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Developing a Cutting Tool with Mild Steel for Printed Circuit Board

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Abstract

This paper describes the design and fabrication of a cutter using mild steel for the printed circuit board. The board contains cuprum as a trace to connect the electricity current to electronic component like resistors and capacitors. The printed circuit board was widely used in electronic and electric components. The normal way to cut the printed circuit board is using hand due to the sensitive of it. By developing the cutter, it is easy to cut the printed circuit board with more efficient without damaging the board. The performance of the cutter that fabricates using mild steel is only average due to its hardness. It becomes dull very fast.

Keywords: Printed circuit board (PCB), Cutter, Mild steel, Hardness

Introduction

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 [1]. 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 [1, 2]. Therefore, the quality of tool is the most important factors affecting the precision of memory

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modules of PCB. In order to decrease the tool wear, the development of coating technology on tools are getting greater and greater attention [3, 4, 5] and the film of zirconium series is currently one of the newest research targets. Milosev *et al*.[6] compare the electrochemical properties and thermal oxidation effects between ZrN and chromium nitride (CrN). Nose *et al*. [7] use reactive DC sputtering to study the comparison between colors of ZrN and titanium nitride (TiN) films.

Beside manual cutting by hand, there are two type of PCB cutter or separator currently been used by electronic industry which is cut one by one and cut all in one time. For one by one cutter, normally motorize cutter with computer program is use and this is still very expensive and very slow for mass production. Whereas all in one time cutter is normally use pneumatic power and very bulky machine to ensure smooth and continuous cutting with good quality.

The cutting process was normally to cut the multiblock PCBs to smaller PCB. Multiblock PCBs normally consist of two to eight piece of 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 [2].

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 [8, 9]. Titanium carbide has higher wear resistance than tungsten carbide but not is as tough. Titanium carbides

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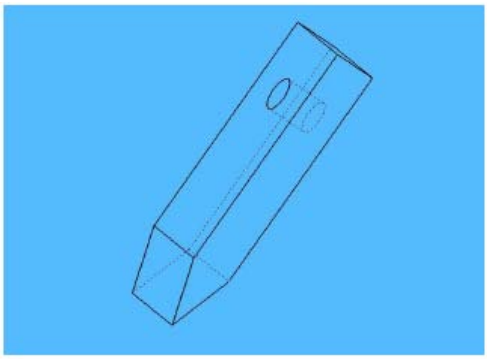
suitable for machining hard material mainly steel and cast irons and for cutting at speeds higher than those appropriate for tungsten carbide [8, 10].

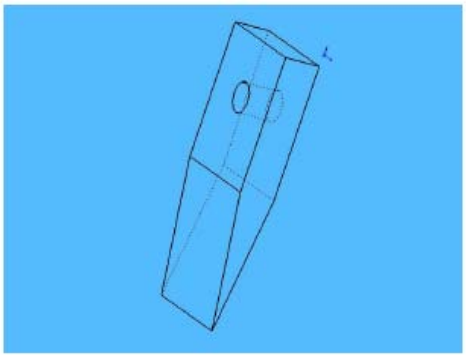
Carbon steels are the oldest of tool materials and have been used widely for drills, taps, broaches and reamers since the 1880s. Lo-alloy and medium-alloys steels were developed later for similar applications but with longer tool life [10, 11]. Although inexpensive and easily shaped and sharpened, these 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 [8].

Design of the cutting tool

Computer-aided design (CAD) software was employed to develop the three dimensional (3-D) designs as shown in Figure 1. Manufacturing tools paths can be generated from the 3-D models and some of the part can be created directly from 3-D database by using 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 easily to obtain. After the sketch complete, we will make the comparison of all sketching to choose the best and suitable design.



Design A



Design B

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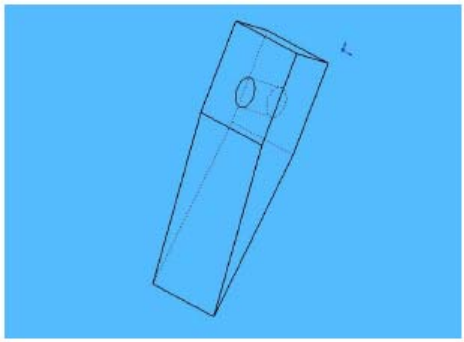

Design C

Figure 1: Design made from the CAD software

The next sequence is the analysis of the design using Finite Element software. In this analysis, the stress and strain like the pneumatic cylinder and cutting tools are been tested. If the analysis fail or not meet the minimum value of force, the model has to redesign and repeated the analysis until obtain the satisfactory values. After finish the modeling and analysis of 3D model, now the step is to fabricate the cutting tool. Mild steel was chosen as the material for the cutting tools. Milling technique was chosen to fabricate the cutting tool

Experimental set up

After complete with the cutter, the next part is assemble the cutter to the hydraulic pump. Aluminum rods have been chosen as a stand or workstation to hold the hydraulic cylinder. Before assemble of the cutter, aluminum rod need to be drilled with M8 drill size. For the tap, M8+1.25mm tap size was used. The important thing when making the tread is to make sure the hole and tap is in a straight line.

After attach the cutter to the hydraulic cylinder and assemble the aluminum alloys, the model now can be tested. The dimension of the cutter is 100 mm length, 28 mm width, and 6mm thickness.

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The printed circuit board also have been replaced by wired board because it hard to find the unused printed board.

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 145 mm length, 65 mm width and 2 mm 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 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, make sure the cutter and stopper fir properly in with the double acting cylinder. After 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 the 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.

Results and Discussion

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

$$P = F / A$$

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where P is pressure, F is force and A is area

The pressure same to 2 MPa while area equal to 0.027 m^2, so the force is 729000 N (729 kN). This value is suitable to cut the printed circuit board. During running the machine, the cutter able to cut the printed circuit board, but the way it cut is not very perfect. This is because the stand makes some displacement when the hydraulic cylinder starts to move. It becomes unstable so that the cutter also becomes unstable. So the cutter not able to cut the printed circuit board at right place. Figure 2 shows the board after cutting.

Figure 2: The board after cutting

Conclusion

Cutter that made from mild steel is not the best choice. This is because it has low hardness behavior than high speed steel. After used for several time, the cutter become dull. This will reduce productivity time and cost more. So there will be 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

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numerical control (CNC). CNC can cut the cutter with fine finishing, better than using convectional milling machine and drilling machine. Using convectional 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. The power that produces from hydraulic cylinder also big if compared to pneumatic cylinder and it not suitable to cut the sensitive printed circuit board. The quality of the board that has been cut using this machine also poor because of the power that was produced was big.

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