DESIGN AND MANUFACTURING OVERVIEW OF PCB DRILLING MACHINE

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Abstract

Although used in a very large variety of applications, drilling is one of the most complexes and least understood manufacturing processes. Most of the research on drilling was done in the field of metal cutting for mechanical parts since; in this case, high precision and quality are needed. The use of composite materials in engineering applications has increased in recent years, and in many of these applications drilling is one of the most critical stages in the manufacturing process. This is because it is among the last operations in the manufacturing plan of composite parts. De lamination and extensive tool wear are among the problems which drilling of composite materials are currently facing. In this paper we have focused on design and manufacturing of drilling machine to drill a small size hole on composite material like PCB.

Keywords: *Drilling, PCB, Design, Composite material, Manufacturing*

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1. Introduction:

Manufacturing a PCB drilling machine requires a great deal of accuracy because sudden variation in speed may cause rough operation and while manual drilling if feed rate is to fast it may cause vibration of sheet and if RPM is to high it may cause melting of sheet metal .While manufacturing we must ensure that spindle must not vibrate at high speed and motor, spindle and column must aligned rigidly to avoid vibration. Assembly of PCB drilling machine is easy as most of parts is available and we need not to manufacture it. Feed mechanism must not be as rigid as in metal cutting. To ensure this we need to provide spring force as feed force because when we feed manually it may cause excessive force so spring force may dilute the excessive amount of force.

2. Design of PCB drilling machine:

2.1 Design of spindle speed and power requirement.

Design of PCB drilling machine require to calculate cutting force and power required for it .To calculate these we need to fix the range of diameter we can drill on machine. In this paper we have calculate all the value for the maximum diameter of 3 mm, for that we are going to produce machine.PCB is made from acrylic material and for that surface feet per meter and inch per revolution can be selected from table no. 1.

$RPM=\frac{3.82\ X\ SFM}{D}$ ………………………….. (1)

$IPM=IPR\ X\ RPM$ ……………………. (2)

For drilling acrylic the recommended values for SFM and IPR are given in Table 1 below.

Diameter of bit (inch)	SFM	IPR
1/16	20-160	0.001
1/8	20-160	0.002
1/4	20-160	0.004
3/8	20-160	0.006
1/2	30-90	0.008
3/4	30-90	0.010
□1	30-90	0.012-0.015

Table 2.1: Recommended values for SFM and IPR

These recommended values can be used with the above equations to determine drilling settings.

Spindle speed can be selected directly from the graph shown in figure 1.

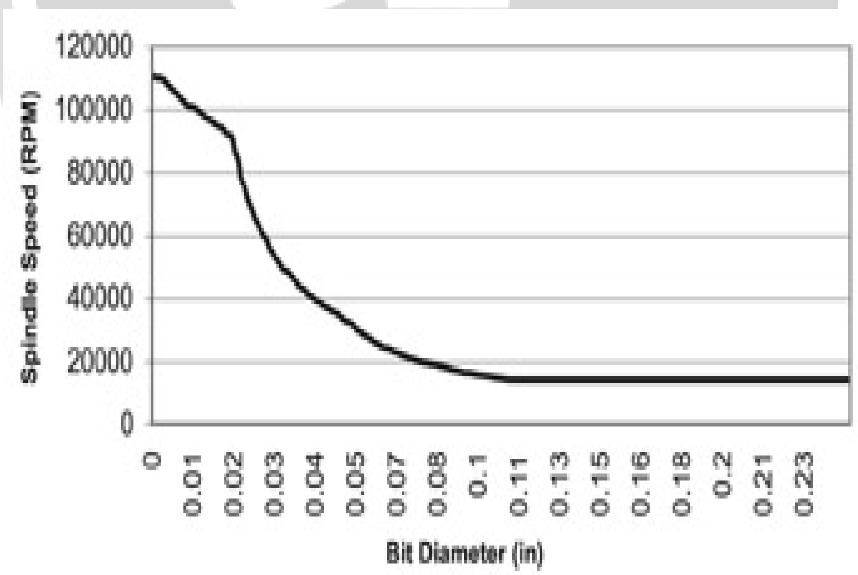

Figure 2.1 Spindle speed (RPM) recommendations for acrylic circuit board drilling

After finding the value of rpm n, we can further proceed to find specific cutting force in order to find motor power to select motor of appropriate HP.

Speed $n=\frac{v_{c1000}}{D_{c\ \pi}}$ 1/min………………………………… (3)

Cutting speed $VC = \frac{D_c \pi n}{1000}$ m/min…………………………………….. (4)

Feed per revolution $f = f_z$ X Z mm………………….(5)

In order to find metal removal rate we need to find feed rate V_f by putting the value of feed per revolution f, by putting value of feed per tooth f_z and number of tooth Z.

Feed rate $V_F = f$ X n mm/min…………………….. (6)

Metal removal rate can be found out from the value of feed rate V_f and cutter die meter D_c .

Metal removal rate $Q = \frac{V_f \, X \, n \, X \, {D_c}^2}{4X \; 1000}$ cm^3/min…..……... (7)

Motor power can be calculated by putting value of metal removal rate Q and specific cutting force K_c.

K_c can be found from equation no. (9) Where K_{c1} is specific cutting force for $1mm^2$ cross section chip end h is chip thickness in mm and m_c is increase in K_c curve.

Power requirement $P_{mot} = \frac{Q \; K_c}{60000 \; \eta}$ KW (8)

Specific cutting force $K_c = \frac{K_{c1}}{h m_c}$ (9)

From the above equation we can find power required is 0.06 KW by considering 10 to 20% surplus torque requires while cutting. So we can select motor of 12 volt to with 18000 RPM to drill a hole of 3mm size.for different range of speed DC stepper motor is selected.

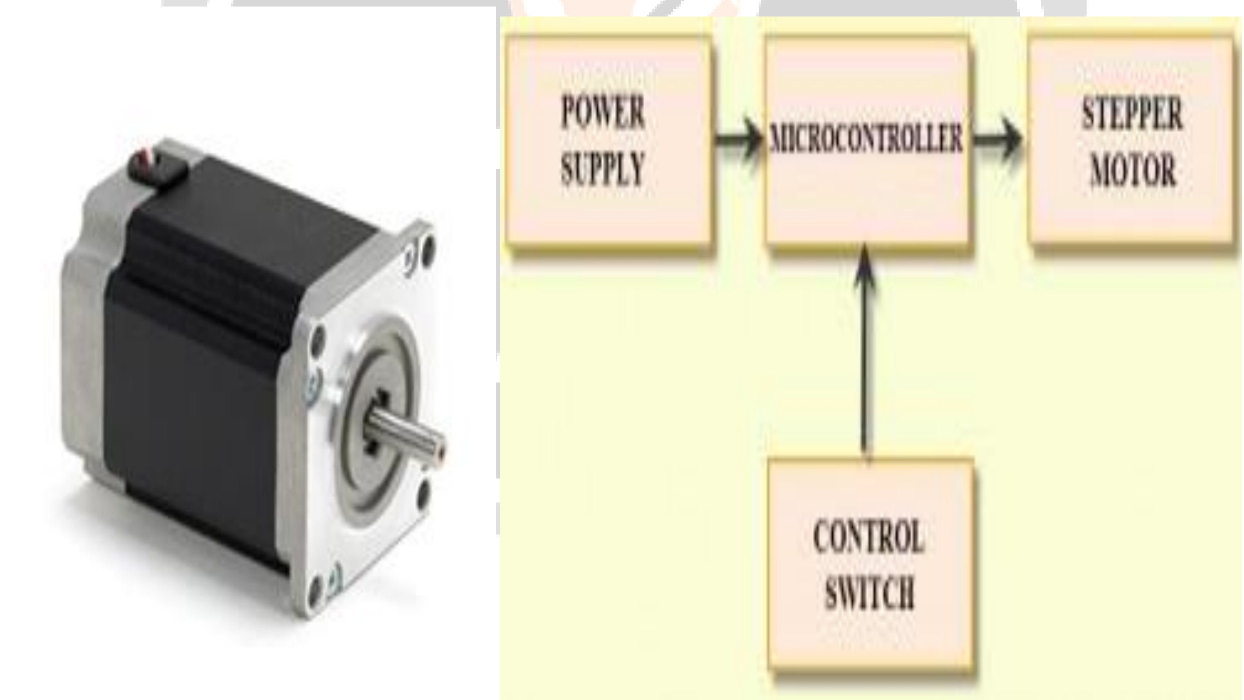

Figure 2.2 DC stepper motor with block diagram of control unit.

2.2 Design of drill bit.

Drill bits are commonly made of high-speed steel (HSS), cobalt, HSS with carbide tips or solid Carbide. Metal-working high-speed steel twist drill bits can be used with some modification. Tip angles on standard drill bits are commonly 118°-130°. This point angle must be ground to 60°-90°. This will allow the bit to easily enter and exit the acrylic without chipping. Larger tip angles commonly cause cracking and blow out as the bit exits the sheet. For most acrylic sheet drilling operations, bits with a 90° tip angle should be used. A bit with a 90° tip angle will generate small chips which are easier to evacuate, reducing melting and improving hole quality. Care must be taken at the points of entry and exit. Generally, bits with a 90° tip angle are recommended. Bits with 60° tip angles are also used, especially for holes with diameters of 1/2" and greater.

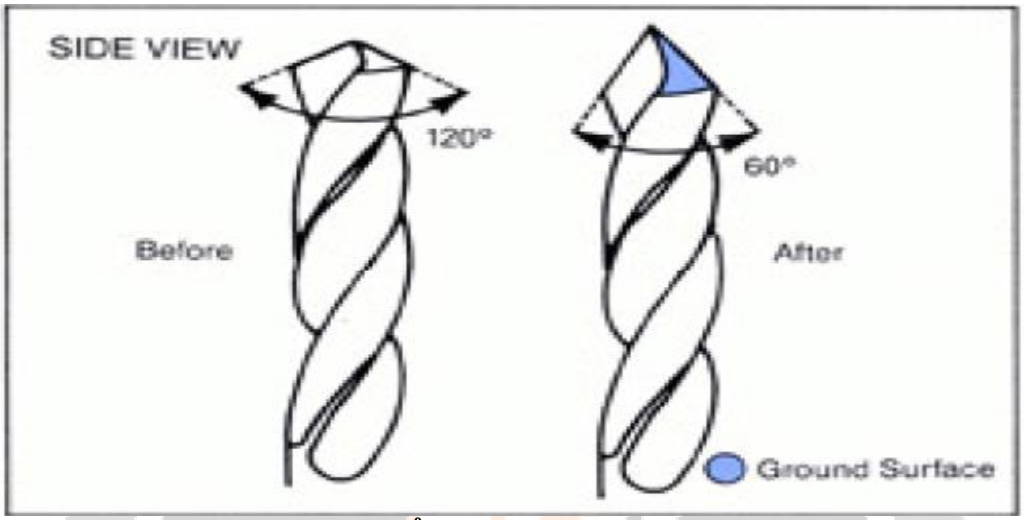

Figure 2.3 60^0 tip angle for drilling in acrylic material

The cutting edge must be ground "flat" to a 0-4° rake angle. This cutting edge will scrape the acrylic, not gouge it. The surface behind the cutting edge must be ground away to clearance angles of 12-15°. This back relief reduces metal/plastic contact and heat build-up. This modification is standard on most high quality twist drill bits.

Bit geometry affects the quality of drilled holes since it affects chip size and chip evacuation. Larger diameter bits and bits with smaller tip angles produce larger chips. If hole depth (H) is less than bit diameter (D), large chips are easily ejected. As the depth of the hole increases, i.e. H>D, larger chips become more difficult to eject because of the close clearance between the bit and the hole walls. Increasing bit tip angle decreases the size of generated chips, facilitating chip ejection.

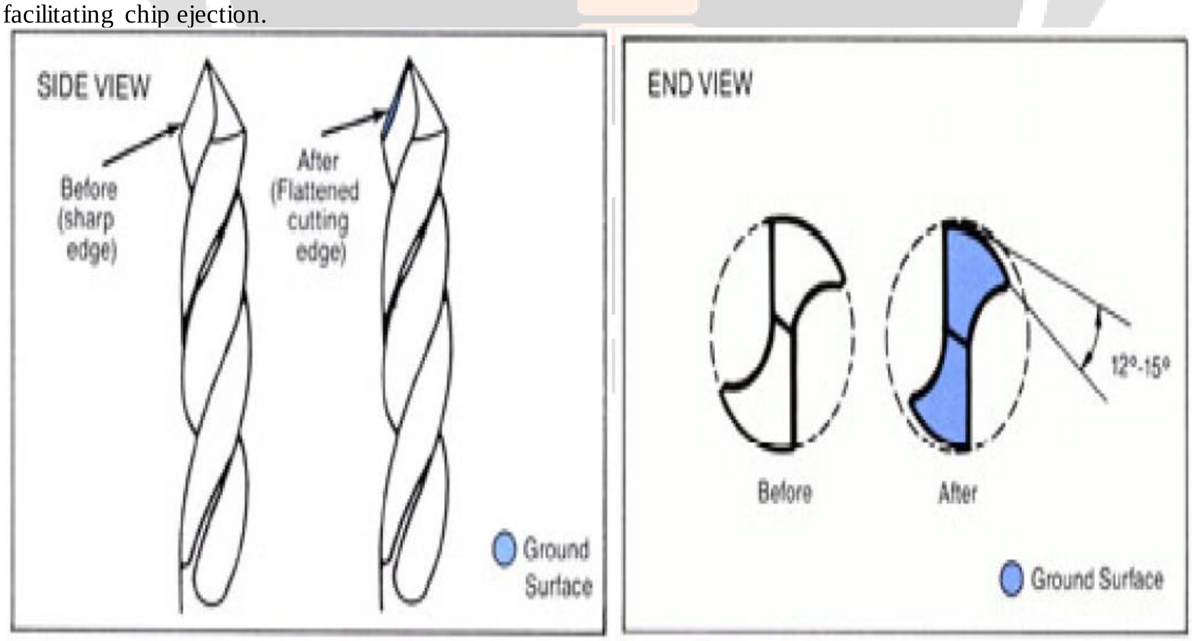

Figure 2.4 Rake angle and clearance of drill bit

However, as mentioned above, if the tip angle is too large, larger than 90°, blow out and chipping may be a problem when the when the bit exits the acrylic. The helix angle on a bit is the angle between the cutting edge and a vertical line along the center of the bit. Bits with a moderate helix angle aid in chip ejection and are recommended for drilling of plastics. Small helix angles interfere with chip ejection, increasing melting. Helix angles, which are too large, can cause cracking around the hole edges. Typically a helix angle of 15-30° is recommended.

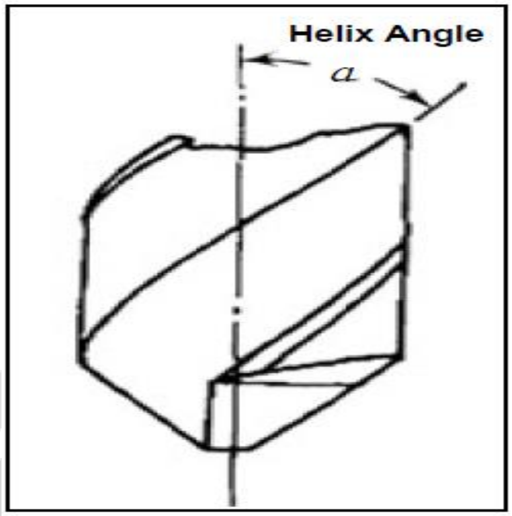

Figure 2.5 .helix angle of tool bit.

3. Conclusion:

Design of PCB drilling machine is very important aspect as we require drilling on very delicate material like acrylic. Designing with different speed range will give wide application of drilling machine with various diameter hole can be drilled in single machine and it will reduce cost of manufacturing.

4. Future scope:

Current system can be improved to reach higher speeds and grater torque. The developed system can be built up for milling PCBs also.

5. References:

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