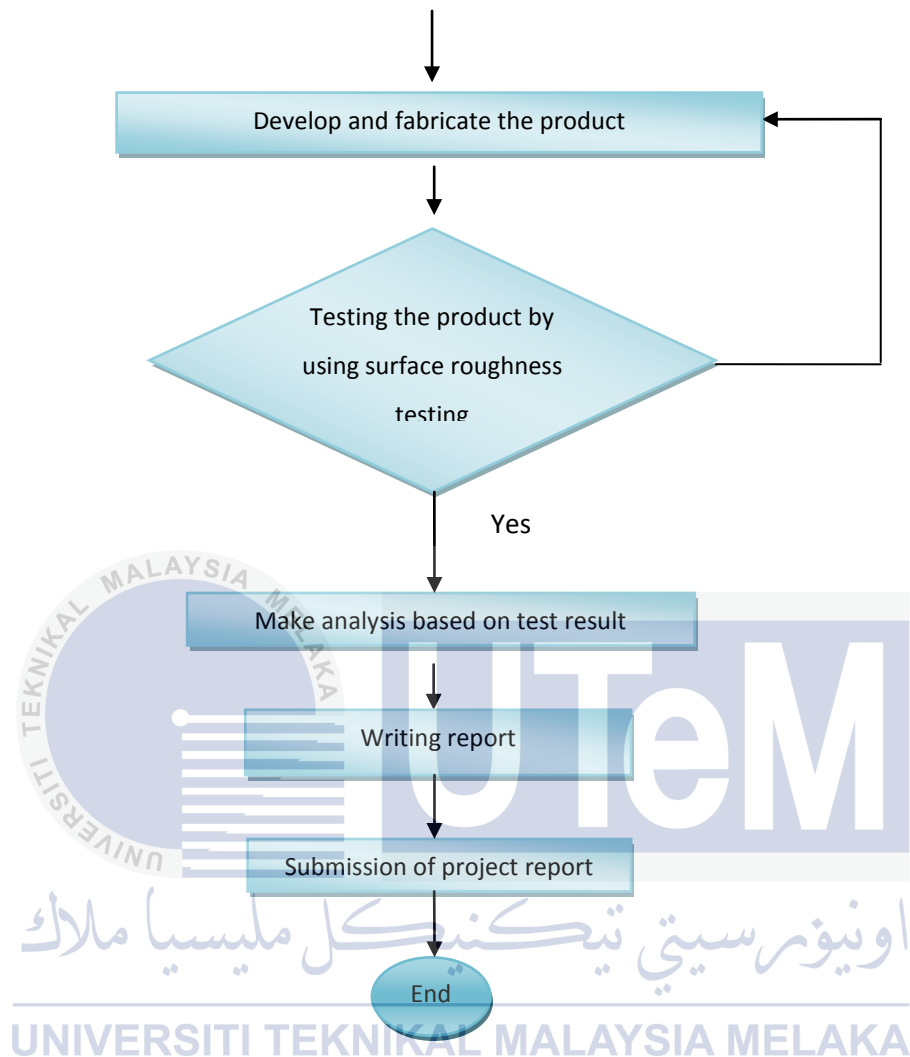


Figure 3.1 System Development Life Cycle (SDLC)

3.2 Component Selection

The linear positioning table can be started once the system requirements had been determined. Requirements included toggle clamps and other parts of the project. The process involved determining which components needed to be purchased, purchasing the necessary parts,

and designing parts that could not be purchased off-the-shelf which mean it has to be machined. The bill of material is shown as in the Table 3.1 below:

Table 3.1 Bill of Material

Part	Part Name	Material	Estimation Size (mm)	Quantity
1	Base Rails	Aluminum	500 x 40 x 40	2
2	Wood Table	Wood	230 x 180 x 10	1
3	Cross Shaft	Aluminum	400 x 120 x 40	1
4	Roller Housing (Side)	Aluminum	120 x 10 x 85	2
5	Roller Housing (Cross Shaft)	Aluminum	120 x 140 x 85	1
6	Nylon Roller	-	30mm Diameter	12
7	Toggle Clamp	-	-	4
8	G-Clamp	-	-	4

3.3 Overall Design

An online research need to be done first to know if there are any other similar products on the market to ensure that this product is not replicated. There are other similar linear sliding tables in use, but the main differences being in the intended purposes. None of the existing linear tables were designed for the use at drill press machine. Then, a sketch is drawn after considering the suitable concepts and ideas. Eventually, after the sketch is approved and accepted by supervisor, then it is redraw by using Solid Work software. The expected final design is shown

as in figure below. The linear table uses rollers to ensure the smoothness as it is moving. Three rollers are used for each of its housing. The positioning of the roller is two-to-one which means two rollers at top and one at bottom. The figure of the part to locate these rollers is shown in Figure 3.9.

Next, material of table that will be used is plywood. This is the only part in this project that uses wood as its material. This is because of it is used as the base for drilling process. Basically, during drilling process for sheet metal parts, the cutting tool will pass through the workpiece. So if the base is made up of aluminum material, it will damage the cutting tool. It will cause tool wear in a very short amount of time or even fractured or broken. The purpose of using wood table is to reduce tool wear and it is interchangeable. Eventually, the wood table will wear and damaged so it can be changed. Four clamps are attached to the wood table. It is placed at center of each side of the table. The overall product design is shown in Figure 3.2 below:

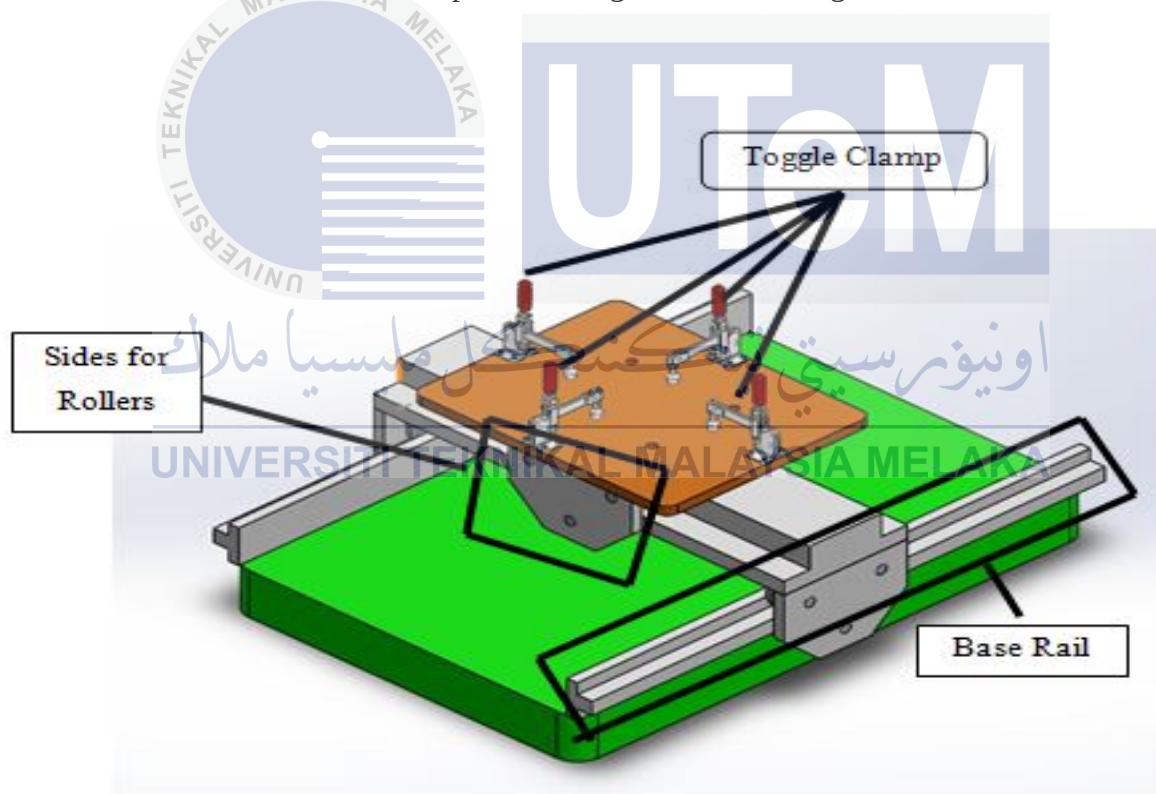


Figure 3.2 The Overall Project Design

The clamps used are toggle clamps as it is suitable to clamp sheet metal or plate. All these clamps will be fixed to the wood table with screws. Besides, this wood table is designed to slide in x-axis direction along a cross shaft. In the meanwhile, the cross shaft itself is allowed to move in y-axis direction. Two side shafts will act as its rail. The cross shaft will slide along these rails that traverse the entire length of available workspace. Each side shaft is attached on existing table of the drill press by using G-clamp. Motion is accomplished along each axis manually, which operator can move it as he wants. Stoppers will be placed at each endpoint for each shaft to restrict its movement or to avoid it from out of runway. A goal for the linear X-Y table can ease operator which he only need to clamp once for entire drilling process according to a certain limits. Further consideration suggested that a rectangular table would be better suited for the test material's positioning and reaching patterns.

3.4 Selected Hardware/Component

The off-the-shelf items were identified first because the rest of the device was designed around the constraints while the selected hardware placed on the system. The hardware included toggle clamps, nylon rollers and G-clamps.

Table 3.2-List of Hardware or Component

COMPONENT	TYPE
1. Clamps	C-clamp
2. Rollers	Nylon
3. Clamps	Toggle

3.4.1 Nylon Roller

Rollers come in various shapes, sizes and materials. When selecting what type of roller that suitable for this project, the benefits that make them better choices than the other should be consider. One of the most widely used types is those manufactured using nylon. Some of the advantageous include:

- i. Less noise: this is because nylon rollers do not generate as much vibrations or sound as that caused by ones made out of steel.
- ii. Lubrication: Nylon rollers do not need lubrication due to their chemical nature which makes it possible for them to move freely without getting stuck.
- iii. Rust: nylon rollers cannot develop any rust therefore the sliding table will work more efficiently.
- iv. Lightweight: they can move at a faster speed than the steel ones and make it possible to move rapidly.

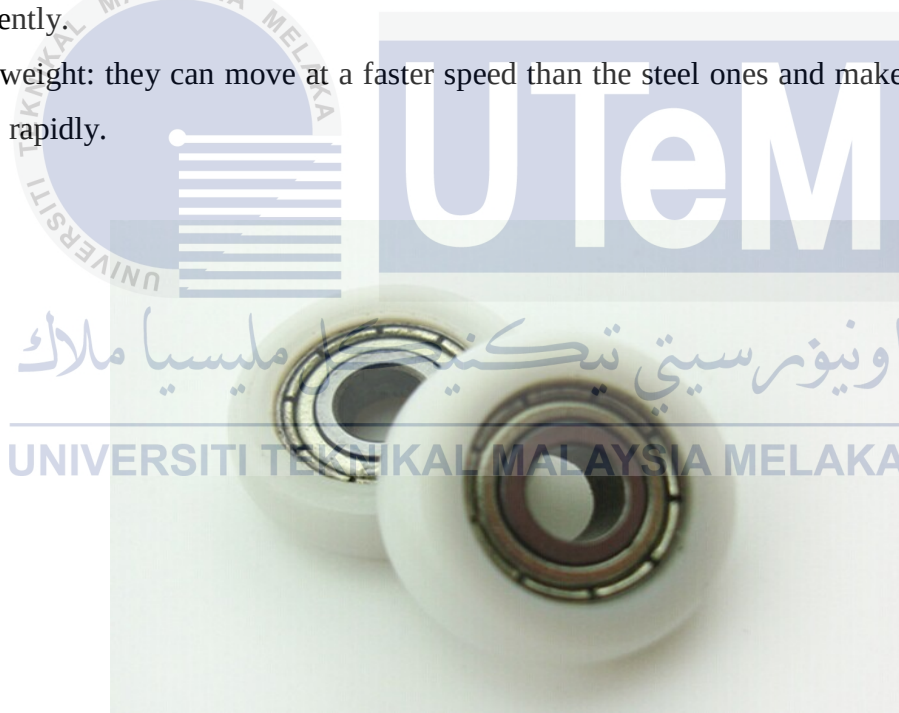


Figure 3.3: Nylon Rollers

[http://www.aliexpress.com/promotion/industry-business_nylon-roller-bearings-promotion.html]

3.4.2 Toggle Clamps

Toggle clamps are one of the most common and effective device to clamp thin metal parts like sheet metal. They firmly hold down a workpiece, keeping it stationary. The tool uses a unique pivot and lever system to function. Below are some advantages of using toggle clamps:

- i. **Efficiency:** installation of toggles is fast and easy. It has a high operating reliability. The highly efficient setup of toggles enables the work can be done accurately and quickly. This reduces work time significantly.
- ii. **Adaptability:** toggles can adapt to work pieces of varying heights. It has adjustable screws which enables you to apply the desired clamping force.
- iii. **Improved safety:** The positive locking action keeps both the tool and work piece securely in place. This helps to prevent accidents due to lose grip or slipping. Most toggles allow to exert a high level of force onto the work piece. The superior holding power is a boost to overall safety while working.
- iv. **Ergonomics:** Toggle clamp handles are designed to minimize strain while working. This allows you to maximize on work efficiency. Most models have contoured handle grips which fit better into the hands. The handle can easily be modified into a bent position which allows you to keep the wrist straight. This helps you avoid fatigue, strain injuries and related problems as you work.

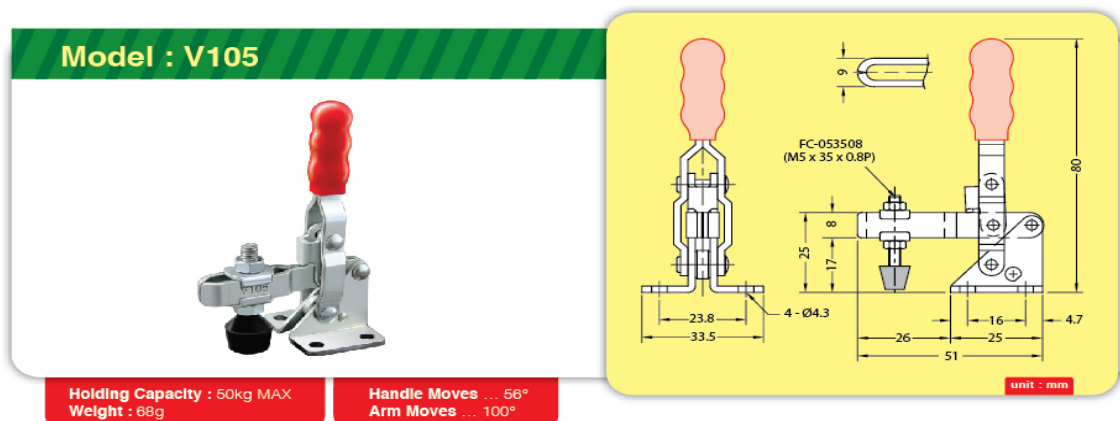


Figure 3.4 Toggle Clamp

[http://jsclamp.com/product_detail.php?vid=V105]

3.4.3 G-Clamps

C-clamp or G-clamp has high clamp force and numerous uses. The long screw thread tends to make it slow in use, so quick release clamps are preferred where their lower clamp force is sufficient. G clamps are prone to denting the workpiece, due to high force on a small pad, or scratching workpieces. Loose load spreading pieces of wood, plastic, etc are used to avoid this, but make handling the assembly less easy.



Figure 3.5 G-clamp

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[<http://www.armstrongtools.com/clamps-and-lifting-eyes/armstrong-78-115-c-clamp-general-service-pattern-15.html>]

3.5 Designed Components & Machining Strategies

After all the hardware or components and stock of materials are available, the project then proceeds to machining. The machine that involves in machining all the parts is conventional machine such as milling and drilling machine. The machining process and strategies will be discussed later.

The side shaft (base rails), wood table, cross shaft and roller housings of the X-Y table had to be designed and machined. Most of these components were machined from stock aluminum because it was deemed structurally strong enough for intended purposes. Along with aluminum providing great weight and cost savings over other potential materials, it was also stainless. If the ferrous metal were used for the majority of the components, eventually it will rust. This will disturb the smoothness of the sliding table. It will require more energy as it is hard to move due to rust.

3.5.1 Base Rails

The X-Y table consists of two base rails, left and right which serve two functions. The first is to coordinate the motion of y-axis with rollers through the rails. The second function is to affix the load and handle assembly to the rest of the system. The dimension for both rails is same. First of all, the raw material or stock needs to be cut according the dimension of (500x40x40) mm. This process can be done using milling machine with face mill as it cutting tool.

Then, by using endmill, cut the workpiece with depth of 12.5 mm and width of 14.5 mm. Repeat the same step at bottom side. The finish part will look like figure below. Repeat the entire step to get the base rail for left side.

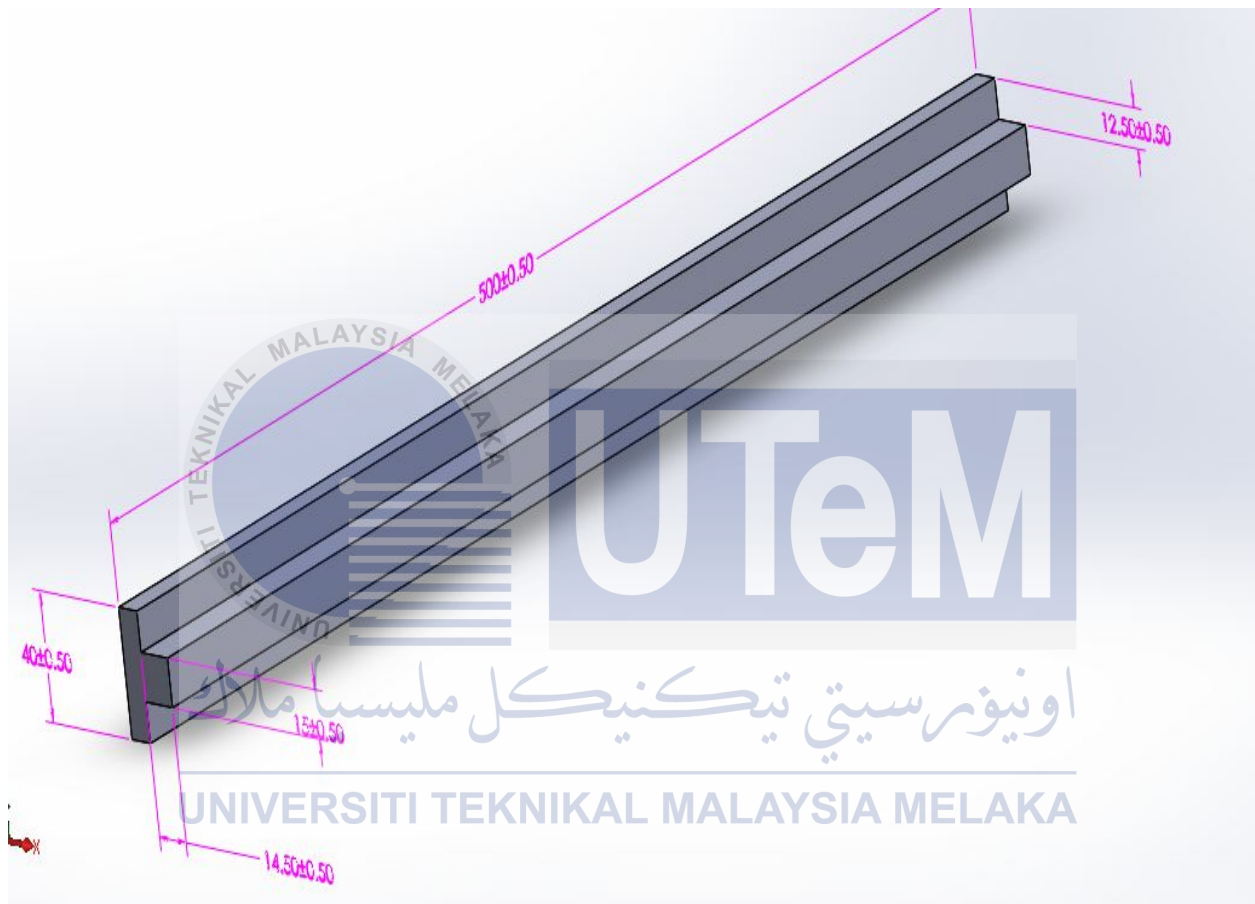


Figure 3.6 Base Rail (Part 1)

3.5.2 Wood Table

Material of table that will be used is wood. This is the only part in this project that uses wood as its material. First of all, the raw material or stock needs to be cut according the dimension of (230 x 180 x 10) mm. From a rectangular stock of wood, jigsaw is used to get the edge fillet. Next, drill four holes following the dimension that has been made by using drill press machine with 8mm diameter cutting tool. By using tap tool, tapped all this holes to make thread. All these holes will be used to combine the table with roller housing at cross shaft by using screw.

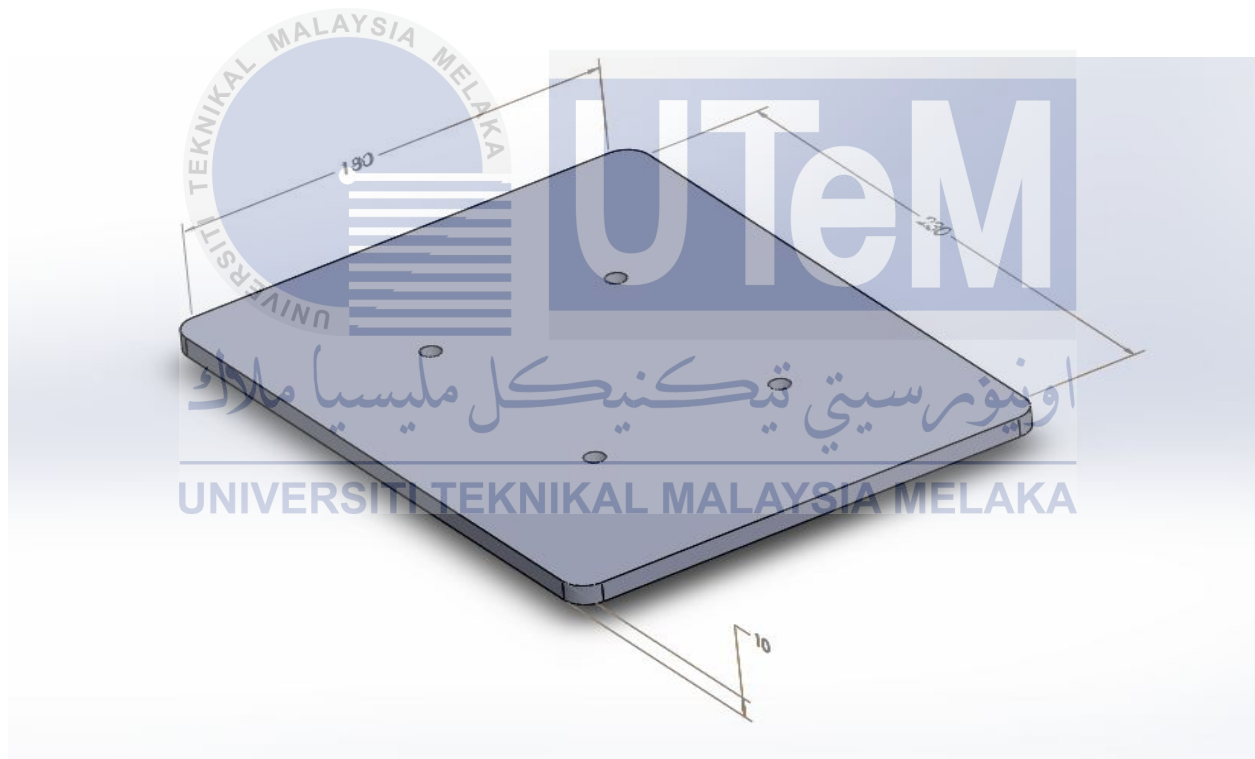


Figure 3.7: Wood Table (Part 2)

3.5.3 Cross Shaft

The X-Y table consists of one cross shaft which then will be combined with wood table. Its function is to coordinate the motion of x-axis with rollers through the rails. First of all, the raw material or stock needs to be cut according the dimension of (400 x 120 x 40) mm. This process can be done using milling machine with face mill (16 mm diameter) as it cutting tool. Then, by using endmill (10 mm diameter), cut the workpiece with depth of 25 mm and width of 25 mm. Repeat the same step at the other side. The finish part will look like Figure 3.5 below.

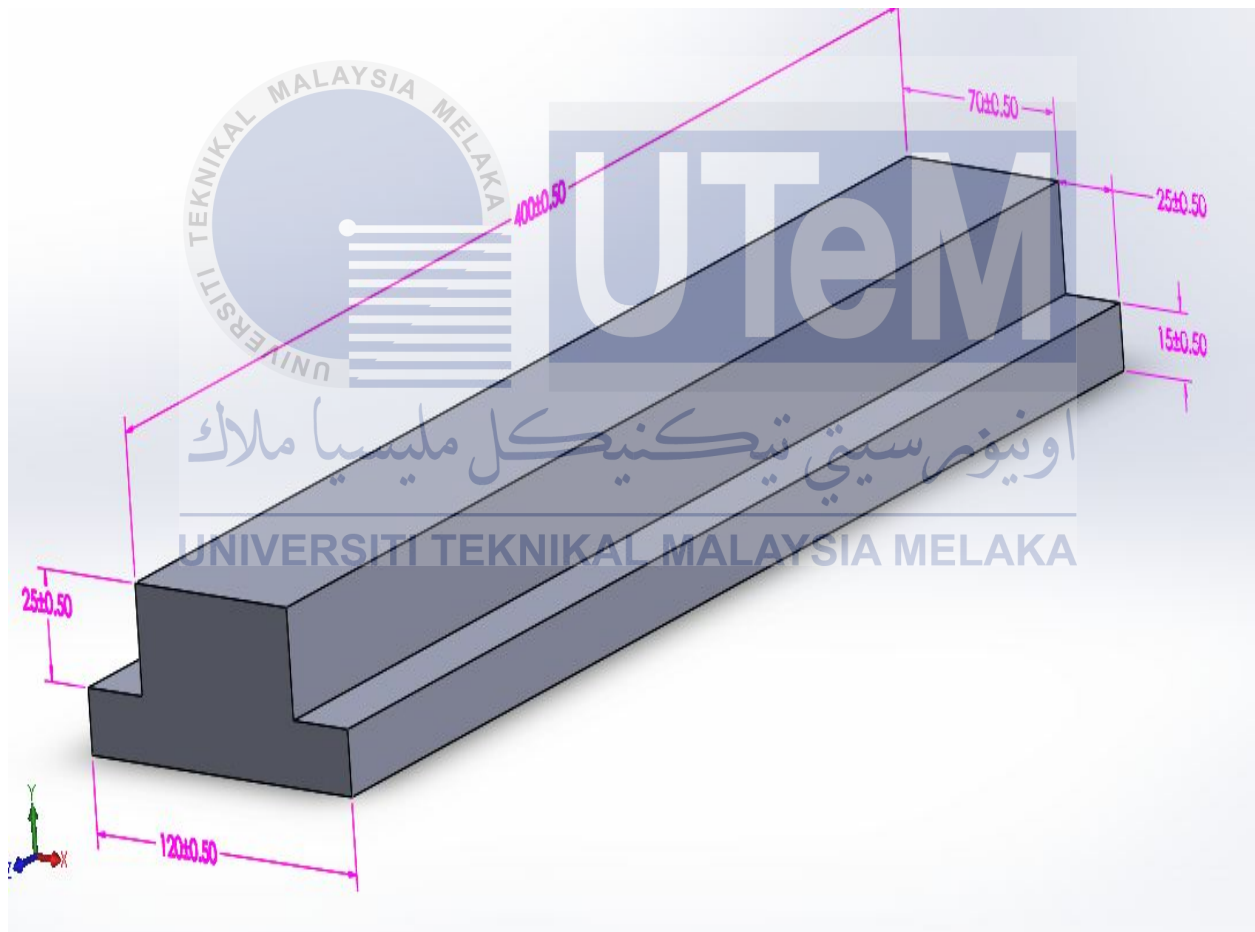


Figure 3.8 Cross Shaft (Part 3)

3.5.4 Roller Housing (Side)

Figure 3.6 shows roller housing, which acts as the place for nylon roller. First of all, the raw material or stock needs to be cut according to the dimension of (120 x 10 x 85) mm. This process can be done using milling machine with face mill (16 mm diameter) as it cutting tool. Then, make a line on the top surface by using a marker or pen by following the dimension made for chamfer. Use endmill (10 mm diameter) to cut the workpiece by following the lines that has been made. Repeat the same step at the other side. Three holes were drilled by using drill at drilling machine by using 6mm diameter of drilling cutting tool. These holes located at the side of the side roller housing by following the exact dimension to locate rollers.

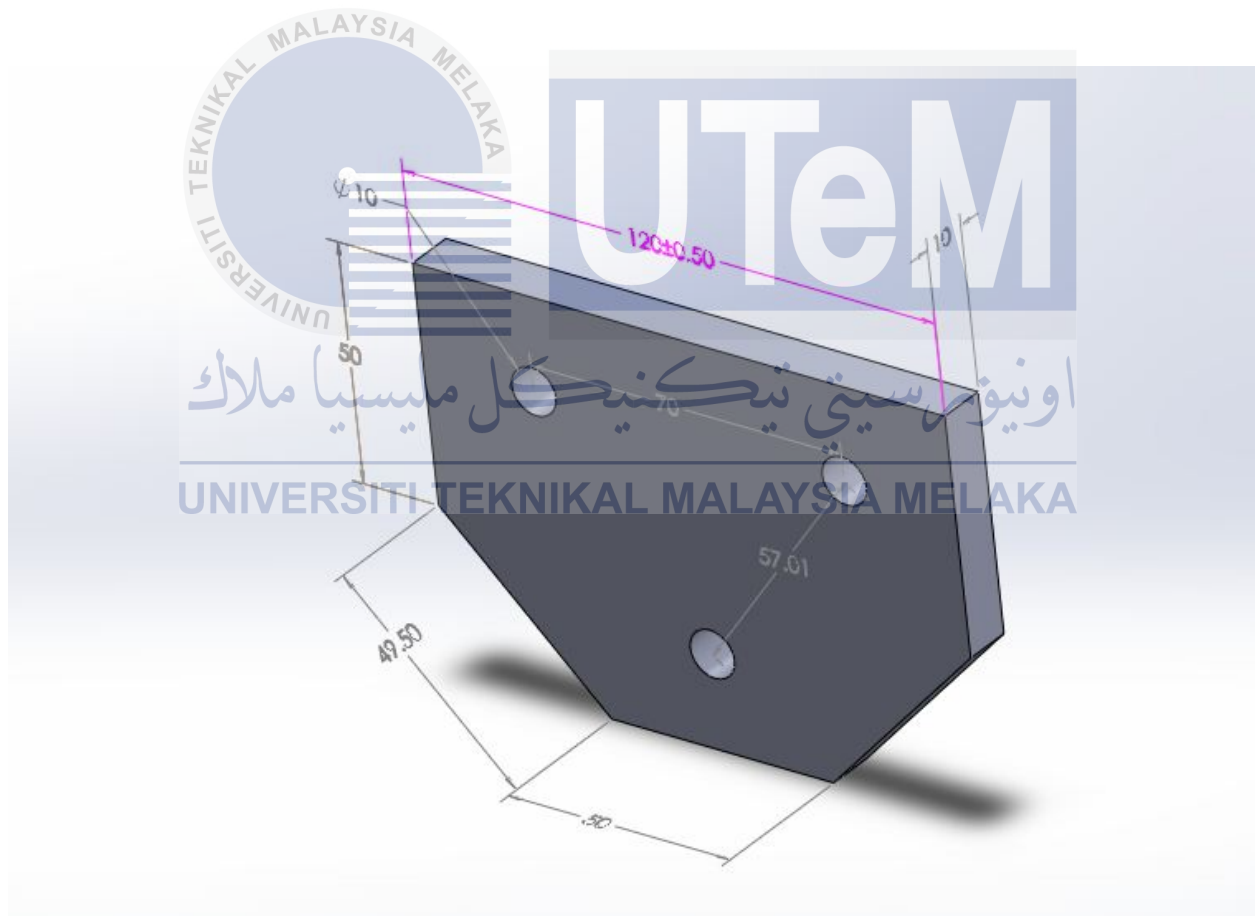


Figure 3.9 (Side) Roller Housing (Part 4)

3.5.5 Roller Housing (Cross Shaft)

Figure 3.7 shows roller housing which will be placed on cross shaft. Its function is similar to roller housing for the side rails. The differences between these two housings are the design and the location to place the part. First of all, the raw material or stock needs to be cut according to the dimension of (120 x 140 x 85) mm. This process can be done using milling machine with face mill (16 mm diameter) as its cutting tool. Then, make a line on the surface by using a marker or pen by following the dimension made for chamfer. This can be done by using the same cutting tool to cut the workpiece by following the lines that have been made. Then, by using the same cutting tool, cut the inner side of the part with a depth of 75 mm and width of 120 mm. The finished part will look like the figure below. Total of six holes need to be drilled by using drill at drilling machine using 6mm diameter of drilling cutting tool. These holes are located at the side of roller housing by following the exact dimension to locate rollers.

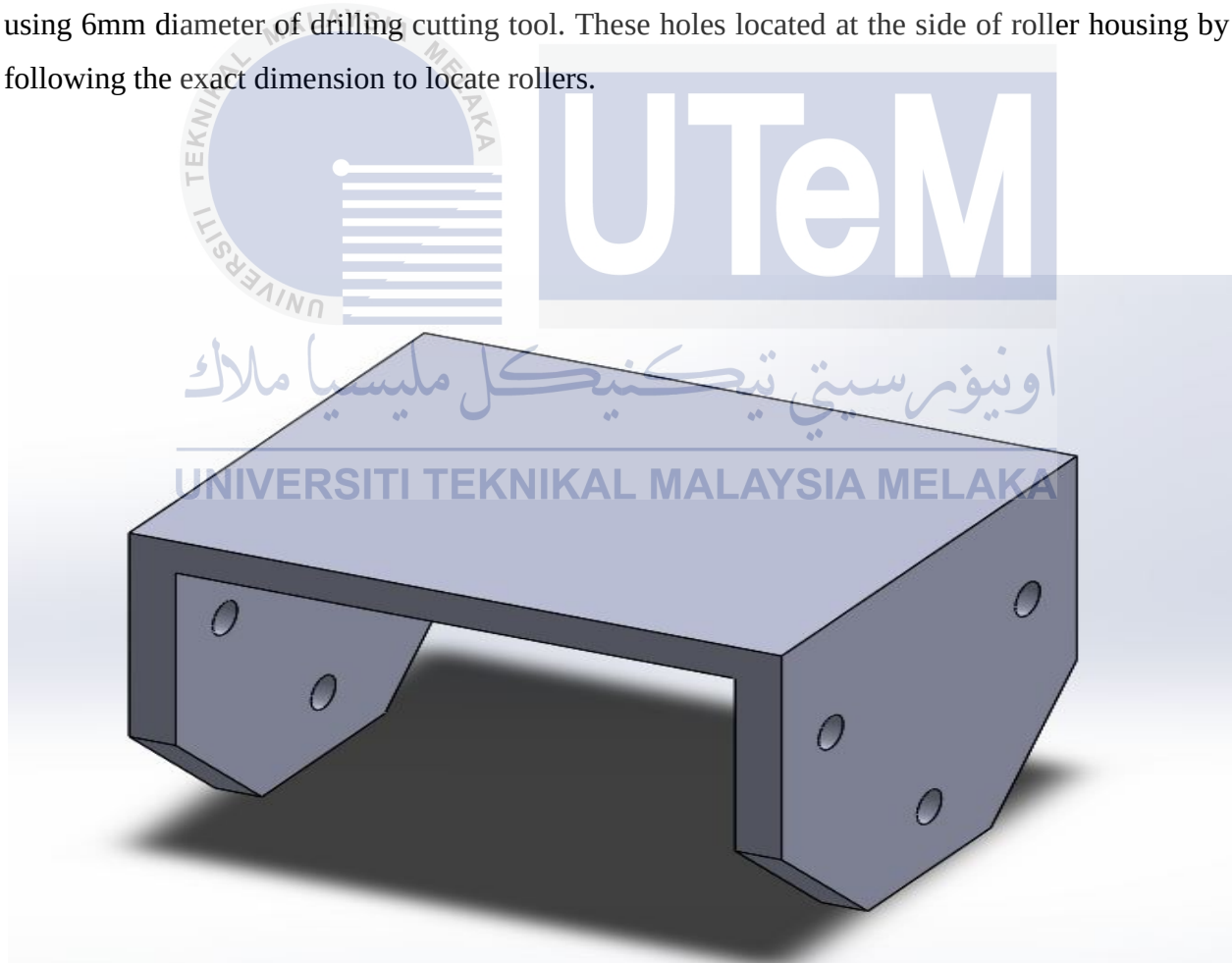


Figure 3.10 (Cross Shaft) Roller Housing (Part 5)

3.6 Part Assembly

First of all, four clamps are attached to the wood table. It is placed at center of each side of the table. The clamps used are toggle clamps as it is suitable to clamp sheet metal or plate. All these clamps will be fixed to the wood table with screws. Then, combine the table with roller housing for the cross shaft by using screw through the holes that has been made previously. At the roller housing, put six rollers through all the holes that has been made by using screws. Six means three for each side. After that, put it on the rail of cross shaft. Let it slide freely on the rail. Next, stopper will be put at both end of the cross shaft to limit or prevent the roller from slide out of the rail. A simple screw can be made as the stopper.

Then, locate the rest of the rollers on each of roller housing (side) which means three for one side. Next, combine them with cross shaft by using appropriate screws. After that, put all the combined parts on the base rail. Let them slide freely then put stoppers at each end of the base rails. The product now is completely combined or mate. Finally, locates the entire product that has been completely assembled, on the existing drill press table. The product is securely fixed on the table by using G-clamp. Four G-clamps are used to clamp it at each endpoint of the product.

3.5 Evaluation of the product

In the future, it will be desired to conduct an active assist experiment. After the product is complete, two experiments will be conducted to test the product. The experiments are surface roughness testing and clamping time testing. Experiments will be conducted by using drilling machine. Two samples of same size and material will be used for the experiment to compare the result between using the table and without it.

3.5.1 Surface roughness testing

For the experimental studies, test samples will be prepared. Two experiments will be conducted by using sheet metal of 1mm thickness. The experiment will be carried out on a drilling machine. The drilling machine is equipped with 2.2 kW spindle motor and 0.75 kW feed motor. Drilling operations will be performed by using a drill bit of same size. All the experiments will be carried out with new tool inserts. The surface roughness parameter, arithmetic mean surface roughness of the workpiece is checked out using microscope and the result will be calculated and recorded.

3.5.2 Clamping Time testing

This experiment is conducted on drill press machine. Same operator will drill two samples with and without the sliding table respectively. Firstly, the operator drills the workpiece without using the sliding table. The time taken to drill the workpiece is taken. The operator then repeats the experiment by using sliding table. Both time taken then will be tabulated and compared.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, the results of the data analysis are presented and followed by a discussion of the research findings. Data were analyzed to identify, describe and explore either the product of this project is acceptable or otherwise. Data were obtained by conducting tests on the project then analyzed by using optical comparator (profile projector).

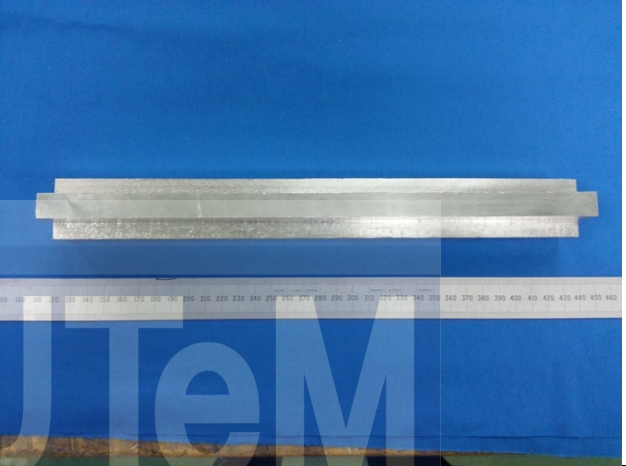
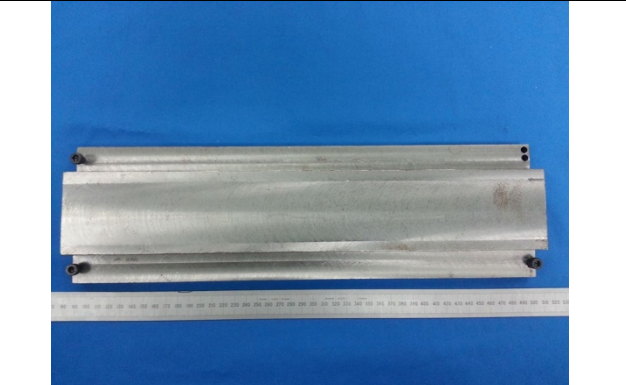
4.2 Presentation of Findings

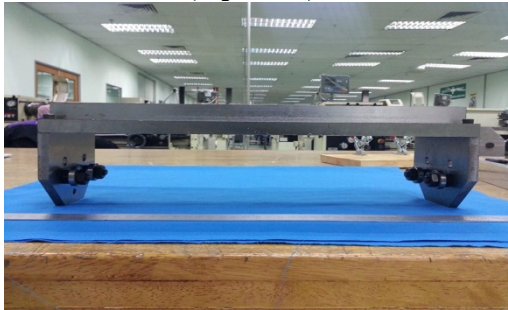
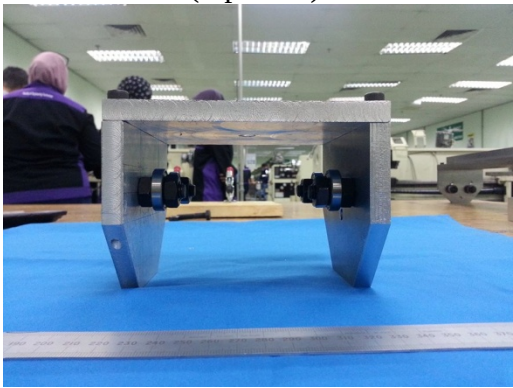
After the project is completely developed, data are gathered and analyzed. This includes finish product, product testing and product analysis. These data are important to determine this project's limitation, weakness and its efficiency.

4.2.1 Finish Product

After going through all the machining process as planned in methodology, all the parts were completely machined. These parts are shown in table below:

Table 4.1 Finish Product

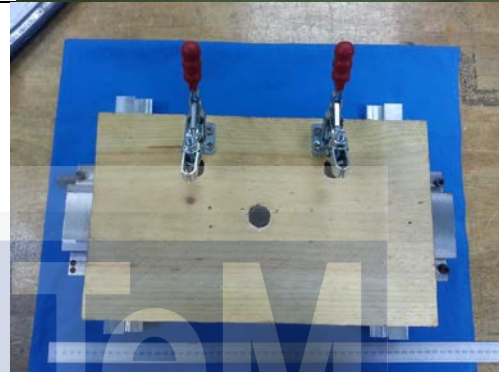
Part Name	Figure
1. Base rail	
2. Wood Table	
3. Cross Shaft	

	(top view)  (front view with sides)
4. Sides	
5. Top Beam	 (top view)  (front view with sides)

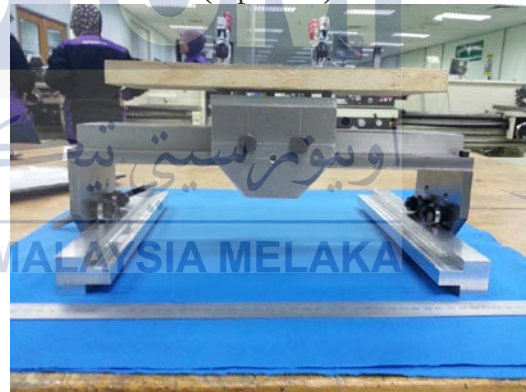
6. Overall parts



7. Assembled Part



(top view)



(front view)



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4.2.2 Discussion

Changes have been made to some of the part in terms of material and design. As discussed in previous chapter, type of material used for all of the parts that will be machined (except for wood table), is aluminum. However, due to its price which is quite expensive, it is replaced by mild steel. Therefore, both of aluminum and mild steel are used to complete this project in order to reduce the cost.

Then, there were a few parts of the project that has been redesigned. One of them is top beam. The initial design is as shown in figure below:

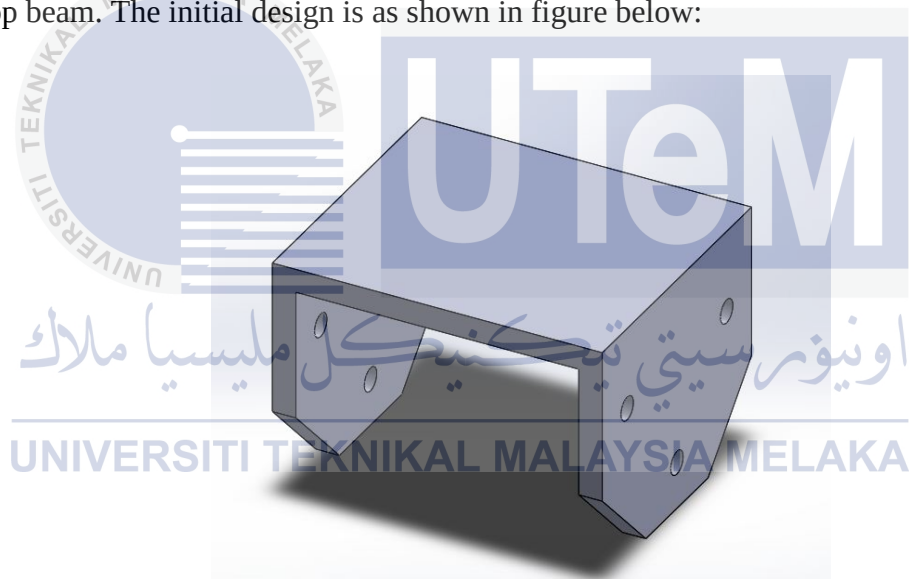


Figure 4.1 Top Beam (initial)

The problem with this part's design is it will yield too much waste if it is machined all at once. So basically, the design was not changed completely but it was divided into to three different parts. Hence, the material waste can be reduced without changing the overall part design and its function. The part that has been machined and assembled is shown in figure below:



Figure 4.2 Top Beam (final)

Next, the initial planning for the roller housing part, it should locates three rollers for each side. However, the rollers were replaced by bearings and the number of bearing of each side was reduced to two as shown in figure below:



Figure 4.3 Sides with Bearings

This changes need to be made because of two bearing is enough and sufficient to support the load of cross shaft. If one more bearing is placed there, it would be a waste.

Last but not least, there are a few dimensions of the parts that have been changed so that it can suit or fit with the new design. The new dimension and parts are stated in table below. All of the changes that have been discussed can be simplified as in the table below:

Table 4.2 New Changes

Part	Description	Initial	Final
1. Cross Shaft	Material	Aluminum	Mild Steel
2. Side for cross shaft	Material	Aluminum	Mild Steel
3. Nylon roller	Hardware	Nylon Roller	Bearing
4. Bearing	Hardware (quantity)	12	8
5. Toggle Clamp	Hardware (quantity)	4	2

And the new bill of material of final product which including new changes are shown in the table below:

Table 4.3 New Bill of Material

Part	Part name	Material	Actual size (mm)	Quantity
1	Base Rail	Aluminum		2
2	Wood Table	Wood		1
3	Cross Shaft	Mild steel		1
4	Sides for Roller(cross shaft)	Mild steel		2
5	Sides for Roller(top beam)	Aluminum		2
6	Bearing	-		8
7	Toggle clamp	-	-	2

4.3 Optical Comparator

In previous chapter, the method to test and analyze this project was by using surface roughness testing. However, the test was not relevant due to the thickness of the sample was too small. Therefore, the test was replaced by using profile projector.

Profile projector or often simply optical comparator is a tool that applies the concept of optics to the inspection of manufactured parts. In a comparator, the magnified silhouette of a part is projected upon the screen, and the dimensions and geometry of the part are measured against prescribed limits. It can reveal defects like scratches, burrs, indentions or undesirable chamfers which both micrometers and calipers can't reveal.

But for this project, only dimensions were measured and analyzed. In the drillability test works, the measurement of hole diameter is highly important to specify the hole quality. The figure of optical comparator is shown below:



Figure 4.4 Optical Comparator

These are the procedures to use this device:

1. Switch on the optical profile projector.

2. Place the clean workpiece on the glass of the table.
3. Focus it properly by moving focusing wheel and move the work table to obtain correct magnified image of the object.
4. Horizontal (x-axis) can be taken by right hand side micrometer and the vertical (y-axis) measurement can be taken from front side micrometer.

4.4 Experimental Setup

For the experimental studies, test samples were prepared. Two piece of aluminum sheet metal with size of 150mm x 100mm x 1mm were used. Both of the samples were assigned with name Sample A and Sample B respectively. Sample A was for drilling operation by using the table (finish product) and Sample B was for drilling operation without using the table. Eight points were marked on each of the samples for drilling purpose.

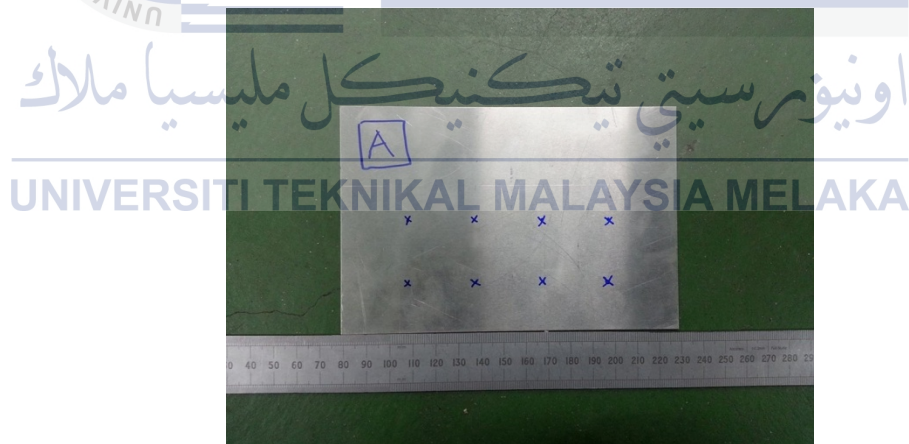


Figure 4.5 Sample A

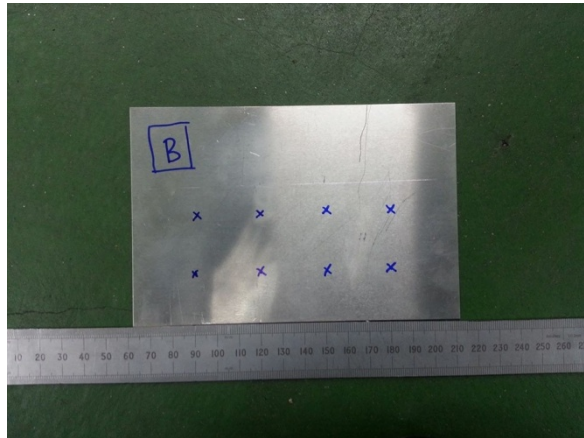


Figure 4.6 Sample B

Just like other drilling operation, the samples were center-punched first. It was used to mark the center of each point. This step was necessary because a drill bit has tendency to 'wander' if it is not start in a recess. In a simple way, center punch forms a large enough dimple to guide the tip of drill bit. The figure below shows the samples after being center-punched and the tools to do it. The figure 38 below shows the sample after the center punch process was done.

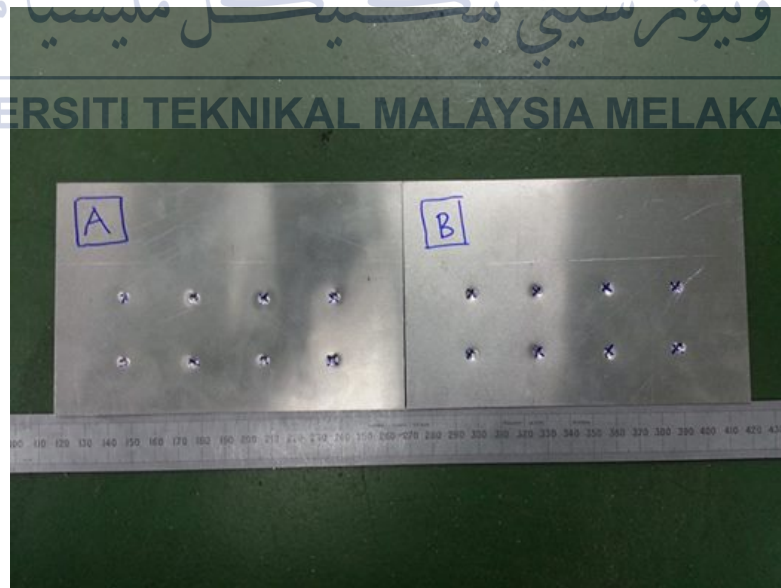


Figure 4.7 Center-punched Samples



Figure 4.8 Center Punch Tool

After all of the points were center-punched, the samples were ready to be drilled. Drilling tests were carried out using a Drill Press Machine (ALZSTAR 30). In order to get precise data, operator and machining parameter were kept constant. The experiment set-up is shown in table and figure below:

Table 4.4 Parameter Setup

Samples	Cutting Parameters			Drill Bit Diameter (mm)	Material
	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)		
A	17.5	0.1	1	3.5	Aluminum
B	17.5	0.1	1	3.5	Aluminum



Figure 4.9 Experimental Setup for Sample A

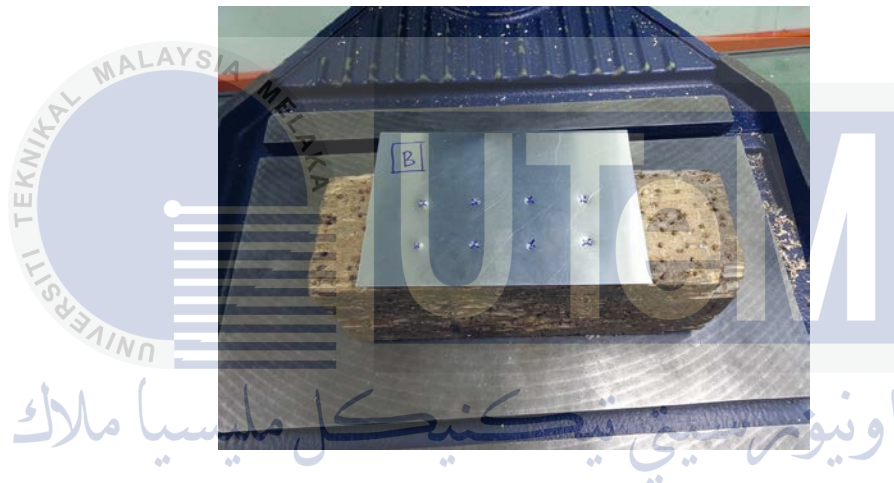


Figure 4.10 Experimental Setup for Sample B

Time taken to drill eight holes were taken then recorded for each samples. Time taken starts from when the samples were already set up on the machine.

After drilling operation was complete, the samples were brought to metrology lab to measure holes diameter. Hole diameter of each hole that were drilled in the experiment were measured one by one by using optical comparator. Once the optical comparator was turned on, Sample A was cleaned and placed on the glass of the table.

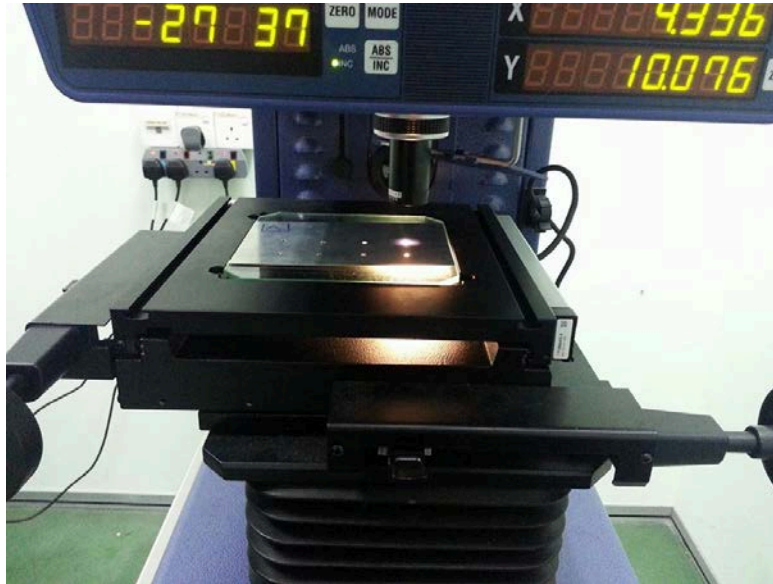


Figure 4.11 Sample on Optical Comparator

The work table was moved by moving the X-axis and Y-axis until the holes were appearing on the screen. Then, the focusing wheel was adjusted until correct magnified image of the object is obtained. After clear image on the screen was appeared, the work table was moved again so that the hole image was at the center of the screen.



Figure 4.12 Hole Image at the Screen Center

Once the image was at the center, the work table was moved in direction of X-axis either left or right until the circumference of the image was at the end of the chart as shown in figure below.

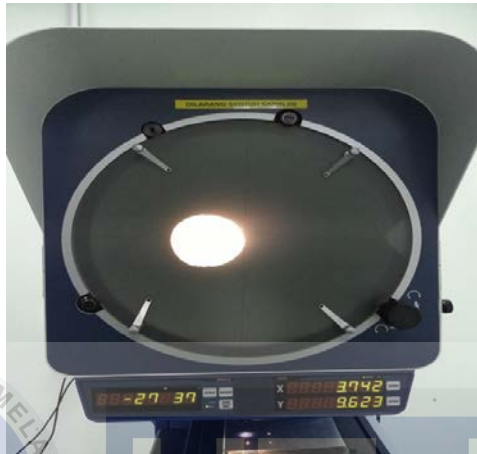


Figure 4.13 Position of Image to Set Zero

The next step was to set zero then move in opposite direction of the X-axis so that the diameter of the image was obtained. The data was recorded and tabulated in a table. The same steps were repeated for sample B.

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4.5 Result Analysis

After the experiment was conducted, the data was gathered, tabulated and compared. For ease of understanding, a graph was constructed along with the data below it.

4.5.1 Hole Diameter

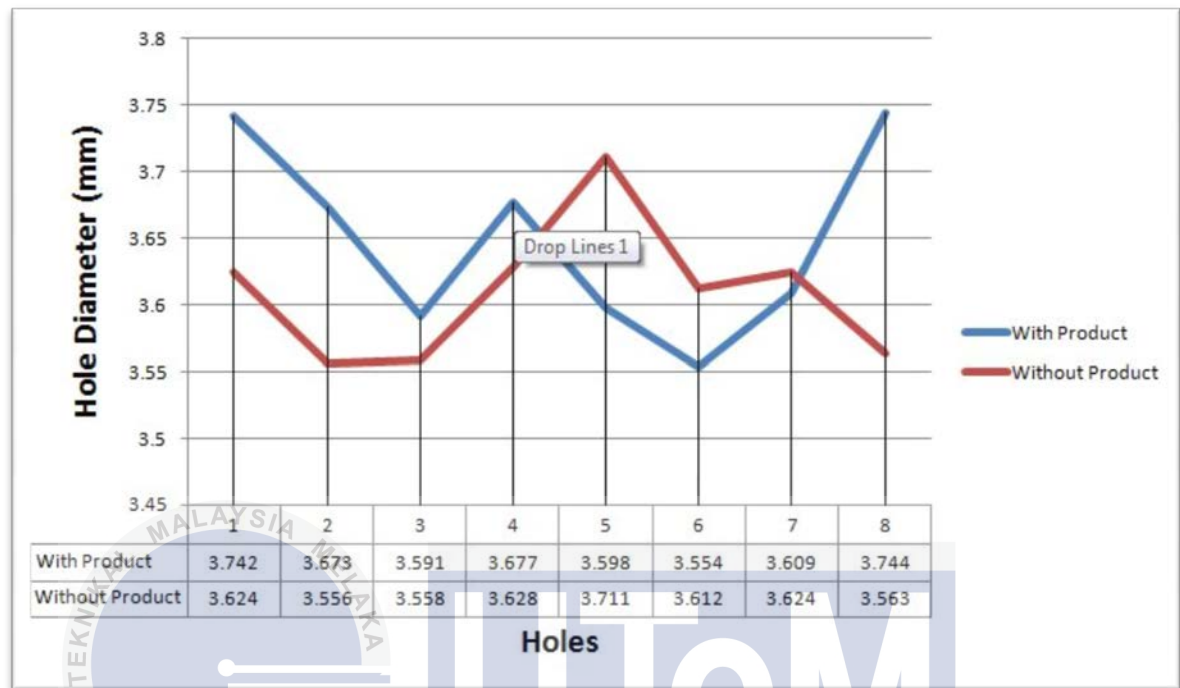


Figure 4.14 Collection of Data with Graph

Based on the graph, it can be seen that the data was not precise and accurate. The variation in the graph exists might be due to a few factors:

1. Tool wear
2. Result of deflection
3. Vibration
4. Cutting Parameters
5. Locking system

After all, the experiment was conducted without taking these factors into consideration. This is because, the objective of the experiment conducted was to compare the result between the use of this project and without this project. Furthermore, the drilling operation conducted was by operator not by machine (CNC machine). So the variation might also be due to human error such as shaking hands, parallax error and so

on. To achieve the objective of this experiment, the average holes diameter and standard deviation were calculated. The result was tabulated in the table below:

Table 4.5 Value of Mean and Standard Deviation

Sample		A	B
Holes	1	3.742	3.624
	2	3.673	3.556
	3	3.591	3.558
	4	3.677	3.628
	5	3.598	3.711
	6	3.554	3.612
	7	3.609	3.624
	8	3.744	3.563
Mean		3.6485	3.6095
Standard Deviation		0.071336	0.051752

Based on the calculations made, the mean (average) of Sample A was 3.6485 and Sample B was 3.6095. This shows that the average diameter values closest to the nominal diameter (3.5mm) was Sample B (without product) compared to the Sample A (with product). This means that Sample B has more accurate result as the average diameter value has less difference to nominal diameter.

Besides, based on the standard deviation value, Sample B has lesser value compared to Sample A. Hence, Sample B has less variation to the mean value when compared to Sample A. Hereby, Sample B is more precise than Sample A as it has lesser standard deviation value.

4.5.2 Time Taken

Table 4.6 Time Taken to Drill Eight Holes

Sample	Time Taken (min)
A	01.11
B	01.10

Based on time taken to drill eight holes on each sample, it shows that Sample A (with product) takes a bit longer to complete the drilling operation compared to Sample B (without product). This is due to experiment set-up for Sample B which was conducted without using any clamping device. There was no device provided for drilling machine in the lab. Basically, to do any drilling operation, it requires a fixed clamping device such as vise. To drill many holes, it requires longer time as the workpiece need to be clamped many times. While in this scenario, Sample B was not clamped at all. The sample can be moved simply after the drilling operation for any holes was finished. This for sure will reduce time as it has the same concept of this project.

CHAPTER 5

CONCLUSION

5.1 Summary of Findings

This study was conducted for the purpose of developing a linear positioning table for drilling machine. The table can be moved linearly which means in X-axis and Y-axis direction so that drilling operation can be done in one single clamping. In addition, clamping device was also provided so that it can provide rigidity and strength during drilling operation. Besides, this project also taking into account of safety measure. This is because the current method to do drilling operation is not by using any clamping device. Operator needs to hold the workpiece by themselves which can be considered dangerous.

The descriptive method of research was utilized in order to complete this project. However, there were some changes made from the previous planning in the methodology. Change that gives the biggest impact in completing this project was by changing some of the part's material. This change has to be made due to cost. To cut costs of project, material of aluminum need to be replaced by mild steel. Due to the change, the finish product became very heavy because of mild steel properties. The rest of the changes made were in terms of design, dimension and hardware. These changes however didn't give any negative impact as it was for product improvement. After the linear positioning table has been completely developed, it was tested to analyze the functionality and rigidity of the product.

5.2 Limitation

While developing this product, there was some limitation that had to be encountered. The limitations were as follow:

1. Cost

The estimated cost of developing this product is about RM 400. It is including high quality of hardware and raw materials. To reduce the cost, material for some of the parts need to be replaced with material of lower price.

2. Time of machining process

Although the times given were 14 weeks to develop the product, it was barely enough. This is because the lab was only available on Wednesday from 2.00 pm to 4.30 pm for each week. And some of the time was used by lecturers to run programs for student. In addition, by using conventional machines, it consumed more time compared to CNC machines. Besides, due to material replacement from aluminum to mild steel, even it can cut cost of expenditure but it costs the time. It took a lot of time to machine mild steel compared to aluminum.

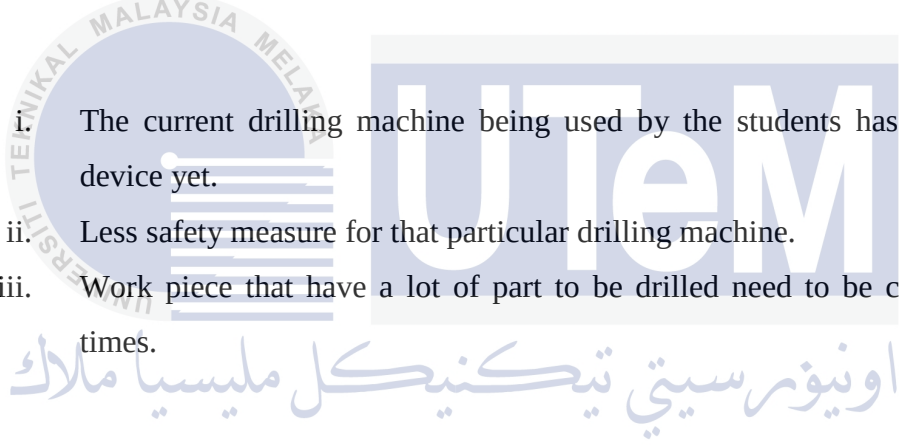
5.3 Recommendations

There are some suggestions and recommendations for the future work that can improve this project. First, all the parts can have better dimensional accuracy by using CNC machine. Better dimensional accuracy gives better result. So, the performance and rigidity of the product will increase. The time taken to develop product also can be reduced. Next, the best raw material that should be used is aluminum. It makes the machining process easier, reduces machining time, and makes the product lighter. It also can increase mobility which means the product can be easily moved from one place to another. Furthermore, in the future research, it is recommended to conduct more experiments on the product to test its efficiency, functionality and rigidity such as

surface roughness testing. However, the thicknesses of the samples need to be increased in order to conduct this test.

5.3 Conclusion

In a nutshell, the objectives of this project had been achieved successfully. The product was completely developed by following the process planning even it needs to have some modification to increase its efficiency and functionality. The product developed can drill many holes in one single clamping. All these problems also were solved once this product was completed:

- 
- i. The current drilling machine being used by the students has no clamping device yet.
 - ii. Less safety measure for that particular drilling machine.
 - iii. Work piece that have a lot of part to be drilled need to be clamped many times.

As conclusion, implementation of linear positioning table even not significantly reduces the process duration of drilling, it still can provide safety measure. Besides, it also provides clamping device which the current drilling machine has no clamping device yet. Furthermore, it can provide high accuracy results once some modifications are made.

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