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JUDUL: **DEVELOPMENT OF CUTTER FOR PRINTED CIRCUIT BOARD USING HYDRAULIC PRINCIPLE**

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Mechanical Engineering.

Signature : ....

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Date : 23/Nov/2007

DEVELOPMENT OF CUTTER FOR PRINTED CIRCUIT BOARD USING HYDRAULIC PRINCIPLE

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A report submitted in partial fulfilment of the
requirements for the award of the degree of
Bachelor of Mechanical Engineering

Faculty Mechanical Engineering
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NOVEMBER 2007

STUDENT DECLARATION

I declare that thesis entitled "*Development of cutter for Printed Circuit Board Using Hydraulic Principle*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

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To my beloved mother and father

Ismail b. Daud
Tengku Adida bt. Tengku Khalid

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ABSTRACT

Cutter was known since long times ago as something that was use to cut the thing into smaller piece. Starting from the usual rock at the rock age till the high technology cutter which was make from the precious and valuable material like diamond at this modern age, the cutter was develop to make our daily life more easier and easier. This project is proposed to design and fabricate a cutter as benefit to cut the printed circuit board, the board which contains cuprum as a trace to connect the electricity current to the electronic component like resistors and capacitors. The printed circuit board was widely used in modern electronic and electric component like radio and computer because it can minimize the space and reduce the manufacturing cost by assemble all electronic components together. The usual way to cut the printed circuit board is by using hand because the sensitive of it. By develop the cutter it will make the way to cut the printed circuit board is more efficient without give the damage to the board. In this project, the main purpose of study is to develop the cutter to make sure the cutter can achieve it objective. Developments of cutter are starting by choosing the right cutter's material then design and finally fabricate the cutter.

ABSTRAK

Pemotong telah dikenali sejak dahulu sebagai alat untuk memotong sesuatu benda kepada kepingan yang lebih kecil. Bermula dengan penggunaan batu biasa di zaman batu hinggalah pemotong berteknologi tinggi yang diperbuat daripada bahan bernilai dan berharga seperti berlian pada zaman moden ini, pemotong telah direka untuk memudahkan urusan harian kita. Projek ini bertujuan mereka dan membentuk pemotong untuk papan litar bersepadu yang mengandungi kuprum sebagai trek untuk mengalir arus eletrik kepada peralatan elekronik seperti kapasitor dan perintang. Papan litar bersepadu telah digunakan secara meluas dalam peralatan elektrik moden seperti komputer dan radio kerana ia dapat menjimat ruang dan mengurangkan kos pembuatan dengan menyatukan semua peralatan elektrik. Cara biasa memotong papan litar bersepadu adalah dengan menggunakan tangan kerana litar ini sensitif. The pembentukan pemotong ini ia dapat memotong papan litar bersepadu dengan lebih efisien tanpa merosakkan litar tersebut. Dalam projek ini, pengajian utama adalah merekabentuk pemotong untuk memastikkan ia mencapai objektifnya. Kerja merekabentuk bermula dengan pemilihan pemotong yang dikehendaki kemudian mereka dan diakhiri dengan membentuk pemotong tersebut.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Printed Circuit Board (PCB) is main component is electronic device like computer, television and handset. The function of this board is to hold and support the component like capacitor and to connect the electronic component using conductive paths ways or trace. After the manufacturing of the board is finish and complete, it usually came in large size and all the board is attach to each other. So, to put in it in the device, the large board needs to cut to become small one. The process to cut the PCBs is usually using hand or scissor. This is because the PCB is sensitive and easy to damage. But this process is slow and using more workers. So the new ways are develop to find the effective ways to cut the board.

In this project the cutter will be develop using the best material. Before fabricate it, the design must be choose to make sure the cutter is suitable to cut the board. The meaning of design and develop here is to design the machine using engineering drawing software like Solidwork then fabricate it to make this machine work. Printed circuit board is the board that consist of layer of fiberglass and carbon. It usually use in electronic device to make sure the electricity work perfectly and to minimize the space because many electrical components can be assembles on it. While hydraulic is science that dealing with the mechanical properties of liquid. It works like pneumatic but hydraulic use liquid while pneumatic use air as a medium.

1.2 Project Objective

The main propose for this project is to develop and design the cutter for printed circuit board (PCB) using hydraulic principle that can be used for to cut the PCB.

1.3 Scope of Project

The scope for this project:

i. Using Solidwork software to made 3D model
ii. Check the failure analysis
iii. Fabricate and assemble all part for this project

1.4 Problem Statement

In manufacturing industries, cost and time are important factor to make the profit. We must set the time correctly if we want to gain the higher profit. Some of this wasting time is depend on what the type of machine that we use. Some machines are work slowly, not accurate and hardly to maintenance while the other type are faster, accurate and easy to maintenance. Machines that work faster and accurate are usually high price and slower machine is lower price. So choosing the right machine is hard because we have to choose the machines that suitable for our budget and our productivity. Using slower machines can slower productivity but if we use faster machine we have to think of the price of it. So to settle this problem have to develop new type of machine that is faster but the price of is suitable for industries use.

CHAPTER 2

LITERATURE REVIEW

2.1 Printed Circuit Board

Printed circuit board (PCB) sometimes called printed wiring board (PWB) is a flat board that holds chips and other electronics components. It was use to mechanically support and electrically connect electronic component using conductive paths ways or traces. PCB is inexpensive can be highly reliable. They require more layout effort and higher initial cost than point to point constructed circuit but are much cheaper and faster in high production volume.

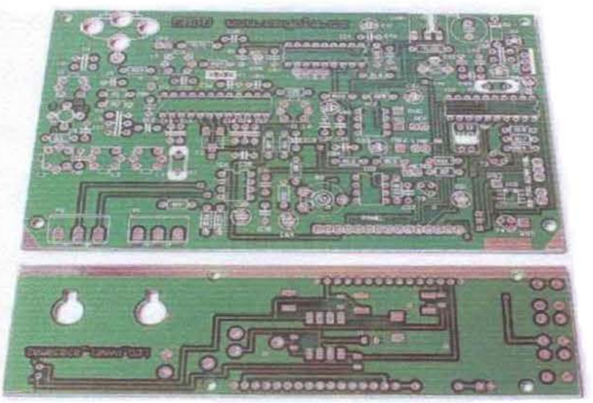

Figure 2.1: Printed Circuit Board

The inventor for PCB is Paul Eisler (1907-1995), an Austrian engineer who working in England. In 1936, he made one circa as part of a radio set. Around 1943 when the War World II occurs, United State of America (USA) began to use the technology on large scale to make radio for army use. After the war, in 1948, USA released the invention for commercial use. Printed circuit board not becomes popular in consumer electronic until middle 1950s, after the Auto-Assembly process was developed by the United State Army. Before printed circuit was develop, point-to-point construction was used but for prototype and small production runs, wire wrap can be more efficient.

There are many good reasons for using printed circuit board instead of other interconnection wiring methods and component mounting technique:

i. The size of component assembly is reduced with corresponding decrease in weight.
ii. Quantity production can be achieved at lower unit cost
iii. Component wiring and assembly can be mechanized
iv. Circuit characteristic can be maintained without introducing variation in inter-circuit capacitance
v. They ensure a high level of repeatability and offer uniformity of electrical characteristics from assembly to assembly.
vi. The location of part is fixed, which simplifies identification and maintenance of electronic equipment and systems.
vii. Printed circuit board wiring personnel require minimal technical skills and training. Changes of miswiring of circuited wiring are minimized.

Most PCBs are composed of between one and twenty-four conductive layers separated and supported by layers of insulating material (substrates) laminated (glued with heat, pressure & sometimes vacuum) together. Layers may connect together through drilled holes called vias. To form an electrical connection, the small rivets are inserted into the holes. Even though they may not form electrical connection to all layers, these holes are typically drilled completely though the PC board.

There is no standard thickness for printed circuit board. The limiting factor for printed circuit board thickness is the diameter of the smallest hole, especially when the holes are plated though.

The final board thickness will depend upon the number of conductor layers and on the electrical layer-to-layer spacing requirements of the design. In multi-layer boards the increase in cost is not directly proportional to the increase in the number of conductive layers. For example, doubling the number of layers from four to eight will probably increase cost by only 30 per cent. However, if the number of conductor layer exceeds 10, the extra layer cost increase at a rapid rate.

The lower temperature to make sure PC board can be use is -55° C and maximum temperature is 125° C. Nowadays; PC board is widely used in electronic device like computer, aircraft and satellite. The life time of PC board is depending on which industries it was use. For example for computer, PC board can give it service for 5 years . For more detail about PC board life time, see Table 2.1

2.1.1 Component of a Printed Circuit Board

The essential components of a printed circuit board are:

i. the base, which is a thin board of insulating material, rigid or flexible which support all conductor and component
ii. the conductor, normally of high purity copper in the form of thin strips of appropriate shapes firmly attached to base material

The base provides mechanical support to all copper areas and all components attached to the copper. The electrical properties of the completed circuit depend upon the dielectric properties of the base material and must therefore, be known and appropriately controlled

Table 2.1: Life time of PC board

Types	**Min Temp**	**Max Temp**	**Service**
Consumer	0°C	+60°C	1-3 years
Computer	+15°C	+60°C	5 years
Telecommunication	-40°C	+85°C	7-20 years
Civilian Aircraft	-55°C	+95°C	10 years
Industrial	-55°C	+55°C	10 years
Military Ground/Ship	-55°C	+95°C	5 years
Space	-40°C	+85°C	5-20 years
Military Aircraft	-55°C	+95°C	5 years
Auto Engine	-55°C	+125°C	5years

The conductors provide not only the mechanical support and all necessary electrical component but also the solderable attachment points for the same.

When the completed board mechanically support and all necessary electrical connections to the components, it is essentially a Printed Circuit Board or Printed Wiring Board. The term printed became popular because the conductive area are usually generated by means of a printing process like screen printing or photo-engraving, which are commonly use to print drawing or inscriptions.

2.2 Laminated of Printed Circuit Board

The basic function of the laminated is to provide mechanical support for electronic components and to interconnect them electrically. Laminated for PCBs are composite materials. They can be simply described as product obtained by pressing layers of a filler material, which is the mixture of filler reinforcement and resin on which all conductors and components are mounted is called base material. This can be either rigid or flexible material.

2.2.1 Epoxy

Epoxy is polyepoxide is a thermosetting epoxide polymer that cures when mixed with a catalyzing agent or hardener. Most common epoxy resins are produced from a reaction between epichlorohydrin (reactive organic compound) and bisphenol-A (a chemical compound with two phenol functional groups in its molecule that belongs to the phenol class of aromatic organic compounds. It is prepared by reaction of two equivalents of phenol with one equivalent of acetone). It was produced in 1927 in United State of America. While the first synthesis of bisphenol-A based epoxy resin is produced by Dr. Pierre Castan who works with Ciba, Ltd. Of Switzerland. Because of that Ciba Company became one of three major epoxy resin producers worldwide.

Epoxies will not stick to mold-release compound recommended for use with epoxy and polyethylene sheeting, like disposable paints tarps and sandwich bags. Epoxy does not stick to the shiny side of packaging tape or paraffin wax.

The applications for epoxy based materials are extensive and include coatings, adhesives and composite materials such as those using carbon fiber and fiberglass reinforcements, although polyester, vinyl ester, and other thermosetting resins are also used for glass-reinforced plastic. The chemistry of epoxies and the range of commercially available variations allow cure polymers to be produced with a very broad range of properties. In general, epoxies are known for their excellent adhesion, chemical and heat resistance, good to excellent mechanical properties and very good electrical insulating properties, but almost any property can be modified for example silver-filled epoxies with good electrical conductivity are available, although epoxies are typically electrically insulating.

Epoxy resin formulations are also important in the electronics industry, and are employed in motors, generators, transformers, switchgear, bushings, and insulators. Epoxy resins are excellent electrical insulators and protect electrical components from short circuiting, dust and moisture.

In the electronics industry, epoxy resins are the primary resin used in over molding integrated circuits, transistors and hybrid circuits, and making printed circuit boards. The largest volume type of circuit board is a sandwich of layers of glass cloth bonded into a composite by an epoxy resin. Epoxy resins are used to bond copper foil to circuit board substrates, and are a component of the solder mask on many circuit boards.

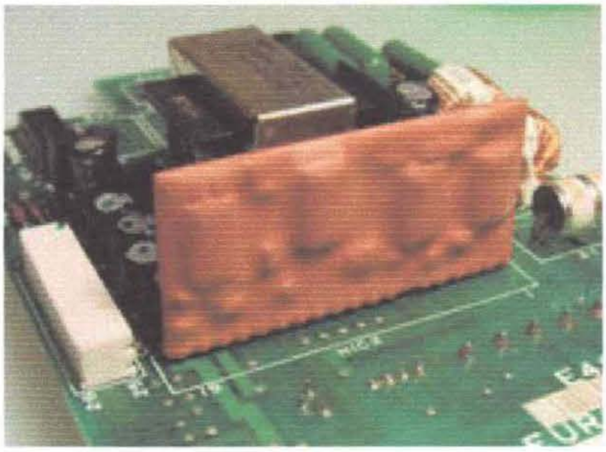

Figure 2.2: Epoxy on PC board

2.2.2 FR-4

FR-4 or Flame Resistant 4 is a material that was used to make printed circuit board. It described the board itself with no copper covering. The FR-4 that used to make the PC board is usually Ultra Violet (UV) stabilized with a tetrafunctional resin system. The FR-4 is typically is yellowish colour. FR-4 is manufactured as insulator (without copper) is typically a difunctional resin system and a greenish colour.

A PCB needs to be an insulator to avoid shorting the circuit, physically strong to protect the copper tracks placed upon it, and to have certain other physical electrical qualities. FR-4 is preferred over cheaper alternatives due to several mechanical and electrical properties;

i. It is less lossy at high frequencies,
ii. Absorbs less moisture,
iii. Has greater strength and stiffness
iv. Highly flame resistant compared to its less costly counterpart

Besides being used for make PC board, FR-4 also being used for manufacturing insulating or structural component.

2.2.3 FR-2

FR-2 is an abbreviation for Flame Resistant 2. It was used to manufacture the printed circuit board. Its properties are similar to NEMA (National Electrical Manufacturing Association-United Stated based Association) grade XXXP (MIL-P-3115) material, and can be substituted for the latter in many applications.

Table 2.2: FR-4 properties

Property	**Value**
Dielectric constant (Permittivity)	4.70 Max, 4.35 @ 500 MHz, 4.34 @ 1 GHz
Dissipation Factor (Loss tangent)	0.02 @1 MHz, 0.01 @ 1 GHz
Dielectric strength	20 MV/m (500 V/mil)
Surface Resistivity (min)	2x10^5 MΩ
Volume Resistivity (min)	8x10^7 MΩ*cm
Typical Thickness	1.25 mm - 2.54 mm (0.049-0.100 inches)
Typical stiffness (Young's modulus)	17 GPa (2.5x10^6 PSI; for use in PCBs)
Density	1.91 kg/L

FR-2 sheet with copper foil lamination on one or both side is widely used to build low-end electronic equipment. FR-2 is cheaper but it not suitable for devices installed in vehicles because vibration can make crack propagate that can causing hairline fracture in copper circuit traces. Without copper foil lamination, FR-2 is sometimes used for simple structural shapes and electrical insulation.

Table 2.3: FR-2 properties

Property	Value
Dielectric Constant (permittivity)	4.5 @ 1 MHz
Dissipation Factor	0.024-.026 @ 1 MHz
Dielectric Strength	740 V/mil

2.2.4 Polytetrafluoroethylene

Polytetrafluoroethylene (PTFE) is low coefficient of friction and is used as anon-stick coating for pan and other cookware. It is non-reactive and often being use in containers and pipework for reactive and corrosive chemicals. PFTE also know as Teflon under the brand DuPont as DuPont Company discovered PTFE in 1938. Polytetrafluoroethylene or fluorocarbons have good resistance to high temperature (melting point for Teflon is 327°C), to chemical, to weather, and to electricity. They have unique nonadhesive properties and low friction.

Beside that, PTFE also have dielectric properties especially at high radio frequencies, making it suitable for use as insulator in cables and connector assemblies and as material for printed circuit board.

2.2.5 Polyimide

Polyimide is often used in the electronics industry for flexible cable. It has good mechanical, physical and electrical properties at elevated temperatures. They also have good creep resistance, low friction and wear characteristic. Polyimide has nonmelting characteristic of a thermoset but the structure of a thermoplastic. Typical applications for polyimide:

i. pump components
ii. electrical connectors for high temperature use
iii. aerospace part
iv. high strength impact resistance structure
v. sport equipment
vi. safety vest

Table 2.4: Properties of Polyimide

Density	1430 kg/m3
Young's modulus(E)	3200 MPa
Tensile strength(σt)	75-90 MPa
Elongation @ break	4-8%
notch test	4-8 kJ/m^2
Glass temperature	>400°C
heat transfer coefficient (λ)	0.52 W/m.K
linear expansion coefficient (α)	5.5 10-5 /K
Specific heat (c)	1.15 kJ/kg.K
Water absorption (ASTM)	0.32
Dielectric constant (Dk) at 1MHz	3.5
Loss tangent (Df)	0.002

2.3 Hydraulic

Hydraulic is a systems that dealing with liquid. Hydraulic system is same with pneumatic system but hydraulic use liquid media such as oil while pneumatic use gas or air. Although it work using same principle with pneumatic, hydraulic can create large pressure than pneumatic system but pneumatic is cleaner than hydraulic. Hydraulic system is always greasy. Other differential between hydraulic and pneumatic system may be refer in Table 2.5

Hydraulic systems generally rely on pressure in a fluid. Pressure occurs is fluid when it is subjected to a force. Increasing the force will increase the pressure in direct proportion. Decreasing the area also will increase the pressure. Pressure in the fluid can therefore be defined as the force acting per unit area, or;

$$P = \frac{F}{A}$$

where $F = ma$; a = acceleration

m = mass

A = area

The SI system defines pressure as the force in Newton's per square meter (Nm^{-2}). The SI unit of pressure is the Pascal (with 1 Pa = 1 Nm^{-2}). One Pascal is very low pressure for practical use, so the kilopascal (1kPa) or the megapascal (1Mpa) is commonly used. Pressure can also arise in a fluid from the weight of a fluid. This usually known as the head pressure at the bottom of the fluid is directly proportional to height h. the head pressure is given by:

$$P = \rho g h$$

where ρ = density

g = gravity

h = height

Table 2.5: Differential between hydraulic and pneumatic system

	Hydraulic	**Pneumatic**
Energy source	Electric motor	Electric motor or diesel driven
Energy storage	Limited (accumulator)	Good (reservoir)
Distribution system	Limited basically a local facility	Good. Can be treated as aplant wide service
Energy cost	Medium	Highest
Rotary actuators	Low speed. Good control	Wide speed range control difficult
Linear actuator	Cylinders. Very high force	Cylinders. Medium force
Controllable force	Controllable high force	Controllable medium force
Points to note	Leakage dangerous and unsightly. Fire hazard	Noise

2.3.1 Hydraulic Cylinder

Hydraulic cylinders (also called linear hydraulic motors) are mechanical actuators that are used to give a linear force through a linear stroke. Hydraulic cylinders get their power from pressurized hydraulic fluid, which is typically oil. The cylinder consists of a cylinder barrel, in which a piston connected to a piston rod is moving. The barrel is closed by the cylinder bottom and by the cylinder head where the piston rod comes out of the cylinder. The piston has sliding rings and seals. The piston divides the inside of the cylinder in two chambers, the bottom chamber and the piston rod side chamber. The hydraulic pressure acts on the piston to do linear work.

A hydraulic cylinder is the actuator or "motor" side of this system. The "generator" side of the hydraulic system is the hydraulic pump that brings a fixed or regulated flow of oil into the system. Mounting brackets or clevises are mounted to the cylinder bottom as well as the piston rod.

By pumping hydraulic oil to the bottom side of the hydraulic cylinder, the piston rod starts moving upward. The piston pushes the oil in the other chamber back to the reservoir. If we assume that the oil pressure in the piston rod chamber is zero, the force on the piston rod equals the pressure in the cylinder times the piston area. If the oil is pumped into the piston rod side chamber and the oil from the piston area flows back to the reservoir without pressure, the pressure in the piston rod area chamber is Pull Force/(piston area - piston rod area). In this way the hydraulic cylinder can both push and pull.

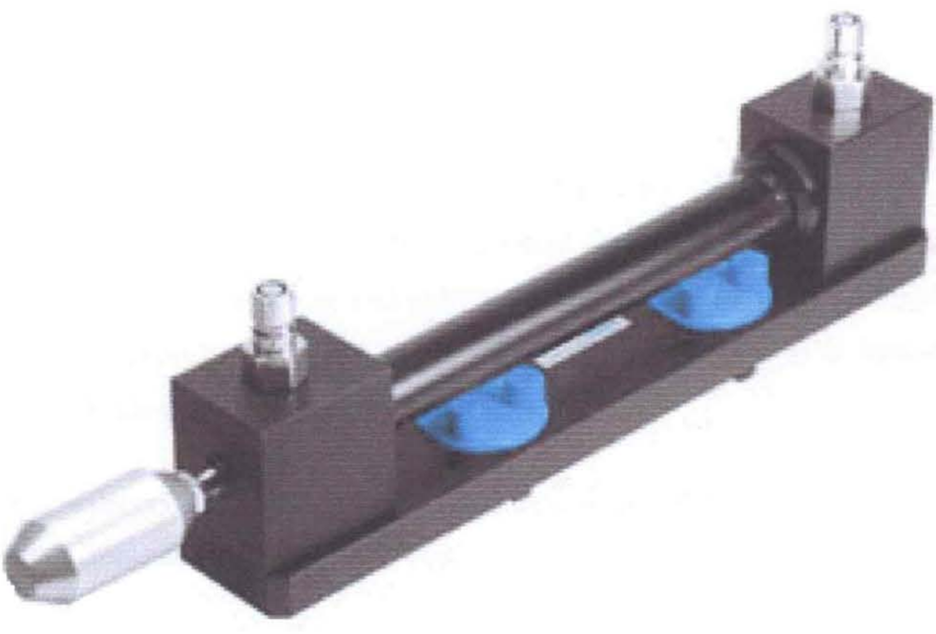

Figure 2.3: Hydraulic Cylinder

A hydraulic cylinder consists out of following parts:

i. Cylinder barrel
ii. Cylinder bottom
iii. Cylinder head
iv. Piston
v. Cylinder bottom connection
vi. Piston rod connection
vii. Feet for mounting of the barrel

The cylinder barrel is mostly a seamless thick walled forged pipe that must be machined internally. The cylinder barrel is ground and/or honed internally. In most hydraulic cylinders, the barrel and the bottom are welded together. This can damage the inside of the barrel. Therefore it is better to have a screwed or flanged connection. In that case also the barrel pipe can be maintained and/or repaired in future. The cylinder head is sometimes connected to the barrel with a sort of a simple lock (for simple cylinders). In general however the connection is screwed or flanged. Flange connections are the best, but also the most expensive. A flange has to be welded to the pipe before machining. The advantage is that the connection is bolted and always simple to remove.

For larger cylinder sizes, the disconnection of a screw with a diameter of 300 to 600 mm is a big problem as well as the alignment during mounting. A hydraulic cylinder should be used for pushing and pulling and no bending moments should be transmitted to the cylinder. For this reason the ideal connection of a hydraulic cylinder is a single clevis with a ball bearing.

In this project we have choose double acting cylinder from Festo brand. These cylinders have control cam and barded fitting. Other specification on this cylinder is on the below:

Table 2.6: Hydraulic cylinder specification

Specification	**Value**
Piston diameter	16mm
Piston rod diameter	10 mm, with M8 thread
Stroke	200 mm
Operationg Pressure	6 MPa (60 bar)
Max. permisibble pressure	12 MPa (120 bar)

2.3.2 Hydraulic Liquid

Hydraulic fluids are a large group of mineral oil, water or water-based fluids used as the medium in hydraulic systems. These fluids are found in machinery and equipment ranging from brakes, power steering, and transmissions to backhoes, excavators, garbage trucks and industrial shredders.

Base stock may be any of: castor oil, glycol, esters, ethers, mineral oil, organophosphate ester, Chutte and polyalphaolefin, propylene glycol, or silicone. Some of the trade names for hydraulic fluids include Durad®, Fyrquel®, Houghton-Safe®, Hydraunycoil®, Lubritherm® Enviro-Safe, Pydraul®, Quintolubric®, Reofos®, Reolube®, and Skydrol®.

Brake fluid is a subtype of hydraulic fluid with high boiling point and low freezing point.Hydraulic systems like the ones mentioned above will work efficiently if the hydraulic fluid used has low compressibility.Fire resistance is a property available with specialized fluids.

Hydraulic fluids can contain a wide range of various chemical compounds; oils, butanol, esters (e.g. phthalates, like DEHP, and adipates, like bis(2-ethylhexyl) adipate), polyalkylene glycols (PAG), phosphate esters (e.g. tributylphosphate), silicones, alkylated aromatic hydrocarbons, polyalphaolefins (PAO) (e.g. polyisobutenes), corrosion inhibitors, etc

Because industrial hydraulic systems operate at thousands of PSI and temperatures reaching hundreds of degrees Celsius, severe injuries and death can result from component failures and care must always be taken when performing maintenance on hydraulics.

2.4 SolidWorks

SolidWorks is a 3D computer aided design (CAD) program that runs on Microsoft Window. It was develop by SolidWorks Corporation in 1993. SolidWorks uses a feature-based "parametric" approach to modeling and assembling. In the SolidWorks 3D modeling environment the creation of a solid or surface typically begins with the definition of topology in either a 2D or 3D sketch. The topology defines the connectivity and certain geometric relationships between vertices and curves both in the sketch and external to the sketch. To this topology are added dimensions which determine the lengths and sizes for the curves and locations for the vertices in conjunction with topological constraints. The dimensions which are added are termed "parameters" because they can be changed either independently or by "parameters" created prior to their creation. The dimensions are limited "parameters" because they cannot be varied by subsequent actions on the sketch in which they are defined.

An example of this limitation is to create a simple rectangle in a 2D sketch, place dimensions on the sides of the rectangle and then to extrude the 2D sketch to form a parallel piped shape. The sketch dimensions cannot be varied based on the location of the 2D sketch (generatrix) along the extrusion length. SolidWorks would not allow the height "parameter" of the rectangle to vary with the square of the distance extruded. In other words the dimensions or "parameters" cannot be parameterized to "parameters" created in the subsequent hierarchy of features.

Parameters are therefore fixed in the feature that contains them. SolidWorks is therefore hierarchical in the creation of features in that subsequent features should have no effect on prior features. To create volume and modifications, SolidWorks employs a feature-based system that can be rolled back to previous states in case something must be changed or multiple configurations of the same part must be handled. To assemble components, mates are created, which define the relative positions of the components to each other.

2.5 Cuttting Tools

Tool steels are steels that are primarily used to make tools used in manufacturing processes as well as for machining metals, woods, and plastics. Tool steels are generally ingot-cast wrought products, and must be able to withstand high specific loads as well as be stable at elevated temperatures.

There is several type of cutting tool that will cut multiblock PCBs to smaller PCB. The type of material is depending on the manufacturer that produces the PCB cutting machine. Usually manufacturer will use the cutting tools that valuable for money, can be uses for a long time, hardness, toughness, and wear resistance. Proper choices of tools and their sharpness are very important in each of mechanical operations for obtaining an acceptable machining finish. There several characteristic of cutting tools:

i. hardness, particularly at elevated temperature, s that the hardness, strength and wear resistance of the tool are maintained at the temperatures encountered in cutting operation
ii. toughness, so that impact forces on the tool in interrupted cutting operation or due to vibration and chatter during machining do not or facture the tool
iii. wear resistance, so that an acceptable tool life is obtained before the tool is indexed or replaced.

iv. Chemical stability or inertness with respect to the material, so that any adverse reactions contributing to tool wear are avoided.

Various cutting tools material with wide range of mechanical, physical and chemical properties is available. Tools materials are usually divided into the following general categories, listed in order in which they were develop and implemented

i. Carbon and medium alloy steels
ii. High speed steels
iii. Cast cobalt alloys
iv. Carbides
v. Coated tools
vi. Alumina-based ceramics
vii. Cubic boron nitride

2.5.1 Carbides

To meet the challenge of higher speeds for higher production rates, carbides were introduced in the 1930s. Because of their high hardness over a wide range temperature, high elastics modulus and thermal conductivity and low thermal expansion, carbides are most important, versatile and cost effective tool and die material for wide range of application. There are two basic types of carbides used for machining operation are tungsten carbide and titanium carbide.

Tungsten carbide tools are generally used for cutting steels, cast irons and abrasive nonferrous materials and have largely replace high speed steel because of their performance. Titanium carbide has higher wear resistance than tungsten carbide but not is as tough. Titanium carbides suitable for machining hard material mainly steel and cast irons and for cutting at speeds higher than those appropriate for tungsten carbide.

2.5.2 High Speed Steel

High speed steel (HSS) is a material usually used in the manufacture of machine tool bits and other cutters. High speed steel was developed to cut at higher speed. They can be hardened to various depths, have good wear resistance and inexpensive. Because of their toughness and high resistance to fracture, high speed steel is suitable for high positive rake angle tools (those with small included angles, for interrupted cuts and for machine tools with low stiffness that are subject to vibration and chatter.

There are two type of high speed steel; molybdenum (M series) and tungsten (T series). The M series contains up to about 10% molybdenum, with chromium, vanadium, tungsten and cobalt as alloying elements. The T series contains 12% to 18% tungsten with chromium, vanadium and cobalt as alloying element. The M series generally has higher abrasion resistance than the T series, undergoes less distortion during heat treating and is less expensive. Consequently, 95% of all high speed steel tools are made of M-series steels.

2.5.3 Carbon And Medium Alloy Steels

Carbon steels are the oldest of tool materials and have been used widely for drills, taps, broaches and reamers since the 1880s. Lo-alloy and medium-alloys steels were developed later for similar applications but with longer tool life.

Although inexpensive and easily shaped and sharpened, these steel do not have sufficient hot hardness and wear resistance for cutting at high speed. Consequently the use of these steels is limited to very low speed cutting operations.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The development of cutting tool is to discuss about the development methodology of the cutting tool, the cutter objective, the design of the cutter and the testing stage of cutting tools

The information in this chapter is only about the methodology. Methodology is defined as the analysis of the method, rules and postulates employed by a discipline. In this chapter all the step to get resources, design and way to fabricate will be include till this project finish. There are several steps to finish this project. For more details please refer to the flow chart on the next page.

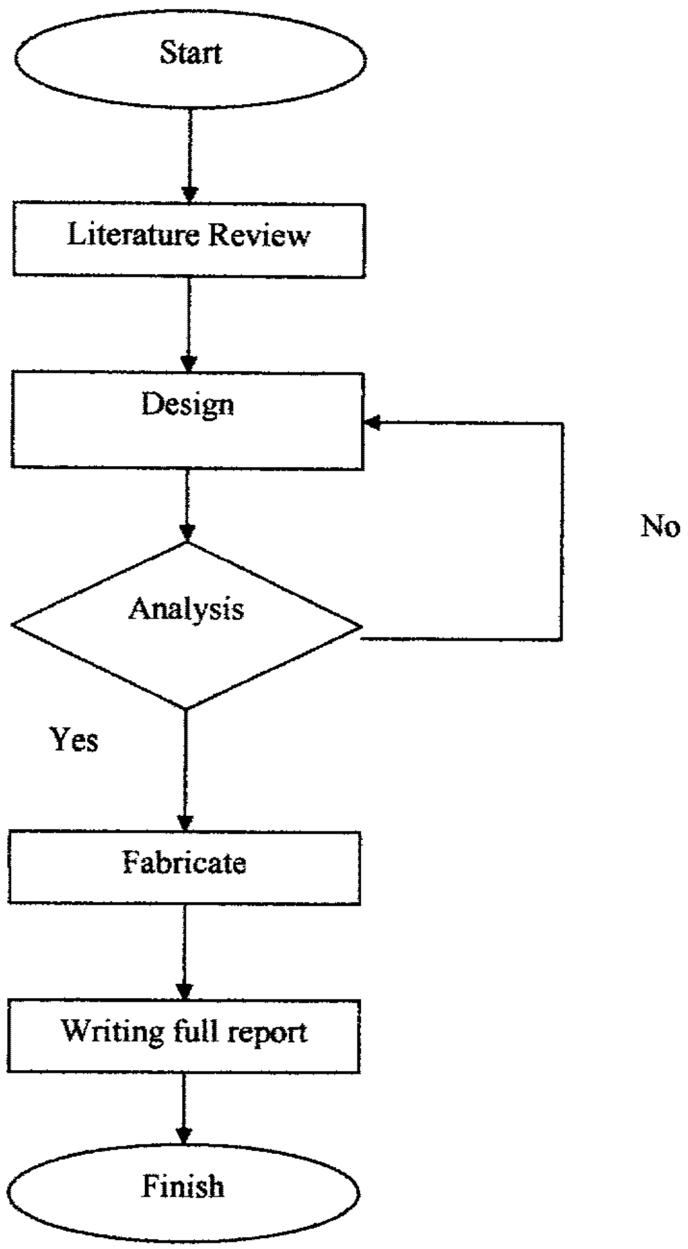

Figure 3.1: Overall process flow chart

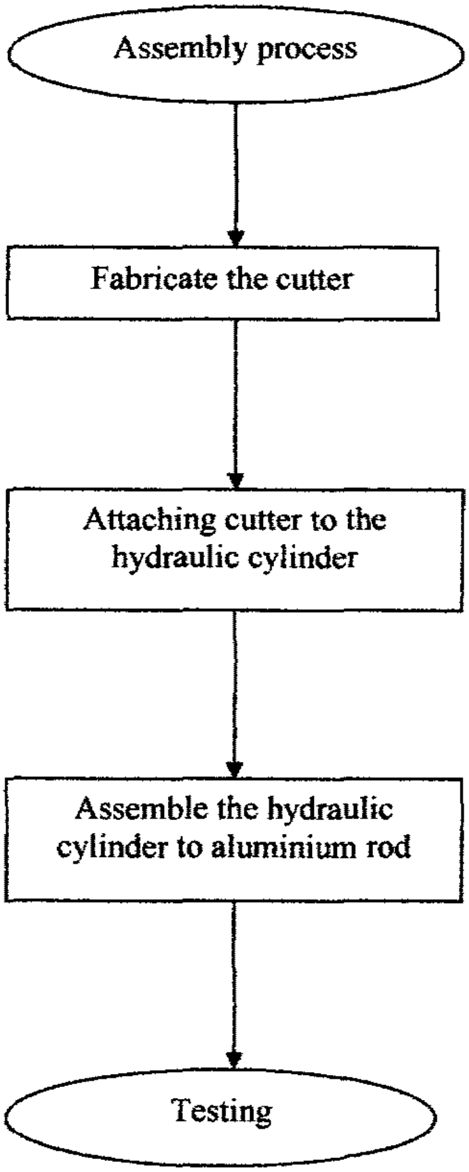

Figure 3.2: Flowchart for assembly process

3.2 Literature review

After determine the objective and scope for this project, the next sequence is doing the literature review. This will cover all the study for this project like size of printed circuit board, how pneumatic works, type of cutting tools and so on. Doing the literature review is the longest time in this project to ensure the student understands what they will do in this project. By doing literature review, more details about Printed Circuit Board and pneumatic can be gain. But before do the literature review, student must know the scope and the objective for this project. This because to prevent misunderstanding while making the literature review. The source of literature review also must be check to make sure the data is correct and can be used for this project.

3.3 Design

After literature review the next step is doing the sketch for this project. The sketch would be the sketch for cutting tool and hydraulic cylinder. The entire sketch will use 3D computer aided design (CAD) software.

Computer-aided design (CAD) software allows the development of three dimensional (3-D) designs from conventional two-dimensional orthographic views with automatic dimension can be produced. Manufacturing tools paths ca be generated from the 3-D models and in some cases, part can be created directly from a 3-D database by using a rapid prototyping and manufacturing method. Another advantage of a 3-D database is that it allows rapid and accurate calculations of mass properties such as mass, location of center of gravity and mass moments of inertia. Other geometric properties such as areas and distances between points are likewise easily obtained. There are many great CAD software packages available, such as, AutoCAD, Unigraphics, Catia, Matlab, SolidWorks and ProEngineer. SolidWorks software has been choosing because the student has learned this software before this and it is easy to design 3D model using this software.

After the sketch complete, we will make the comparison of all sketching to choose the best and suitable design. This is important because only the best design will make this project successful.

After make a research on current cutter on the market, we have agreed to use Design A as our design. This is because Design A has the right and suitable degree of sloping edge. The right edge is important to make sure the cutter can produce maximum force to cut the printed circuit board.

Here is the design what was made by using SolidWorks:

i. Cutter

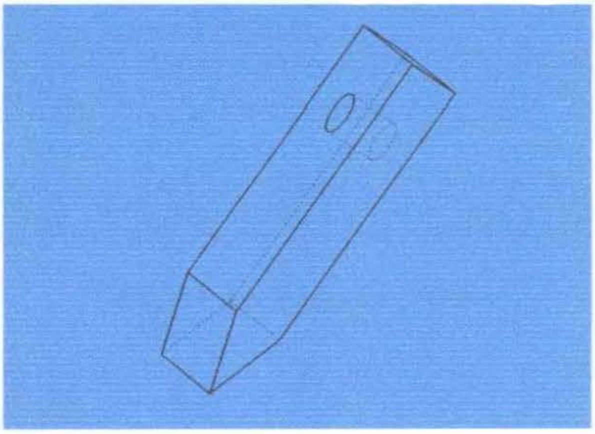

Figure 3.3: Design A

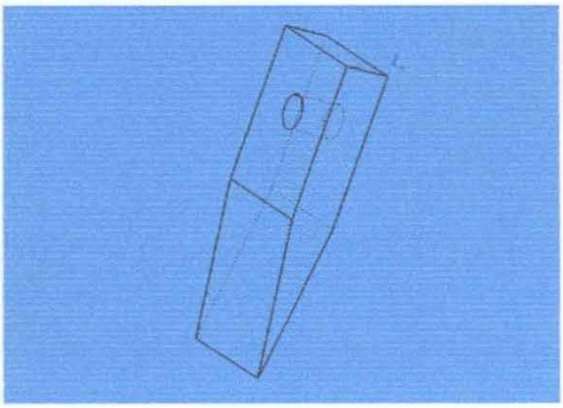

Figure 3.4: Design B

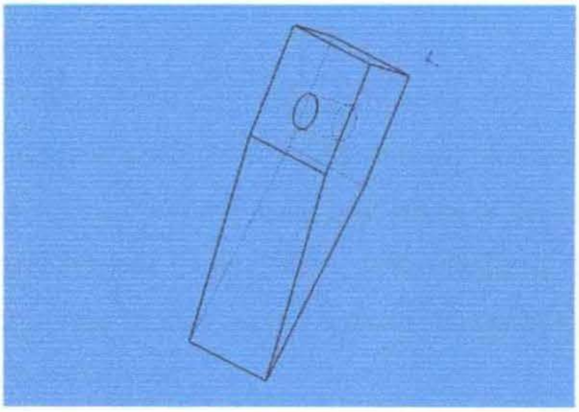

Figure 3.5: Design C

ii. Hydraulic cylinder

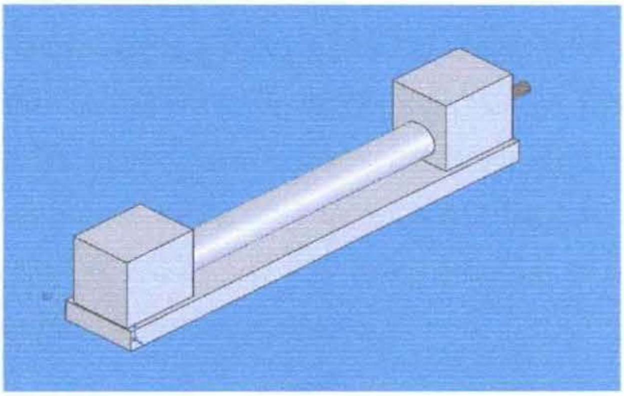

Figure 3.6: Isometric view

ii. Aluminium rod

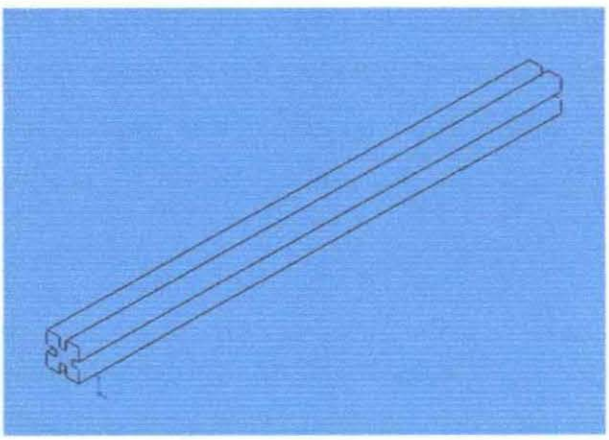

Figure 3.7: Isometric view

3.4 Analysis

The next sequence is analysis the design using analysis computer software, Algor. In this analysis we will test the stress and strain to the material in this project like the pneumatic cylinder and cutting tools. If the analysis fail or not require the minimum value of force, the student has to redesign the model and analysis it again until the satisfy value is obtained.

3.5 Fabricate

After finish modelling and analysis the 3D model, now the step it fabricate using the material that we have choose before this. All the fabricate work will be done at lab with guidance from lab's instructor. Mild steel were choose as the material for the cutting tools. Mild steel were choose because it was hard to find carbide or hi-speed steel in FKM's lab. During all fabricate time; goggle and safety shoes should be wearing to avoid any accidents.

3.5.1 Milling Process

Milling process is the process where a multitooth cutter removes material while travelling along various axes with respect to workpiece. Some of basic types of milling cutters are, slab milling, face milling and end milling. All these 3 type have same function, what make the different is the way they are used in term of milling process.

The most popular milling machine for the student is vertical spindle machine with a swivelling head but for general purpose operation, the column-knee type machines are the most common.

Milling machine is very versatile. They are usually used to machine flat surface and also irregular surface. The others type of process that can be make by using milling machine is bore, cut gear and also produce slot. Milling machine removes a material by rotating a multi tooth cutter that is fed into moving work piece. The spindle for slab milling cutter is located in horizontal while for end milling, boring and drilling are in vertical for face.

In this project, after the designing process for the cutting tools, the milling process is used to fabricate it. Application of face milling from milling process is important to make the shape of the cutter. Consideration of cutter dimension is also important to make the surface is smooth.

3.5.2 Drilling

A drill is a tool with a rotating drill bit used for drilling holes in various materials. Drills are commonly used in woodworking and metalworking. Hole making is among the most important operations in manufacturing. Generally the hole diameters produced by drilling are slightly larger than the drill diameter.

A drill press (also known as pedestal drill, pillar drill, or bench drill) is a fixed style of drill that may be mounted on a stand or bolted to the floor or workbench.

A drill press consists of a base, column (or pillar), table, spindle (or quill), and drill head, usually driven by an induction motor. The head has a set of handles (usually 3) radiating from a central hub that, when turned, move the spindle and chuck vertically, parallel to the axis of the column. The table can be adjusted vertically and is generally moved by a rack and pinion; however, some older models rely on the operator to lift and reclamp the table in position

The table may also be offset from the spindle's axis and in some cases rotated to a position perpendicular to the column.

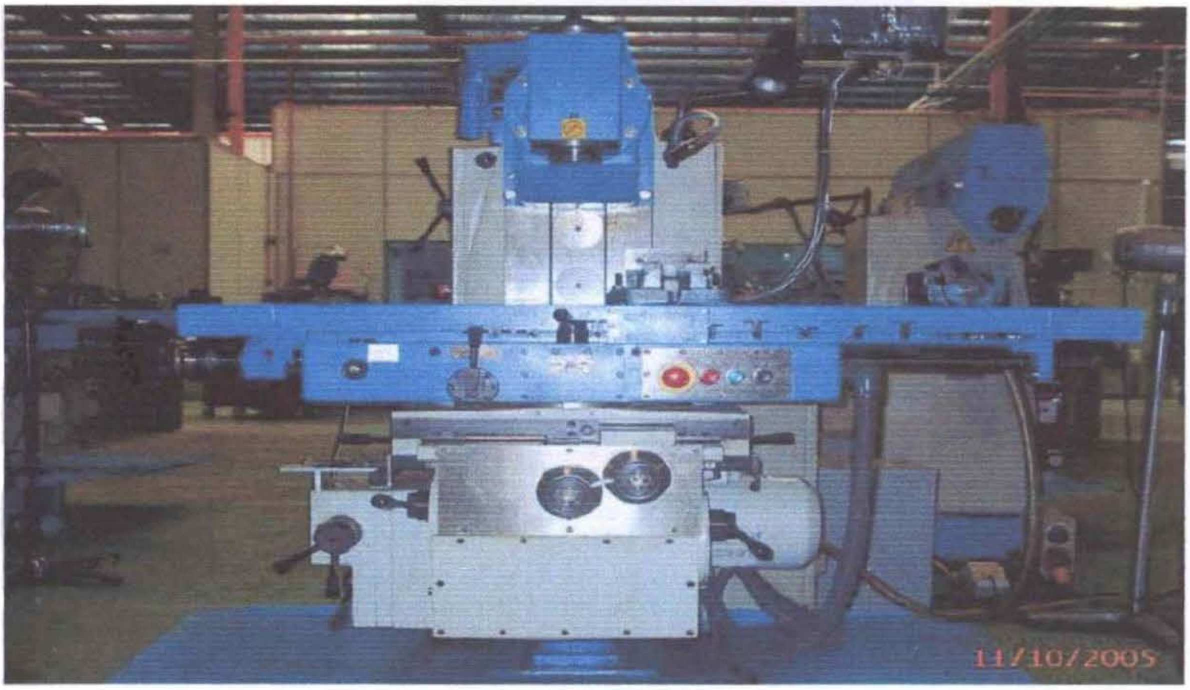

Figure 3.8: Horizontal Milling Machines

The size of a drill press is typically measured in terms of *swing*. Swing is defined as twice the *throat distance*, which is the distance from the center of the spindle to the closest edge of the pillar. For example, a 16-inch drill press will have an 8-inch throat distance.

In order to maintain proper cutting speeds at the cutting edges of drills, the spindle speed on drilling machines has to be adjustable to accommodate different drill sizes. Adjustments are made by means of pulleys, gear boxes or variable speed motors.

The types of drilling machines range from simple bench type units, used to drill small diameter holes, to large radial drill which can accommodate large workpieces. The distance between the column and the spindle centre can be as much as 3 meters.

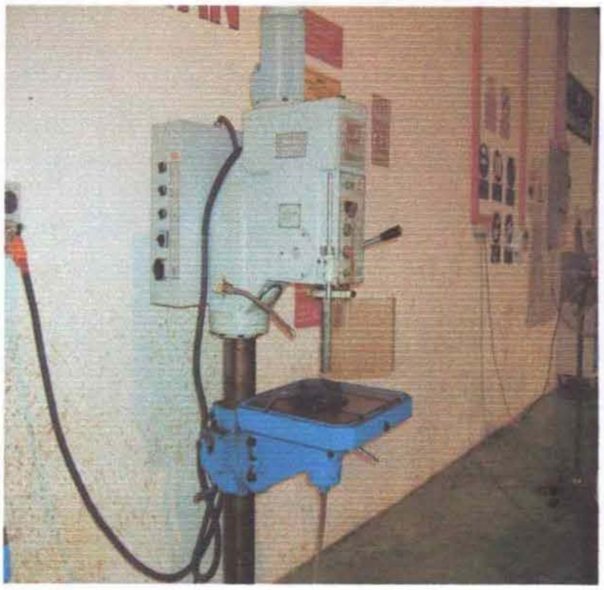

Figure 3.9: Drill machine

In this project, high speed steel (HSS) drilling cutter with size M8 was used to drilling mild steel for cutter and aluminium alloys for the stand. Spindle speed was 800rpm. Depth of for cutter was 10mm while for aluminium was cut for through all. During drilling safety boot and goggle must wear to avoid any accident. .Recommended range for drilling speed and feeds are given in table 3.1

3.5.2.1 Taps

Internal threads in workpiece can be produced by using tapping. A tap is a chip producing threading tool with multiple cutting teeth. Taps are generally available with two, three or four flutes: the most common production tap is the two-flute spiral-point tap. The two-flute tap forces the chips into the hole so that the tap needs to be retracted only and the end of the cut. Three-fluted taps are stronger because more material is available in the flute. Tap sizes range up to 100mm (4 in).

Table 3.1: Recommendations for Speed and Feed in Drilling

Workpiece material	Surface Speed		Feed, drill diameter		RPM	
	m / mm	ft / min	1.5 mm	12.5 mm	1.5 mm	12.5 mm
Aluminium Alloys	30-120	100-400	0.025	0.3	6400-25000	800-3000
Magnesium Alloys	45-120	150-400	0.025	0.3	9600-25000	1100-3000
Copper Alloys	15-60	50-200	0.025	0.25	3200-12000	400-1500
Steels	20-30	60-100	0.025	0.3	4300-6400	500-800
Stainless Steels	10-20	40-60	0.025	0.18	2100-4300	250-500
Titanium Alloys	6-20	20-60	0.01	0.15	1300-4300	150-500
Cast Iron	20-60	60-200	0.025	0.3	4300-12000	500-1500
Thermoplastics	30-60	100-200	0.025	0.13	6400-12000	800-1500
Thermosets	20-60	60-200	0.025	0.1	4300-12000	500-1500

Tapered taps are designed to reduce the torque required for tapping though holes. Bottoming taps are for tapping blind holes to their full depth. Collapsible taps are used in large diameter holes; after tapping has been completed, the tap I mechanically collapsed and without rotation us removed from the hole.

Chip removal can be significant problem during tapping because of the small clearances involved, if chips aren't removed properly, the excessive torque that result can break the tap. The use if a cutting fluid and periodic reversal and removal of the tap from the hole are effective means of chip removal and of improving the quality of tapped hole.

Tapping may be done by hand or with machines such as the following ones:

i. Drilling machine
ii. Lathes
iii. Automatic screw machines
iv. Vertical CNC milling machines combining the correct relative rotation and the longitudinal feed

Special tapping machines are available with features for multiple tapping operations. Multiple-spindle tapping heads are used extensively, particularly in the automotive industry, where 30% to 40% of machining operations involve the tapping of holes. With proper lubrication, tap life may be as high as 10,000 holes. Tap life can be determined with the same technique used to measure drill life. Taps are usually made of carbon steels for light duty applications or of high-speed steel for production for production work.

Productivity in tapping operations can be improved by high speed tapping with surface speeds as high as 100m/min. Self-reversing tapping systems have also been improve significantly and now in use with modern computer controlled machine tools. Several designs are available with operating speeds as high as 5000rpm although actual cutting speeds in most applications are considerably lower.

Cycle times are typically in order of 1-2 seconds. Also some tapping systems now have capabilities for directing the cutting fluid to cutting zone through the spindle and a hole in the tap, which also helps flush the chips out of the hole being tapped.

Here are the basic guidelines for drilling, reaming and drilling operations:

i. Designs should allow holes to be drilled on flat surfaces and perpendicular to the drill motion; otherwise, the drill tends to deflect and the hole will not be located accurately. Exit surfaces for the drill should be also flat.

ii. Interrupted hole surfaces should be avoided or minimized for improved dimensional accuracy.

iii. Hole bottoms should match standard drill point angles. Flat bottom or odd shapes should be avoided.

iv. Through holes are preferred over blind holes, as they are in boring operations. If holes with large diameters are required, the workpiece should have a pre-existing hole, preferably made during fabrication of the part.

v. Part should be designed so that all drilling can be done with minimum of fixturing and without repositioning the workpiece.

vi. It may be difficult to ream blind or intersecting holes because of the possibility of tools breakage. Extra hole depth should be provided.

vii. Blind holes must be drilled deeper than subsequent reaming or tapping operations that may be performed.

3.5.2.2 Material Removal Rate

The material removal rate (MRR) in drilling is the volume of material removes by the drill per unit time. For drill with diameter D, the cross-sectional area of drilled hole is $\Pi D^2 / 4$. The velocity of drill perpendicular to the workpiece is the product feed f (the distance the drill penetrates per revolution) and the rotational speed N where $N = V / \Pi D$. Thus,

$$\text{MRR} = (\Pi D^2 / 4)(f)(N)$$

Check the dimensional accuracy of this equation by noting that MRR = (mm^2) (mm/rev) (rev/min) = mm^3 /min, which is the correct unit for volume removed per unit time.

3.5.3 Grinding

When finishing milling the cutter, the next step is grinding the cutter make it better looks. There several type of grinding; surface, cylindrical, internal and centerless grinding. For this project, we finish the operation by surface grinding. Surface grinding is the largest percentage used in industry.

Typically, the workpiece is secured on a magnetic chuck attached to the work table of the grinder. Nonmagnetic materials generally are held by vises, special fixtures, vacuum chuck or double-sided adhesive tapes.

A straight wheel is mounted on the horizontal spindle of the grinder. Traverse grinding occurs as the table reciprocates longitudinally and feed laterally after each stroke. In the plunge grinding, the wheel is moved radially into the workpiece, as it is when grinding a groove. The size of a surface grinder is determined by the surface dimensions that can be ground on the machine.

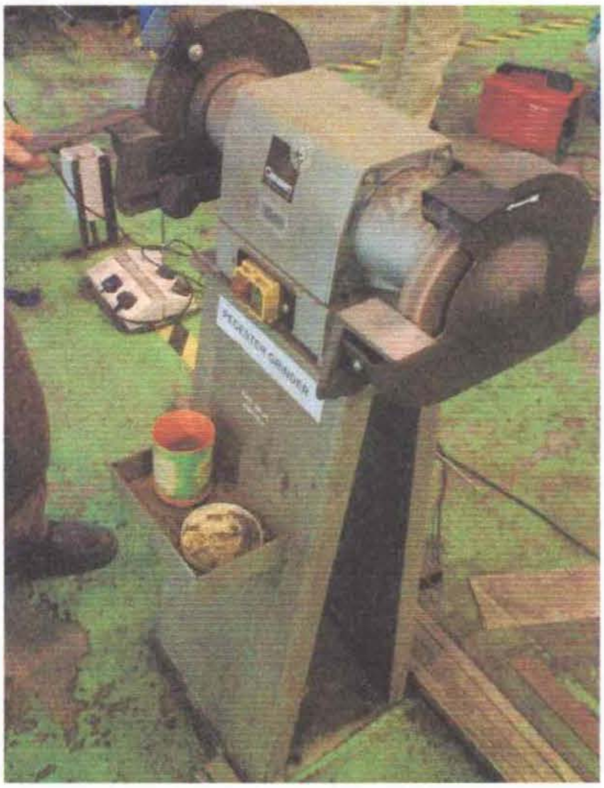

Figure 3.10: Grinding Machine

Figure 3.11: Hand Grinder

3.6 Assemble

After complete with the cutter, the next part is assemble the cutter to the hydraulic pump. Aluminium rods have been choosing as a stand or workstation to hold the hydraulic cylinder. Before assemble the cutter, aluminium rod need to be drilling with M8 drill size. All the drilling works was done at FKM lab. After drilling, we make a tread to make sure the screw is easy to get in the rod. For the tap, we use M8+1.25mm tap size. The important thing when make the tread is to make sure the hole and tap is in a straight line. This is because if it not in straight line, the screw is hard to get into the holes.

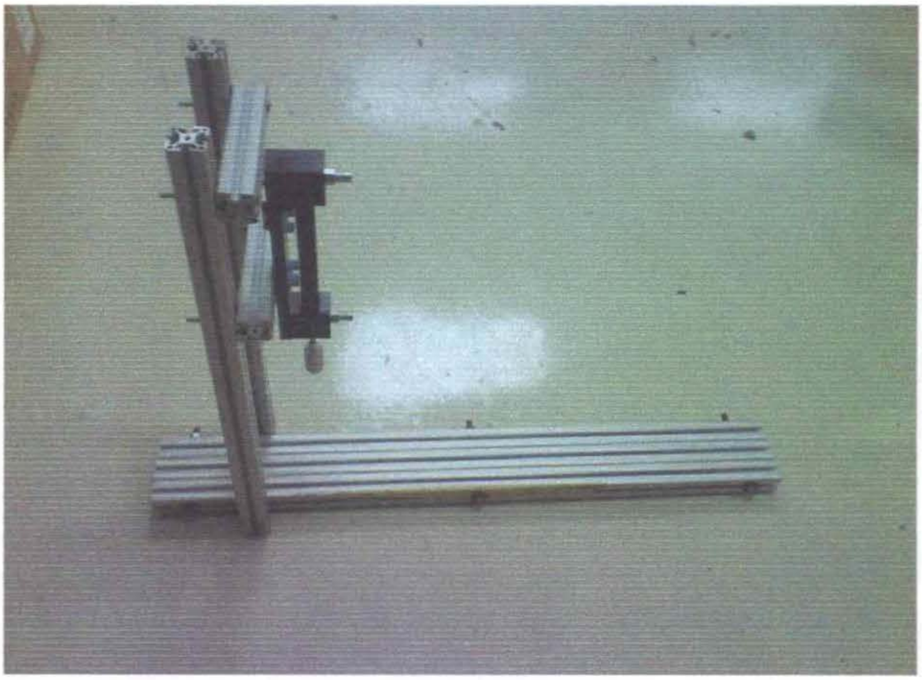

Figure 3.12: Aluminium after assembled

Figure 3.13 Side view

CHAPTER 4

RESULT

4.1 Introduction

In this chapter, the result of the finished project will be discussed. According to project objective, the main objective is to design the cutter using hydraulic system. After fabrication process, component should be run to test what ever there is a problem or not and to make the cutter can cut the printed circuit board or not. If there is a problem, the cutter and workstation should be build and redesign. For not to waste the time, finite element analysis using Algor computer aided engineering (CAE) software. These will analysis the maximum force that will be received by the cutter when it cut the printed circuit board. Another analysis was the analysis of aluminium alloys rod, to check it can stand the load or not.

4.2 Result

After attach the cutter the hydraulic cylinder and assemble the aluminium alloys, the model now can be tested. The dimension of the cutter is 100mm length, 28mm width, and 6mm thickness. Because hard to find high speed steel (HSS) for cutter material, it was replace by mild steel. Although, there are many mechanical behaviour different between high speed steel and mild steel, but due to lack of time mild steel is still acceptable to cut the printed circuit board. The printed circuit board also have been replaced by wired board because it hard to find it the unused printed board because many board manufacture do not want sell to keep their printed circuit board as a secret.

. The wired is also acceptable because it also contain cuprum trace although only have a little bit amount of layer compare to printed circuit board. The dimension of wired board is 145mm length, 65mm width and 2mm thickness.

The first step during testing is assembling the hydraulic parts. The hydraulic part are 3/2 valve buttons, 2 double acting cylinder and electric wire. One of double acting cylinder is used to attach to the cutter while the other one to the stopper. The function of 3/2 valve is to make sure the hydraulic liquid can move two way, backward and forward.

The second step is attached cutter and the stopper. Before attaching it, the cutter and the stopper was be drill to make sure it can be fit to the end of the double acting cylinder. After attach it, we have to make sure the cutter and stopper fir properly in with the double acting cylinder. Then after satisfied, we may open the switch and let the hydraulic liquid get into the double acting cylinder.

After the few second the first double cylinder with stopper will move the wired board to place where the cutter is ready to cut the board. After the board touch the sensor, the sensor will send signal to electronic switch to on the second double acting cylinder with cutter to move down to cut the printed circuit board. The process to cut the board is about 3 second. After cut it, the first double acting cylinder will make another move to take away the wired board, then the process to cut the wired board are finish. The overall time to complete this process is about 30 second.

4.3 Discussion

The force that generate from hydraulic pump is 2 Mega Pascal (MP). So this force will move from hydraulic pump to the cutter through hydraulic cylinder the same amount as much as 2 MP. From the equation:

$$P = F / A$$

where P= pressure
F= force
A= area

We know that pressure same to 2 MP while area equal to $.027m^{2,}$ so if we calculate, we know the force is 729000 N. This value is suitable to cut the printed circuit board.

During running the machine, the cutter while able cut the printed circuit board, but the way it cut it is not too pretty. This is because the stand makes some displacement when the hydraulic cylinder started moving. It becomes unstable so the cutter also becomes unstable. So the cutter cannot cut the printed circuit board at right place. The moveable jaw also cannot move the printed circuit board to the place where the cutter is it.

Figure 4.1: During Cutting

Figure 4.1: After Cutting

CHAPTER 5

CONCLUSION

5.1 Conclusion

After fabricate and assemble the entire component like hydraulic cylinder, cutter and aluminium alloy rod, this project achieved it objectives. Even through, the printed circuit board was been replaced by the wired board due to hard to find printed circuit board. It hard to find printed circuit board because many printed circuit board's manufacture only give limited access to their product and outside people of the company cannot get information about their printed circuit board. The specification and thickness of printed circuit board also different between each other, so final test, wired board was been used.

Cutter that was made from mild steel is not the best choice. This is because it has low hardness behaviour than high speed steel. So after used for several time, the cutter will not sharp any more. This will reduce productivity and waste a time. The cutter needs to be replacing with new cutter. So there will great improvement if the mild steel can be replace by high speed steel. High speed steel has high hardness and it suitable to cut other material. For more accurate dimension, the cutter should be fabricate and cut using computer numerical control (CNC). CNC can cut the cutter with beautiful finishing, better than using milling machine and drilling machine. Using milling and drilling also may cause human errors when set up and running the machine.

Using hydraulic cylinder is the best way to cut the printed circuit board. For the next time, we recommend to used pneumatic cylinder. Pneumatic cylinder is more clean and suitable to use in this project. The power that produces from hydraulic cylinder also big if we compare to pneumatic cylinder and it not suitable to cut the sensitive printed circuit board.

The machine that was develops in this project only suitable for large mass production of printed circuit board. This is because if only a few board need to cut, it wasting time. We need to setup the hydraulic system and electric circuit first before start using the machine. The quality board that have been cut using this machine also poor because the power that was produced is big and we cannot reduce. The force are big because the hydraulic pump at FKM lab's are for study purpose not for industrial purpose so we cannot reduce the power that reduce from the pump.

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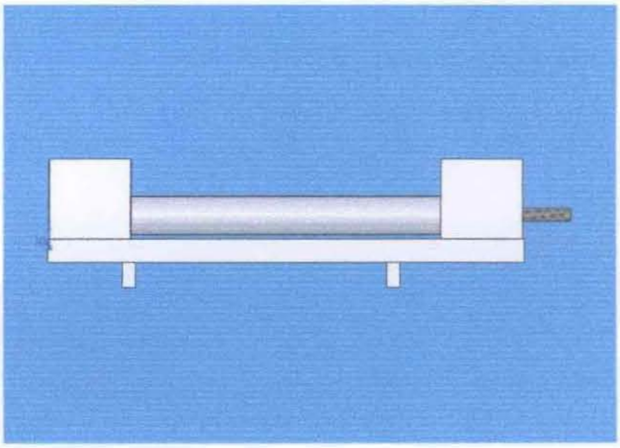
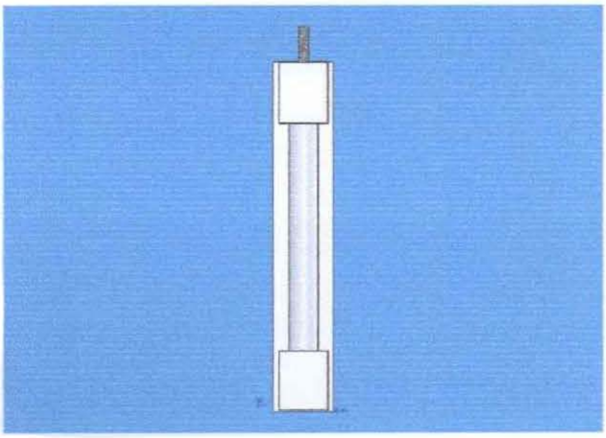
APPENDIX A

COMPUTER AIDED DESIGN (DRAWING)

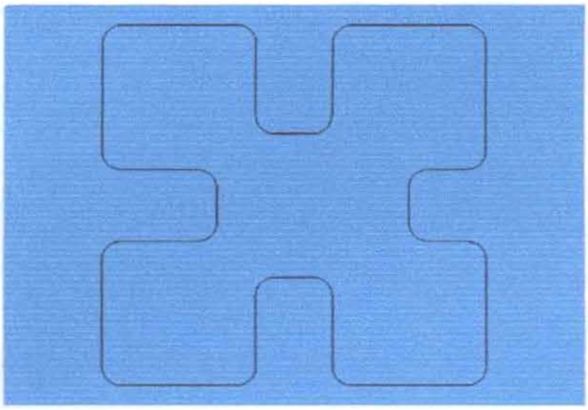


Hydraulic Side view

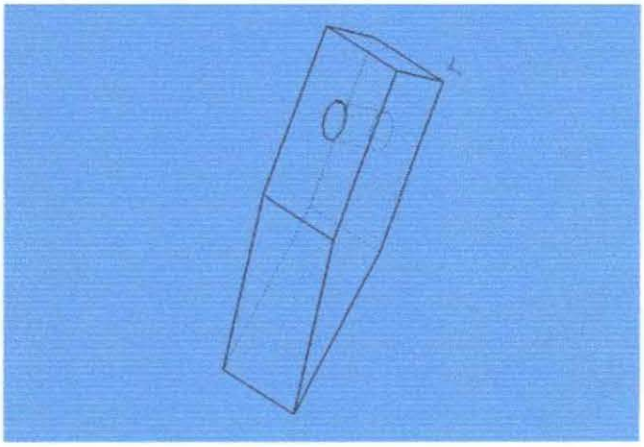


Hydraulic cylinder Top view

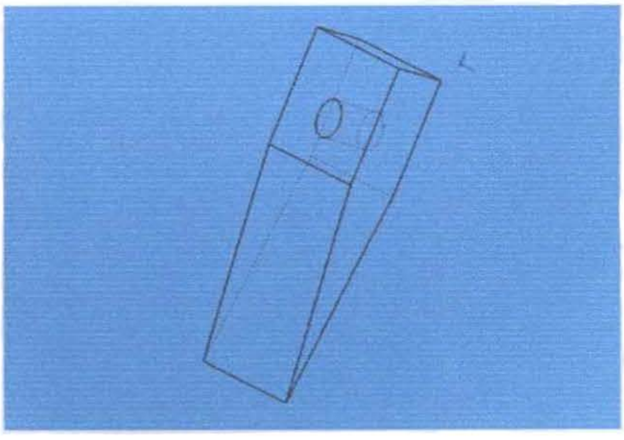
APPENDIX A (Conti)



Aluminium Front view



Design B



Design C