DEVELOPMENT OF CUTTER FOR PRINTED CIRCUIT BOARD USING HYDRAULIC PRINCIPLE

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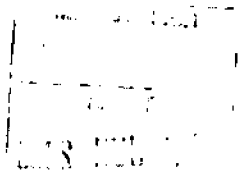

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ABSTRACT

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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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.

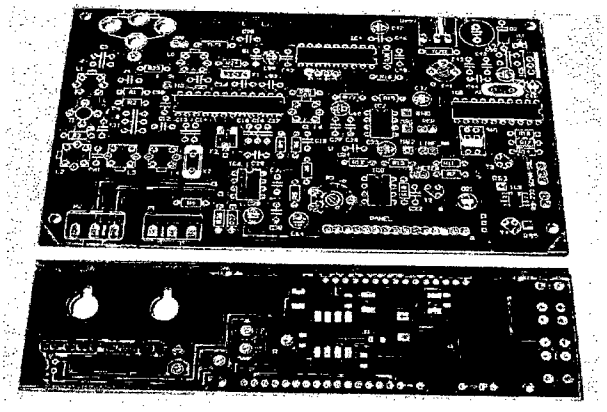

Figure 2.1: Printed Circuit Board

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.

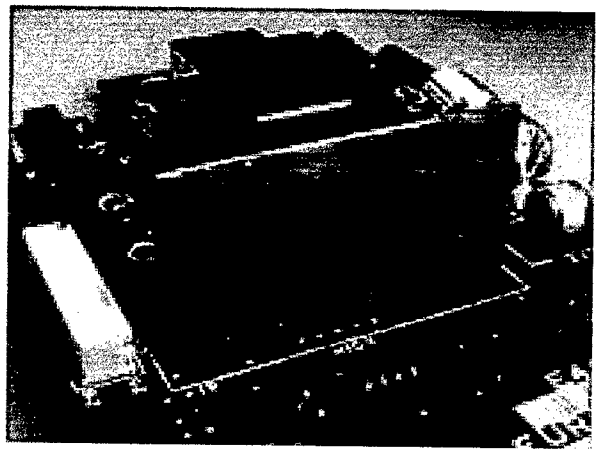

Figure 2.2: Epoxy on PC board

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:

$$P = \rho gh$$

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.

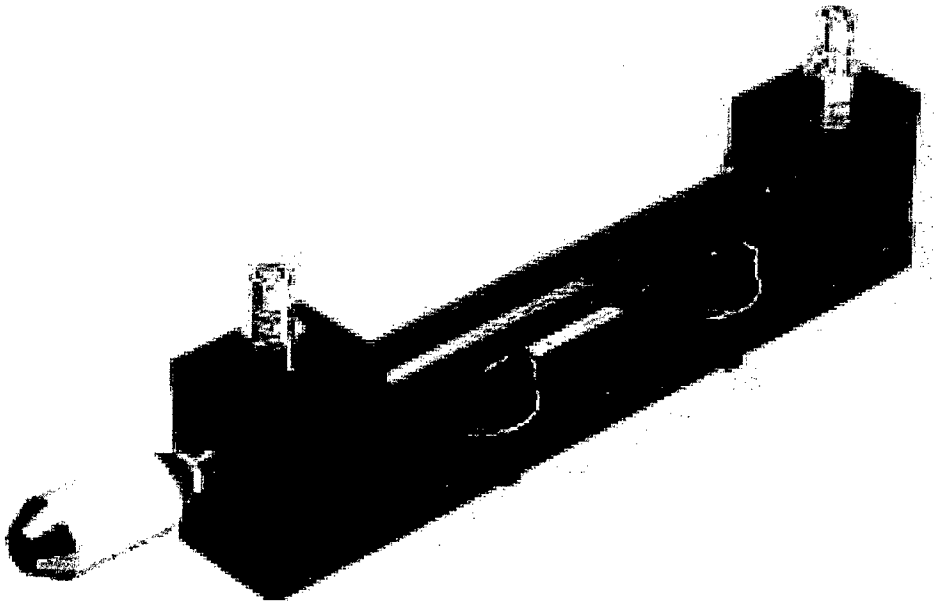

Figure 2.3: Hydraulic Cylinder

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),