Islamic University of Technology (IUT)

Organisation of Islamic Cooperation (OIC)

Department of Mechanical and Chemical Engineering

MCE-4622

TOOL ENGINEERING LAB

Credit:0.75 Credit Hour :(0-0-3/2)

Experiment No	Title of the Experiments
1.	Study the Construction and Sharpening of a turning tool
2.	Study the design of Blanking and Piercing Dies for a washer
3.	Study the Construction and Sharpening of a Milling tool
4.	Study the Construction and Sharpening of a Twist Drill
5.	Study the construction of jigs and fixtures of a faller bar
6.	Study the Drawing Dies for flanged Cup

June 2019

Experiment No: 01

Name of the Experiment: **Study the Construction and Sharpening of a turning tool**

Objectives:

1. Study of different parts of single point cutting tool,
2. Study of different angles of single point cutting tool,
3. Study of sharpening of a single point cutting tool,

Apparatus:

Different types of single point cutting tool, grinding machines (Diamond type cutter).

Theory:

Single point cutting tool: A single-point tool is a cutting tool having one Cutting part and one shank. They are commonly used in lathes, turret lathes, planers, shapers, boring mills and similar machine tools. Single point cutting tools are of two types on the basis of construction. They are:

a. Solid,
b. Tipped
   i. Brazed
   ii. Throw away

Construction of single point cutting tool

Cutting tool parts:

1. Base: Bottom surface of the tool shank.
2. Cutting edge: Leading edge of the tool bit that does the cutting.
3. Face: Surface against which the chip brakes.
4. Flank: Surface of the tool which is adjacent to and below the cutting edge.
5. Nose: tip of the cutting tool formed by the junction of the cutting edge and the formed face.
6. Point: End of the tool that has been ground for cutting purposes.
7. Shank: Body of the tool bit or the part held in the tool holder.

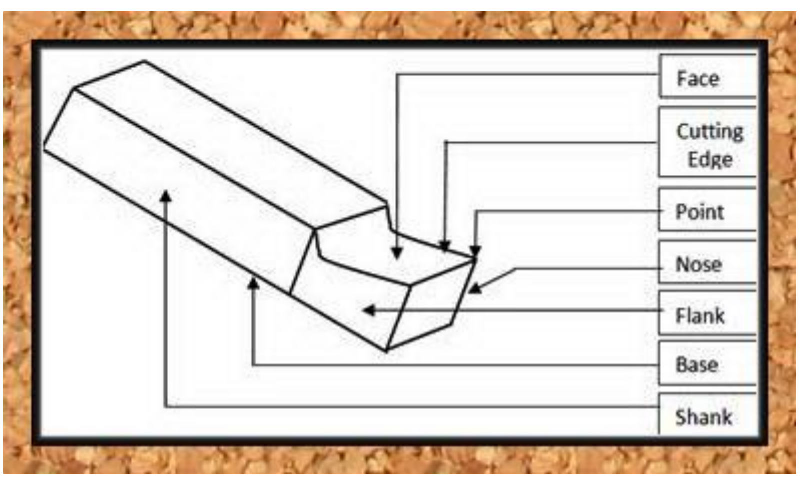


Figure: Different parts of Turning Tool

Lathe tool bits angles and clearance:

1. Side cutting angle: the angle which the cutting edge forms with the side of the tool shank. Cutting angle is from 10-20˚
2. Front/End cutting angle: the angle formed by the end cutting edge and a line at right angle to the centre line of the tool bit. Angle varies from 5-30˚. 5-15˚ is satisfactory for rough cut, 15-30˚are used for general purpose.
3. Side relief angle: Angle ground on the flank of the tool below the cutting edge. The angle is generally 6-10˚.
4. Front/End relief angle: Angle ground below the nose of the tool bits, which permits the cutting tool to be feed in to the work. Angle is generally 10-15˚.
5. Side rake angle: Angle at which the face is ground away from the cutting edge. Angle is generally 14˚.
6. Back/top rake angle: It is the backward slope of the cutting tool face away from the nose. Angle is generally 20˚.

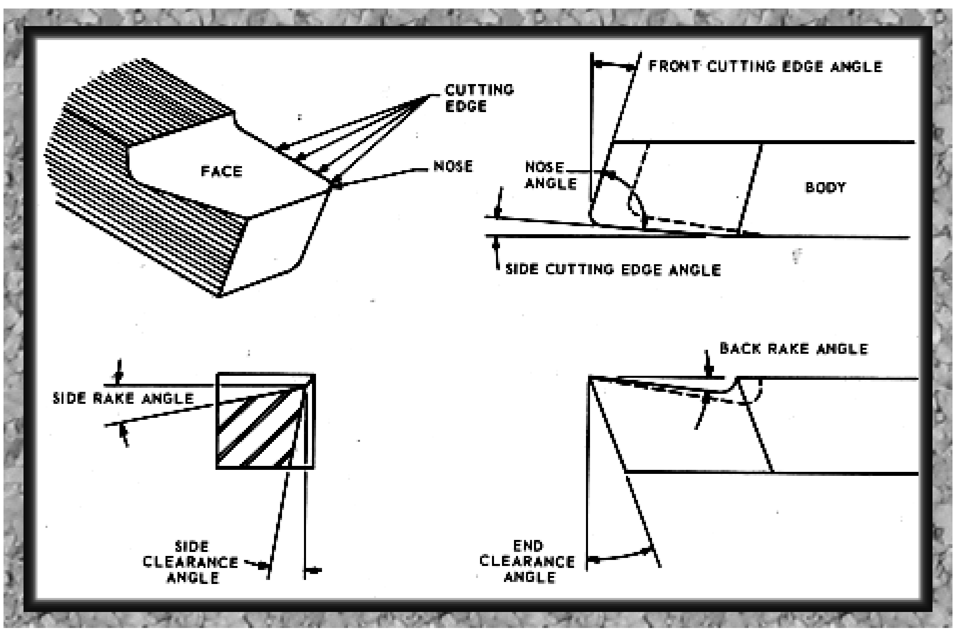


Figure: Different Cutting angle in Lathe bit

Design of single point cutting tool:

To remove greatest amount of material in the shortest length of time consistent with finish requirements, work and tool rigidity, available power of the machine, and relative cost of labor and cutting tools. In design of a single point cutting tool the following factors are to be considered.

i. Type of work piece material and tool material;
ii. Type of operation and surface finish required;
iii. Optimum tool angles;
iv. Permissible cutting speed, feed and depth of cut;
v. Cutting forces;

vi. Condition of work holding:
- Work held as a cantilever;
- Work held in between two centers, both of which can be live or one live and the other dead.
- Work held in chuck and tailstock centre.

vii. Overhung of the tool from the tool post;

viii. Accuracy of the work in terms of permissible deflection (maximum) of job with respect to the tool.

SHARPENING OF TURNING TOOL:

Operating range:

Grinding ordinary Cemented Carbide cutting and forming the chip breaker groove can be carried out without replacing attachments and grinding of special form of cutting tool such as the back of the tip of edge, etc. can be performed accurately by swing the angle scale. Since the WA cup wheel is mounted on one side of grinding wheel spindle, a wide range of operation such as grinding the shank relief, high speed steel, etc. is feasible.

GENERAL PRECAUTION:

1. The wheel should be turned to such a direction in which the wheel presses the tip of cutting tool, that is, the direction of revolution should be from the tip toward the shank. When the wheel should turn in the reverse direction in the grinding operation, the edge is nicked and sharp edge cannot be ensured even when the tool is ground very carefully.

2. In order to maintain the wheel surface in the proper form for a long time, be sure to use the entire area of wheel surface and avoid any forcible or unreasonable grinding. An excessive cutting depth (feed), stuffed grinding wheel, etc. may cause overheating, cracking and breaking of edge tip.

3. While grinding, make sure that the tip of edge is continuously moved from side to side. The tip of the edge should be heated partially.

4. The diamond wheel should be used for grinding the cemented carbide alloy portion only.Make sure not to grind the steel made shank.The angle of clearance should be perfectly pre-ground with the WA wheel.

5. If a cutting tool requires forming of a chip breaker groove and is in such a form that the diamond wheel may touch the shank while the grinding operation is performed, be sure to provide a relief for the wheel, beforehand.

6. Utmost care should be taken to ensure that the tool edge that has been heated by grinding work should never be put in water abruptly. The tool edge shouldnever be pressed so hard as to overheat the tool.When a hot cutting tool is dipped into water, it is broken inevitably. Thermal cracks caused by a temperature difference occur easily on the cemented carbide alloy.

Examples of Grinding:

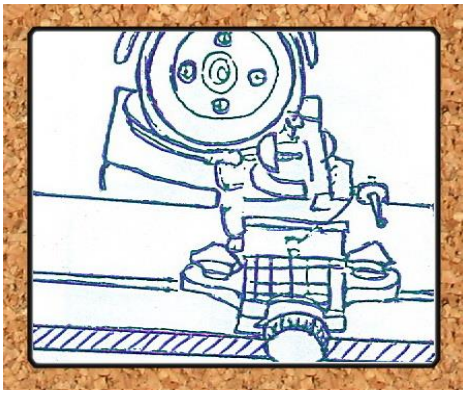


Figure: Grinding Clearance

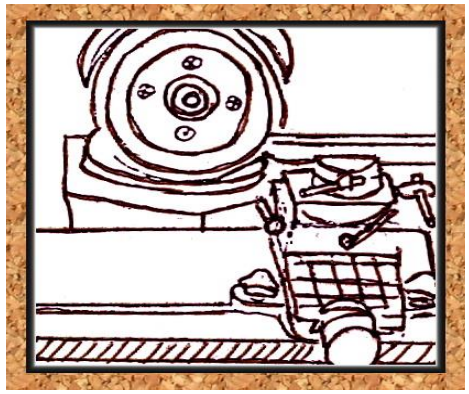


Figure: Grinding rakes

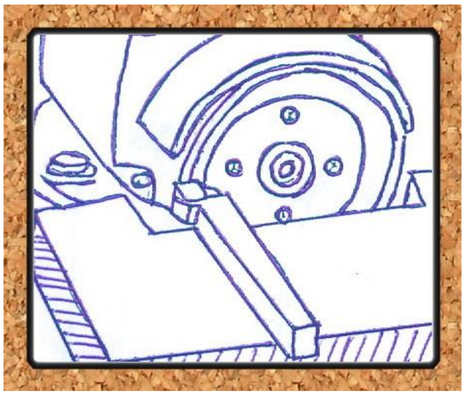


Figure: Manual grinding of front clearance

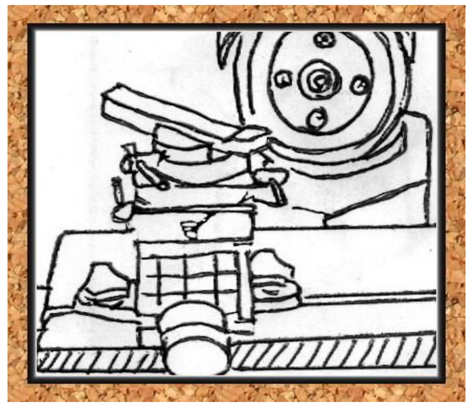


Figure: Grinding back of edge

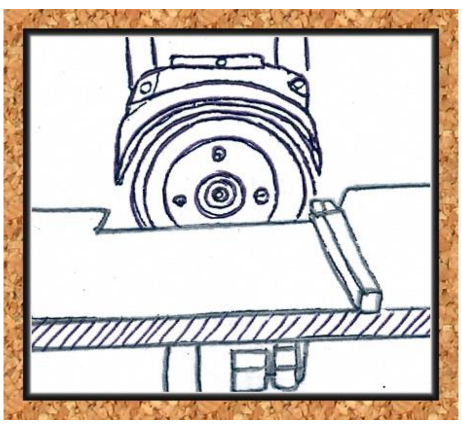


Figure: Grinding front Clearance shank

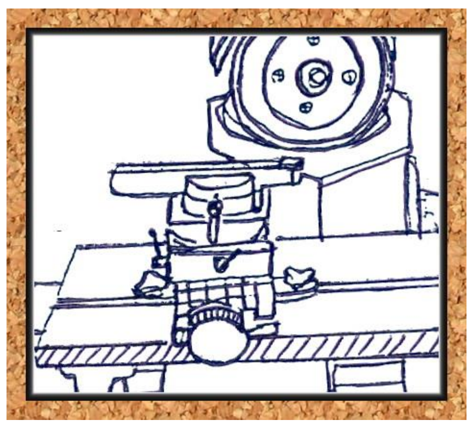


Figure: Grinding Chip breaker groove

1. Grinding tool edge:
   - Hold a tool on the tool holder and set the attachment and table at the required angle.Move the table up and down by operating the vertical movement handle so that the tip of tool approaches the center of grinding wheel and then, check the operating condition of table by moving (stroking) it to left or right.
   - Turn on the switch to start the motor, gradually move the cutting tool close to the surface of grinding wheel by operating the attached cross movement handle and check the dial reading when the cutting tool touches the grinding wheel surface. By using this reading as the standard point of cutting (feeding)depth, grind the cutting tool by stroking (moving) the table by operating the table traverse lever. The proper cutting (feeding) amount is within one graduation of handle scale.

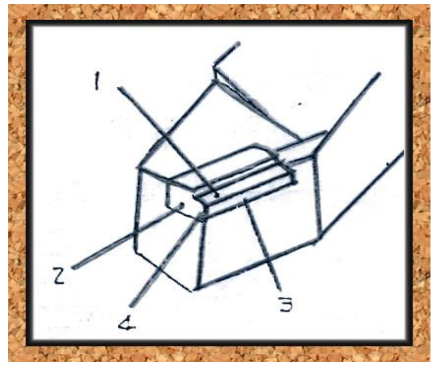


Figure: Grinding Order

Table: General Standards of Tool Angles

Materials to be ground	Different angles			
	Side rake	Front & Side clearance	Side angle	Front angle
Regular steel	-10°- +10°	6°-8°		
Alloy steel	-10° - +15°	6° - 8°		
Cast Iron	0° - +10°	5° - 7°	0° - 20°	4°- 8°
Copper	+5° - +8°	10° - 12°		
Light alloy metal	+10° - +30°	10° - 12°		

2. Radius of roundness of cutting edge

When cutting a steel material, the cutting edge of tool should be kept as small as possible as long as the edge is not broken, because, by doing so, the chips flow smoothly and the life of tool is also expanded When a sharp and pointededge is used, the deformation stress of chips is concentrated to the pointed portion and this portion may be broken or damaged. When cutting cast iron with a considerably small deformation stress, it is permissible to use a comparatively large radius of roundness, which expands the tool life.The radius of roundness of cutting edge is ground manually by placing the cutting tool on the manual grinding base.

Table: General standards of radius of roundness of cutting edge.

Depth of cut(mm)	Radius of roundness of cutting edge	
	Steel, Copper, Al Alloy	Cast iron, Nonferrous metals
Less than 3	0.5	0.8
4-10	0.8	1.6
11-19	1.6	2.4
More than 20	2.4	3.2

Experiment No: 02

Name of the Experiment: **Study the design of Blanking and Piercing Dies for a washer**

Objectives:

1. Study of blanking and Piercing dies for washer.
2. Study of design for blanking and Piercing tool.

Apparatus:

Blanking and Piercing Punch and Die Assembly.

Theory: Blanking is cutting up a large sheet of stock into smaller pieces suitable for the next operation in stamping, such as drawing and forming. Often this is combined with piercing. Blanking can be as simple as a cookie cutter type die to produce prototype parts, or high speed dies that run at 1000+ strokes per minute, running coil stock which has been slit to a specified width. For production parts, the final configuration of the drawn or formed shape needs to be established before the blank die can be built-since the blank size and the slit width size needs to be established precisely. Blanking is often the first step in turning a raw material into a finished product and is rarely the last, except for simple components like, say, washers. But much of the time the blank will then undergo another process to make it into its final form.

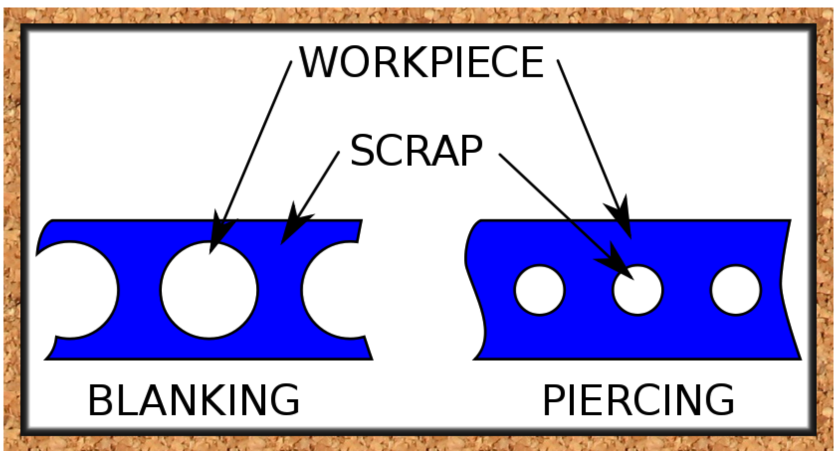


Figure: Comparison of Blanking and Piercing Operation

Piercing is the operation of cutting internal features (holes or slots) in stock. Piercing can also be combined with other operations such as lance and form (to make a small feature such as tab), pierce and extrude (to make an extruded hole). All these operations can be combined with blanking. Piercing of all the holes is best done together to ensure good hole-to-hole tolerance and part repeatability. However if the material distorts, the method described below can be done.

When there are large numbers of holes, in a tight pitch, there could be distortions, due to the high amount of tension on the upper surface due to stretching and compression on the bottom surface. This causes the material not to lay flat. This can be avoided/lessened by staggering the piercing of the holes. Holes are punched in a staggered pattern; then the other holes are punched in the alternate staggered pattern.

Both blanking and piercing is essentially the same thing: A process whereby a particular shape is punched out of a sheet of metal. The difference is that with blanking the outside part is waste, whereas with piercing the inside part is waste. Washers are used in most bolts and nut mechanisms. Washers are punched from G. I Sheet metal. A punch and die assembly is required for the purpose of blanking and piercing. There are two associated parameters concerned. One is the external diameter and another is the internal diameter of the washer. The design of the punch and die assembly depends on the internal and external diameter of the washer required.The punch shaft and top die round plate controls the external diameter and die whereas internal diameter of the punch shaft controls the internal diameter of the washer. The whole assembly was dismantled and all the dimensions were measured with slide calipers accurately. The punch and die mechanism is studied and the parts were assembled again.

The mathematical model of the process can be created by Finite element Simulation Process. In this Process the work piece is imagined to be divided into a number of small parts. The force, stress and Positioning of every part can be simulated calculation using three different co ordinates. Then the two new position of the whole body is generated by simulation of everypart. Thus a complete model based on geometry is produced. For this in each coordinates sensors are set up to the stresses occur due to force.

Job Specifications:

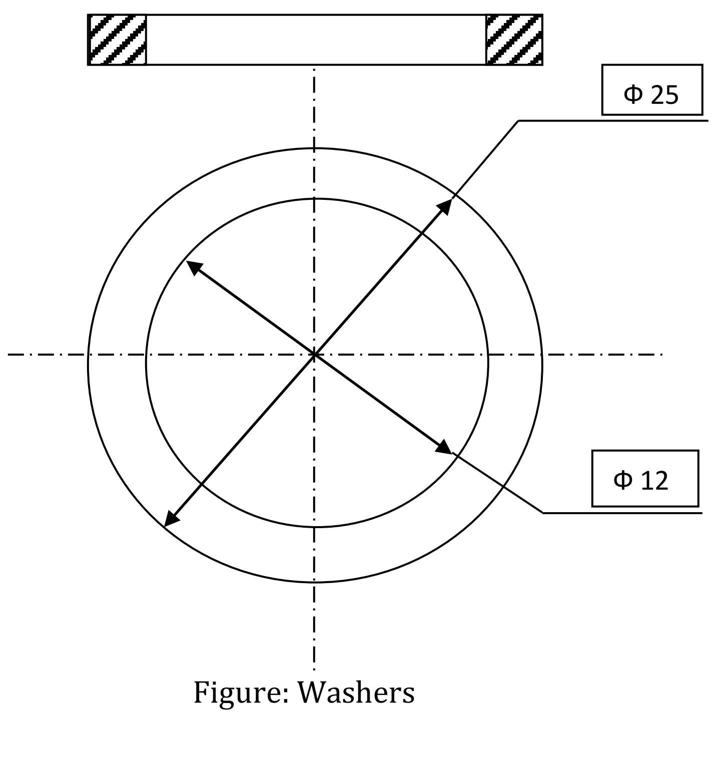


Figure: Washers

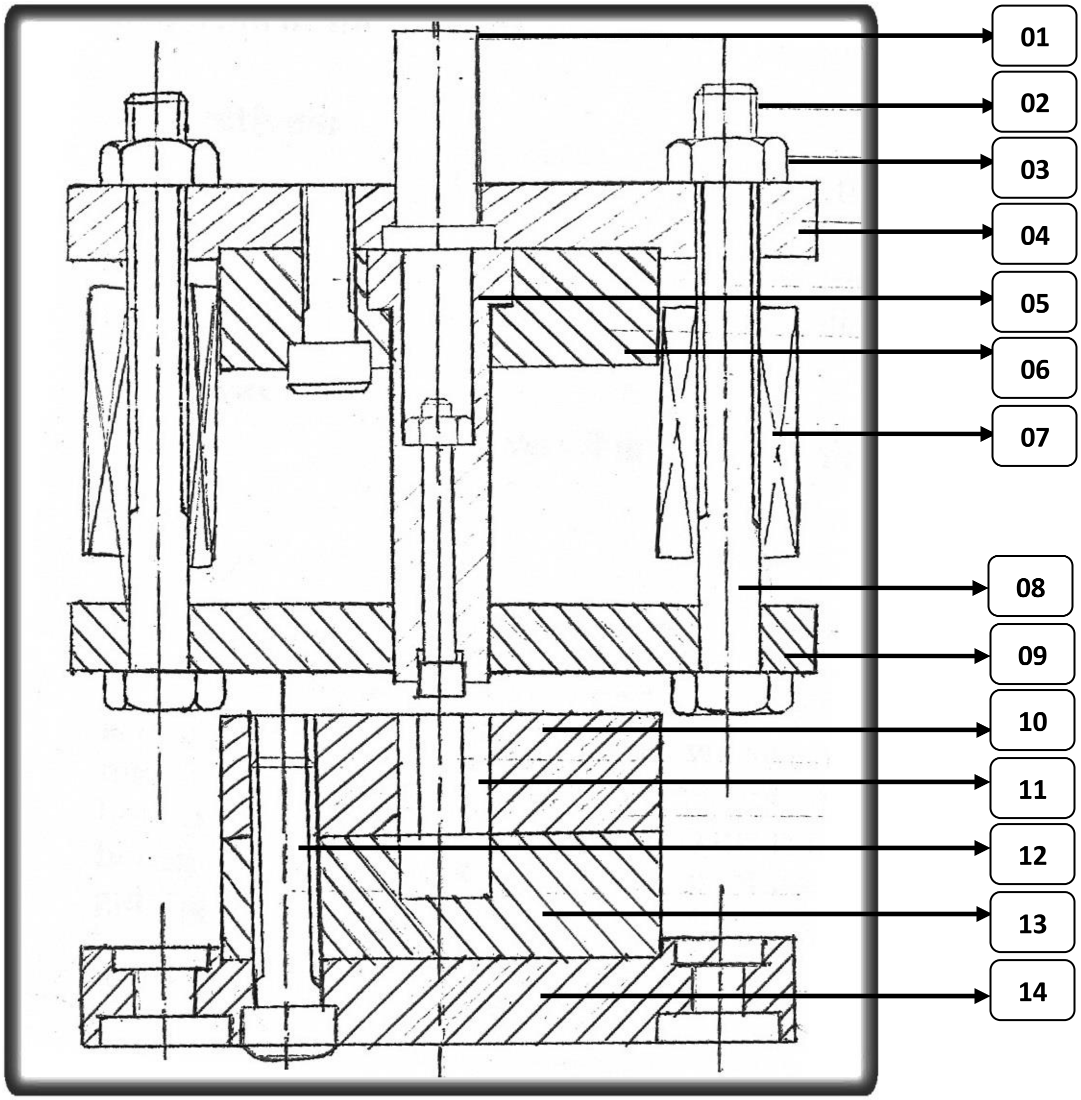


Figure: Die Punch Assembly

Table: Die Punch Assembly (Students should fill the blank columns in the lab with the help of the teacher)

No	Name	Materials	Quantity	No	Name	Materials	Quantity
01	Clamp Shaft			08	Washer Shaft		
02	Bolt M			09	Bottom punch Plate		
03	Nut M			10	Top Dye round Plate		
04	Top Punch plate			11	Die		
05	Bolts M			12	Bolts M		
06	Round Punch Plate			13	Bottom Dye plate		
07	Spring			14	Base Square plate		

Experiment No: 03
Name of the Experiment: Study the Construction and Sharpening of a Milling tool

Objectives:

1. Study of different parts of milling cutter,
2. Study of sharpening of milling cutters,

Apparatus: Different types of Milling Cutter.

Theory:

Milling is the process of cutting away material by feeding a work piece past a rotating multiple tooth cutter. The cutting action of the many teeth around the milling cutter provides a fast method of machining. The machined surface may be flat, angular, or curved. The surface may also be milled to any combination of shapes. The machine for holding the work-piece, rotating the cutter and feeding-is known as the Milling machine.

Milling cutters A milling cutter is a cutting tool that is used on a milling machine. Milling cutters are available in many standard and special types, forms, diameters, and widths.The teeth maybe straight (parallel to the axis of rotation) or at a helix angle. The helix angle helps a slow engagement of the tool distributing the forces.The cutter may be right-hand (to turn clockwise) or left-hand (to turn counterclockwise). A milling cutter is a special type of cutting tool which has multiple cutting edges.There are many advantages of milling cutters compared to single point cutting tool. 1) High machining, 2) Completes required machining operation in required time.There are also disadvantages by employing a milling cutter. 1) High cost, 2) High cutting temperatures are generated, 3) High maintenance cost.

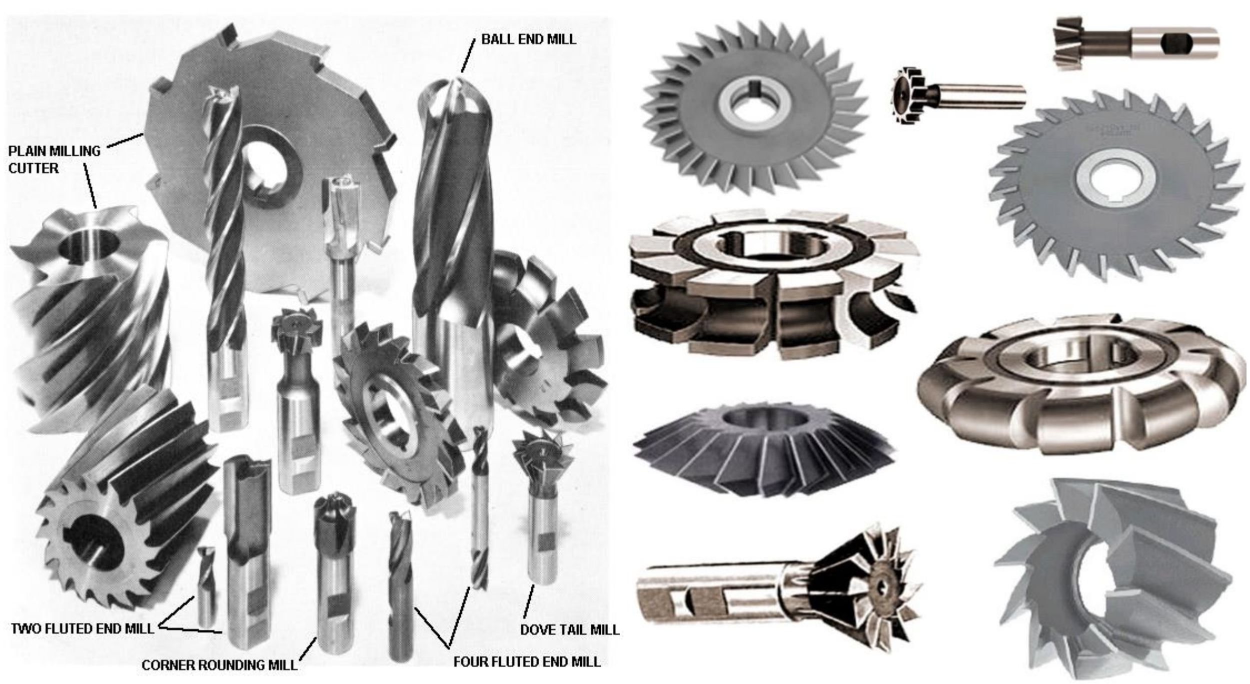


Figure: Different types of Milling Cutters

Milling cutters are of different types: they are classified based on various factors

1. Based on constructional features of the tooth of milling cutter
   a) Solid teeth milling cutter
   b) Inserted teeth milling cutter
   c) Tipped teeth milling cutter
2. According to the relief characteristics
   a) Profile relieved milling cutter
   b) Form relieved milling cutter
3. Based on methods used for mounting
   a) Arbor type
   b) Facing type
   c) Shank type
4. According to the direction of rotation of cutter
   a) Right hand rotational milling cutter
   b) Left hand rotational milling cutter
5. According to the direction of helix
   a) Parallel or straight teeth milling cutter
   b) Right hand helical milling cutter
   c) Left hand helical milling cutter
   d) Alternate helical milling cutter
6. According to purpose or use of cutter
   a) Standard milling cutter
   b) Special milling cutter

Solid teeth milling cutter: Solid cutters are cutters which are made of same material. Generally these cutters are very small in size and width. Solid milling cutters are made from a single piece of material. The most commonly used material is high speed steel. Cost of these cutters are very high as their manufacturing is little complicated and lot of care is required. Cannot do any modifications if there is a little breakage in the body

Inserted teeth milling cutter: In these milling cutters teeth of costly material are inserted in to the body of a cheap material. This arrangement reduces cost by a larger extent. If any teeth is broken or damaged it can be replaced very easily. So, maintenance cost is low. This is the most economical milling cutter.

Tipped milling cutter: In this type of milling cutters, the body of the milling cutters the body is made up of steels and the tip of the tools are made up of cemented carbides or satellite tips. The tips of the tools are brazed to improve hardness.

Profile relieved milling cutters: Relief to the cutting edges is provided at the back of the cutting edge by grinding a narrow land. These cutters generate flat curved or irregular surfaces.

Form relieved milling cutters: A curved relief is provided at the back of cutting edge for these milling cutters. These cutters are sharpened by grinding the face of the tool. These milling cutters are generally used for generating contoured surfaces or formed surfaces.

Arbor type milling cutter: These milling cutters are generally made of central hole and a key way for mounting them directly on the arbor of the milling machine. There are various varieties of designs are available in arbor type milling cutters. According to the type of arbor being used milling cutters are designed.

Shank type milling cutters: These milling cutters are provided with either straight or tapered shank to get it inserted over to the spindle tip and are clamped on both sides by using a draw or friction bolts.

Facing type cutters: These milling cutters are directly fixed securely between the spindle tips or mounted over a small arbor also called stub arbor. This type of cutters are generally used for producing flat edges

Right hand milling cutter: If the cutter rotates in the anticlockwise direction when viewed from the end of the spindle is termed as right hand milling cutter.

Left hand milling cutter: If the cutter rotates in the clockwise direction when viewed from the end of the spindle is termed as left hand milling cutter.

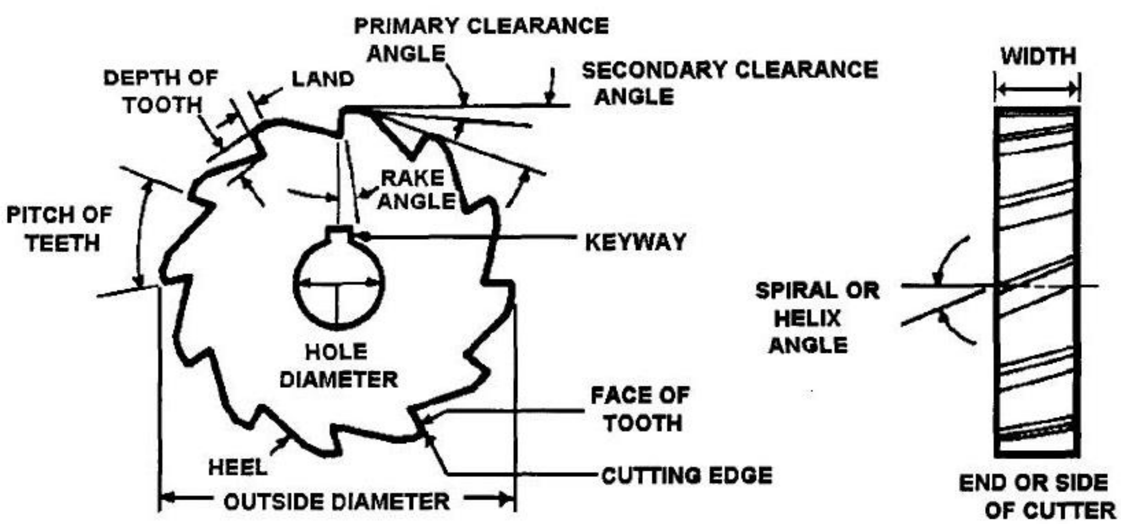
Parallel or straight teeth milling cutter: If the teeth of the milling cutter are straight and parallel to the axis of rotation then it is termed as parallel or straight teeth milling cutter. The angle of helix for these milling cutters is equal to zero.

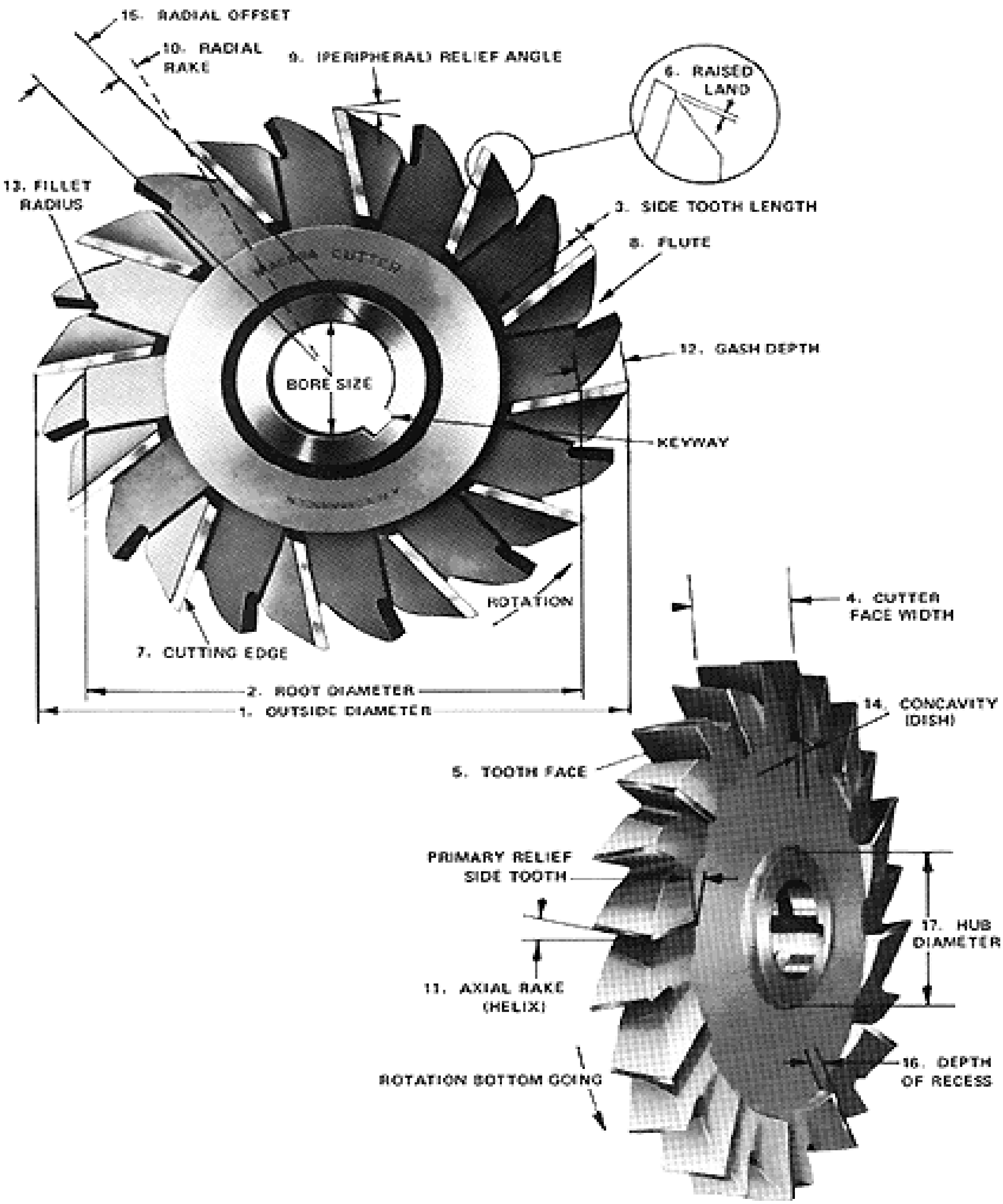
Right hand helical milling cutter: When the helical grove is found to be in the direction of left to right when viewed from the end of one of the faces then the milling cutter is termed as right hand milling cutter. This cutter has an angle of helix which is more than zero.

Left hand helical milling cutter: When the helical groove is found to be in the direction of right to left when viewed from the end of one of the faces then the milling cutter is termed as left hand milling cutter. This cutter has angle of helix which is more than zero.

MILLING CUTTER NOMENCLATURE

A written and pictorial definition of the basic nomenclature of a milling cutter





<u>**Figure: Different parameters of Milling Cutters**</u>

- OUTSIDE DIAMETER. The outside diameter is the diameter of the cylinder passing through the peripheral cutting edges.
- ROOT DIAMETER. The root diameter is the diameter of the circle passing tangent to the bottom of the fillet.
- SIDE TOOTH LENGTH. Length of the raised land along the side tooth. Required to calculate the number of resharpenings available and the modification possibilities.
- CUTTER FACE WIDTH. The cutter face is the surface at the side or end of the cutter body which is perpendicular to the axis of the cutter. The distances between the two faces of plain, helical and side milling cutters, or the length of the outside diameter cylinder is the cutter width, if small, or cutter length,with respect to the diameter.
- TOOTH FACE. The tooth face is that surface of the cutting tooth against which the chip is forced in the metal cutting operation.
- LAND. The land is that part of the back of the tooth adjacent to the cutting edge which is relieved to avoid interference between itself and the surface being machined. A raised land permits numerous re-sharpening before a secondary clearance has to be ground.
- CUTTING EDGE. The cutting edge is the intersection of the face of the tooth with the leading edge of the land.
- FLUTE. The flute, is the chip space between the back of one tooth and the face of the following tooth.
- RELIEF ANGLE. The peripheral relief angle is the angle between the surface formed by the land and a tangent to the cutter outside circle passing through the cutting edge in a diametral plane. It is to prevent the land from rubbing on the surface of the work being cut. Relief and clearance are measured in degrees or in radial fall in inches at a certain specified distance back of the cutting edge on the land. For this latter measurement, a dial indicator may be used to measure the radial fall in thousandths of an inch from the outside or cutting edge diameter back of the cutting edge.
- RADIAL RAKE ANGLE. The radial rake angle of a milling cutter is the angle formed in a diametral plane between the face of the tooth and a radial line passing through the cutting edge. This may be positive, negative, or zero degree.
- AXIAL RAKE ANGLE OR HELICAL RAKE. When a milling cutter has helical teeth, that is, when its cutting edge is formed along a helix about the cutter axis, the resulting rake is called helical rake. If the cutting edge is straight, its rake is axial rake. The axial rake or helical rake angle is the angle formed between the line of the peripheral cutting edge and the axis of the cutter, when looking radially at the point of intersection. This applies in the case of helical mills, half-side mills, staggered tooth mills, face mills, and metal slitting saws having face cutting edges.
- GASH DEPTH. Gash depth is the distance from the outside diameter of the cutter to the fillet radius or root diameter.
- FILLET RADIUS. The fillet radius is the curved surface at the bottom of the flute which joins the face of one tooth to the back of the tooth immediately ahead.
- DISH OR CONCAVITY. The progressive decrease in cutter width from the periphery toward the center.
- RADIAL OFFSET. The radial offset of a milling cutter is the physical dimension that a tooth is behind (for positive rake) or ahead (for negative rake) of a center line drawn parallel with flat, tooth face. It is calculated by multiplying the sine function of the radial rake angle times the radius of the milling cutter.

- DEPTH OF RECESS. The distance from the cutting edge on the land of the side tooth (or the hub which is the same width as the cutter) to the recess is the depth of recess. This dimension is required to determine width and angle modification limits.
- HUB DIAMETER. The hub is the raised ground section between the bore and recess. It is the same width as the cutter. Collar spacers butt adjacent to the hub for holding and spacing of the cutter on the arbor. The hub diameter dimension is required to determine the allowable depth or cut and clearance between cutter and work piece.

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Selecting a milling cutter is not a simple task. There are many variables, opinions and lore to consider, but essentially the machinist is trying to choose a tool which will cut the material to the required specification for the least cost. The cost of the job is a combination of the price of the tool, the time taken by the milling machine, and the time taken by the machinist. Often, for jobs of a large number of parts, and days of machining time, the cost of the tool is lowest of the three costs.

- Material: High speed steel (HSS) cutters are the least-expensive and shortest-lived cutters. Cobalt steel is an improvement on HSS and generally can be run 10% faster. Carbide tools are more expensive than steel, but last longer, and can be run much faster, so prove more economical in the long run. HSS tools are perfectly adequate for many applications. The progression from HSS to cobalt steel to carbide could be viewed as very good, even better, and the best.
- Diameter: Larger tools can remove material faster than small ones, therefore the largest possible cutter that will fit in the job is usually chosen. When milling an internal contour, or concave external contours, the diameter is limited by the size of internal curves. The radius of the cutter must be less than or equal to the radius of the smallest arc.
- Flutes: More flutes allow a higher feed rate, because there is less material removed per flute. But because the core diameter increases, there is less room for swarf, so a balance must be chosen.
- Coating: Coatings, such as Titanium nitride, also increase initial cost but reduce wear and increase tool life.
- Helix angle: High helix angles are typically best for soft metals, and low helix angles for hard or tough metals.

Experiment No: 04

Name of the Experiment: Study the Construction and Sharpening of a Twist Drill

Objectives:

1. Study of different parts and parameters of twist drill,
2. Study of sharpening of twist drill,

Apparatus: Different types of Drill bits (Specially twist drill)

Theory: Drill bits are cutting tools used to create cylindrical holes. Bits are held in a tool called a drill, which rotates them and provides torque and axial force to create the hole. Specialized bits are also available for non-cylindrical-shaped holes. The twist drill bit is the type produced in largest quantity today. It drills holes in metal, plastic, and wood.The original method of manufacture was to cut two grooves in opposite sides of a round bar, then to twist the bar to produce the helical flutes. This gave the tool its name. Nowadays, the drill bit is usually made by rotating the bar while moving it past a grinding wheel to cut the flutes in the same manner as cutting helical gears. Tools recognizable as twist drill bits are currently produced in diameters covering a range from 0.05 to 100 mm (0.0020 to 3.9 in). Lengths up to about 1,000 mm (39 in) are available for use in powered hand tools. The geometry and sharpening of the cutting edges is crucial to the performance of the bit. Users often throw away small bits that become blunt, and replace them with new bits, because they are inexpensive and sharpening them well is difficult. For larger bits, special grinding jigs are available. A special tool grinder is available for sharpening or reshaping cutting surfaces on twist drills to optimize the drill for a particular material.

Manufacturers can produce special versions of the twist drill bit, varying the geometry and the materials used, to suit particular machinery and particular materials to be cut. Twist drill bits are available in the widest choice of tooling materials. However, even for industrial users, most holes are still drilled with a conventional bit of high speed steel. The most common twist drill (the one sold in general hardware stores) has a point angle of 118 degrees. This is a suitable angle for a wide array of tasks, and will not cause the uninitiated operator undue stress by wandering or digging in. A more aggressive (sharper) angle, such as 90 degrees, is suited for very soft plastics and other materials. The bit will generally be self-starting and cut very quickly. A shallower angle, such as 150 degrees, is suited for drilling steels and other tougher materials. This style bit requires a starter hole, but will not bind or suffer premature wear when a proper feed rate is used. Drills with no point angle are used in situations where a blind, flat-bottomed hole is required. These drills are very sensitive to changes in lip angle, and even a slight change can result in an inappropriately fast cutting drill bit that will suffer premature wear.

DRILL BIT GEOMETRY HAS SEVERAL ASPECTS

- *The spiral,* or rate of twist in the drill, controls the rate of chip removal in a drill. A fast spiral drill is used in high feed rate applications under low spindle speeds, where removal of a large volume of swarf is required. Low spiral drills are used in cutting applications where high cutting speeds are traditionally used, and where the material has a tendency to gall on the drill or otherwise clog the hole, such as aluminum or copper.

The point angle, or the angle formed at the tip of the drill, is determined by the material the drill will be operating in. Harder materials require a larger point angle, and softer materials require a sharper angle. The correct point angle for the hardness of the material controls wandering, chatter, hole shape, wear rate, and other characteristics. Ideally the point should be suited to the materials to be drilled. Bits usually come with a 135° split point, although several proprietary designs are also offered.

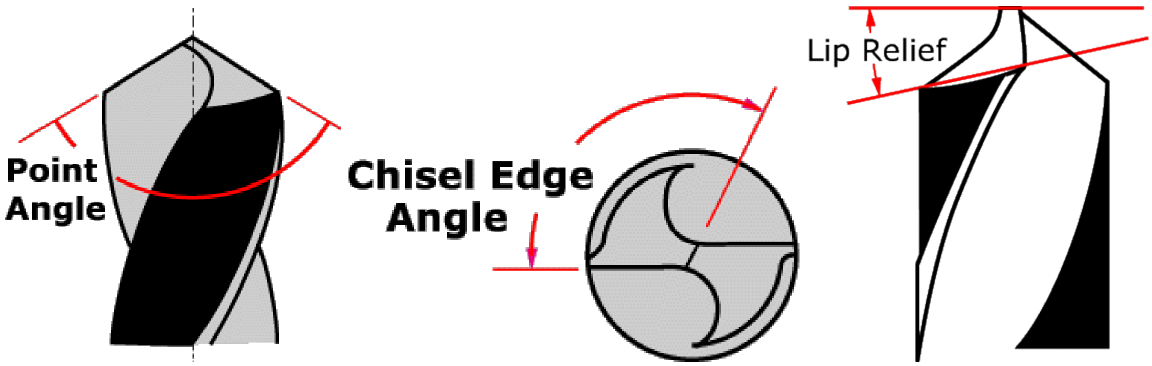


Figure: Difference between point angle and Chisel angle

Material	Point angle	Chisel angle
aluminum	118°–130°	125°–130°
brass	118°–125°	125°–135°
bronze (hard)	118°	115°–125°
copper	100°–130°	125°–135°
plastic	60°–118°	125°–135°
stainless steel	118°–140°	115°–125°
cast iron	90°–118°	115°–125°
cast steel	118°	125°–135°

- *The lip angle* determines the amount of support provided to the cutting edge. A greater lip angle will cause the drill to cut more aggressively under the same amount of point pressure as a drill with a smaller lip angle. Both conditions can cause binding, wear, and eventual catastrophic failure of the tool. The proper amount of lip clearance is determined by the point angle. A very acute point angle has more web surface area presented to the work at any one time, requiring an aggressive lip angle, where a flat drill is extremely sensitive to small changes in lip angle due to the small surface area supporting the cutting edges.
- The Mechanic Drills used widely by vendors to further describe the length of the drill itself. The actual length x diameter must be found and published.
- The Jobber Drills used widely by vendors to further describe the length of the drill itself. The actual length x diameter must be found and published.

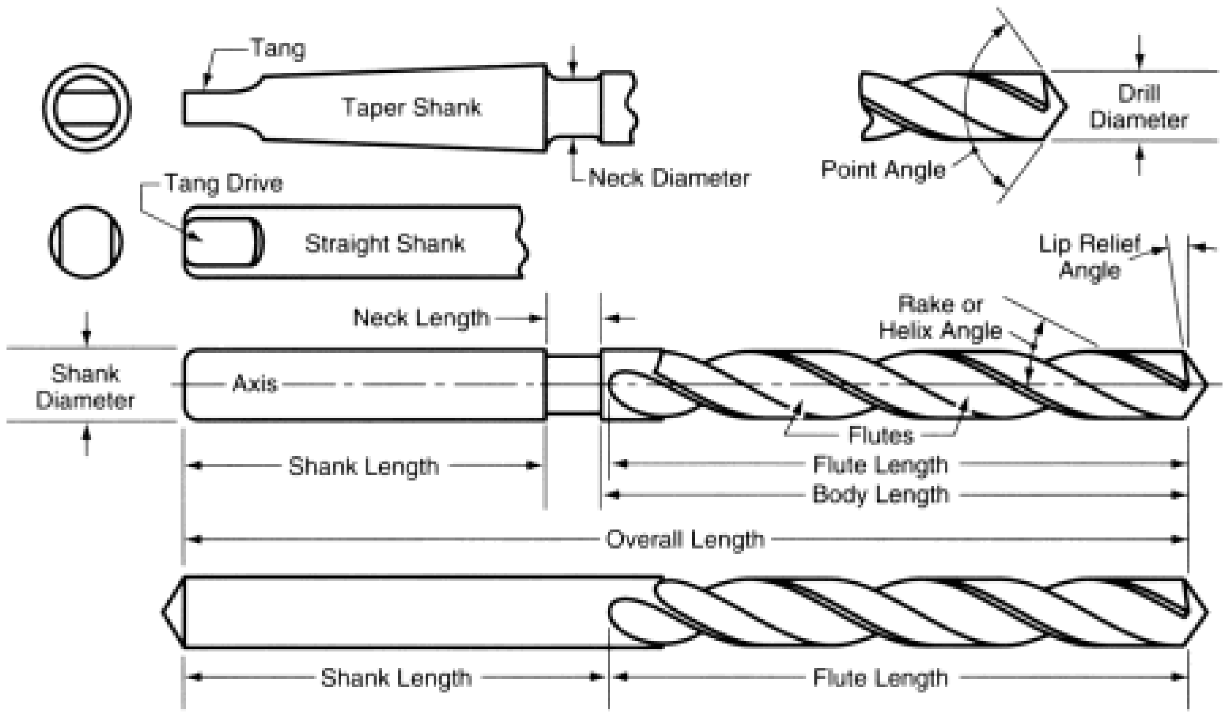
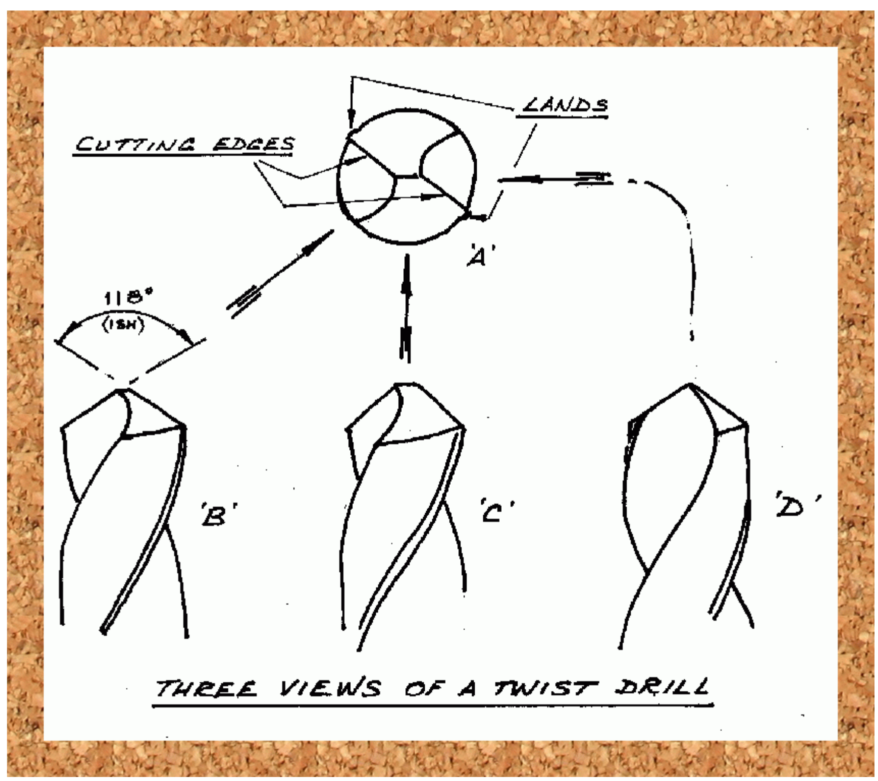


Figure: Different parts of twist drill

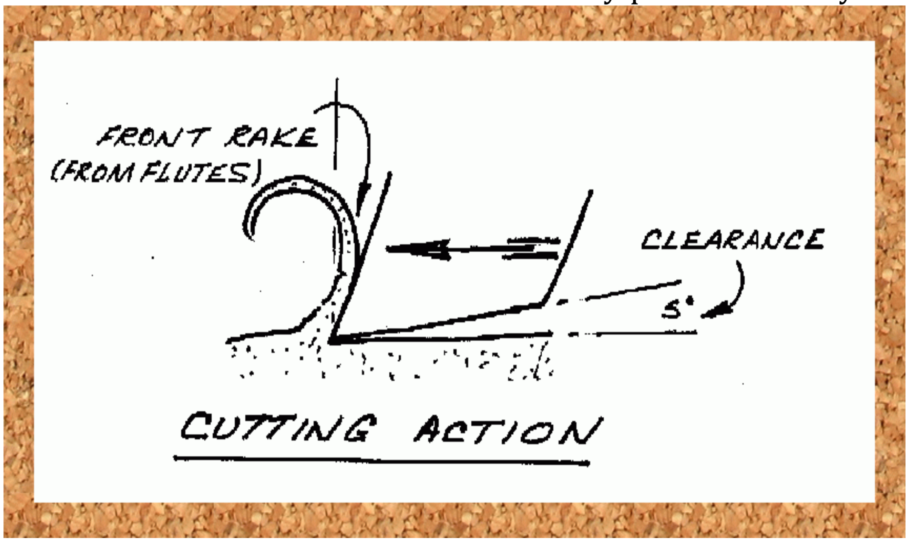
Sharpening Drills



The first sketch shows several views of a typical twist drill. A twist drill has spiral grooves or flutes running along its working length. Looking at the end view 'A', the shape of the flute is such that the cutting edges are straight. Between the inner ends of the cutting edges is the web of the drill and running along the length of the drill just behind the outer ends of the cutting edges are the lands. In view 'B' we are looking at right angles to the cutting edges and the included angle of the point. This is traditionally given as 118 degrees but 120 degrees cuts just as well and indeed a slightly blunter point is often used for hard materials. View 'C' shows the body of the drill with the cutting face sloping upward to the cutting edge; it also shows the ridge along the top of the web. View 'D', looking at the end of the ridge is the only view where the end of the drill appears pointed.

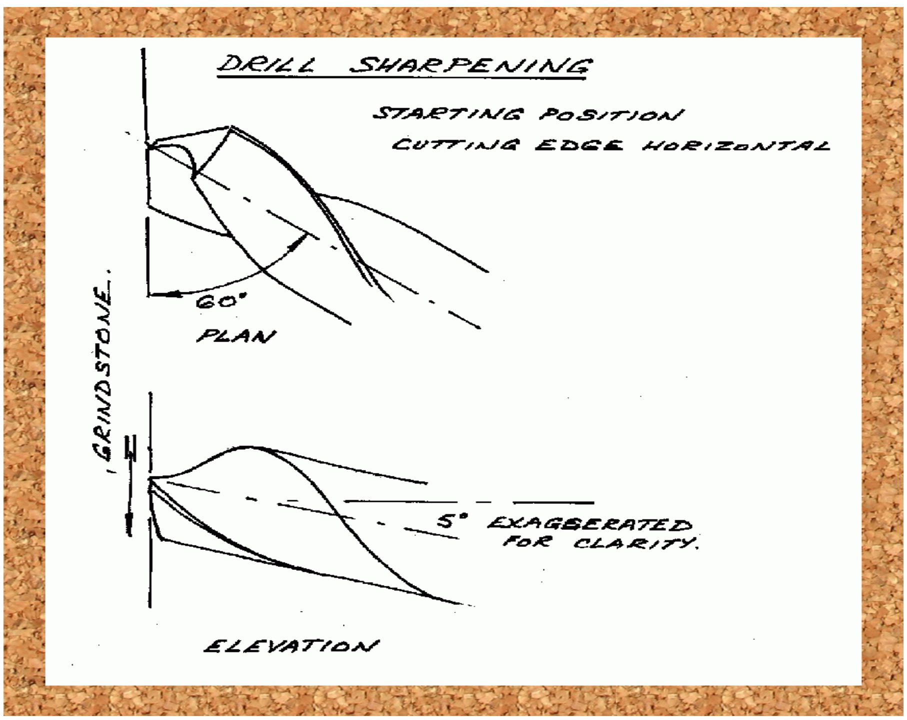
Drill in action

When a drill is cutting, the material nearest the centre of the drill is literally pushed aside by the ridge at the end of the web until it comes within the sweep of the cutting edges. The cutting edges are shown in action in the sketch. For the moment the clearance angle behind the cutting edge is about 5 degrees. Unfortunately when wrapped around a drill this produces a drill face in the form of an eccentric inclined cone so rather than waste a lot of time on the geometry let us just sharpen the drill.



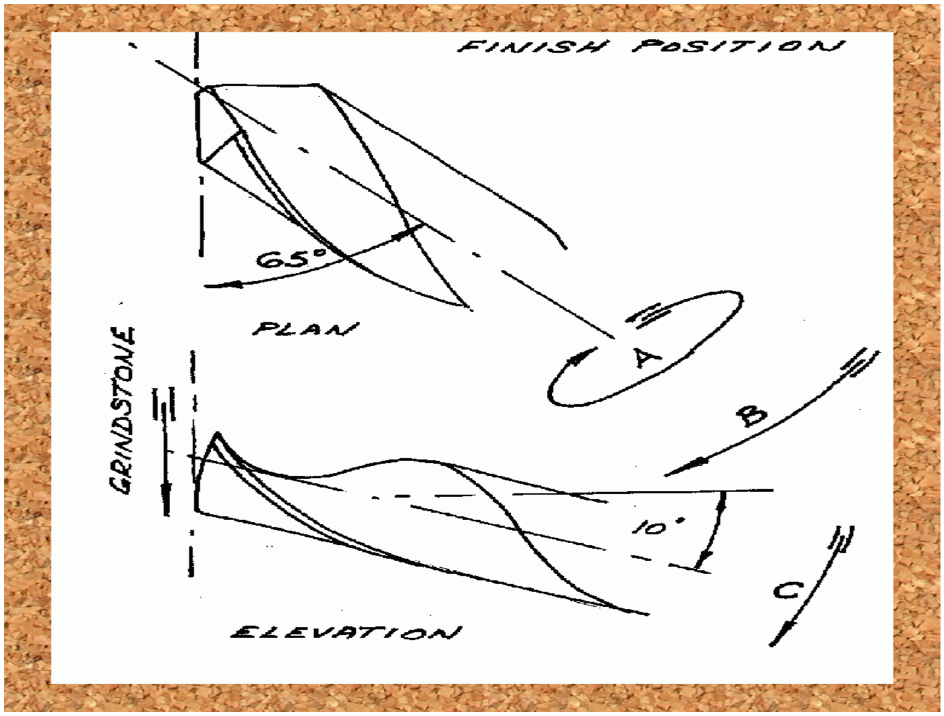
Sharpening the drill

With the grindstone switched off, present the cutting edge of the drill to the side of the stone so that looking down on the drill it is in position 'B' of the introductory sketch and the cutting edge is horizontal against the stone. The cutting edge is tilted upward at 5 degrees. This is the starting position so spend a moment or two getting used to it. Hopefully the sketch will make things clear. Usually balance the leading edge on a finger and hold the back of the drill in the right hand.



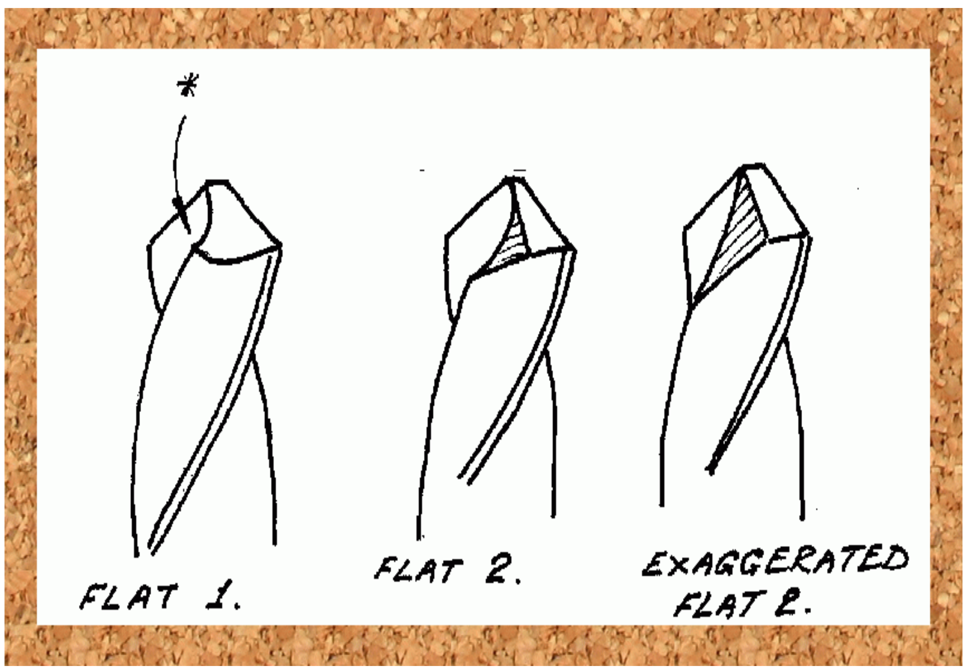
Now look at the sketch of the finish position. Without letting go of the drill, rest the drill against the stone and get your fingers used to this new position. You will find that it requires three movements at once to go from the start to the finish position!

When you have got the feel of it take an old drill about 3/8'' (10mm) dia., switch on the grindstone and give it a try. Do not try to remove great amounts of metal, the object of the exercise is to renew the cutting edge and remove just enough material behind the cutting edge to enable the edge to do its job.Repeat for the other cutting edge. Hold the drill up to the light in position 'B'.

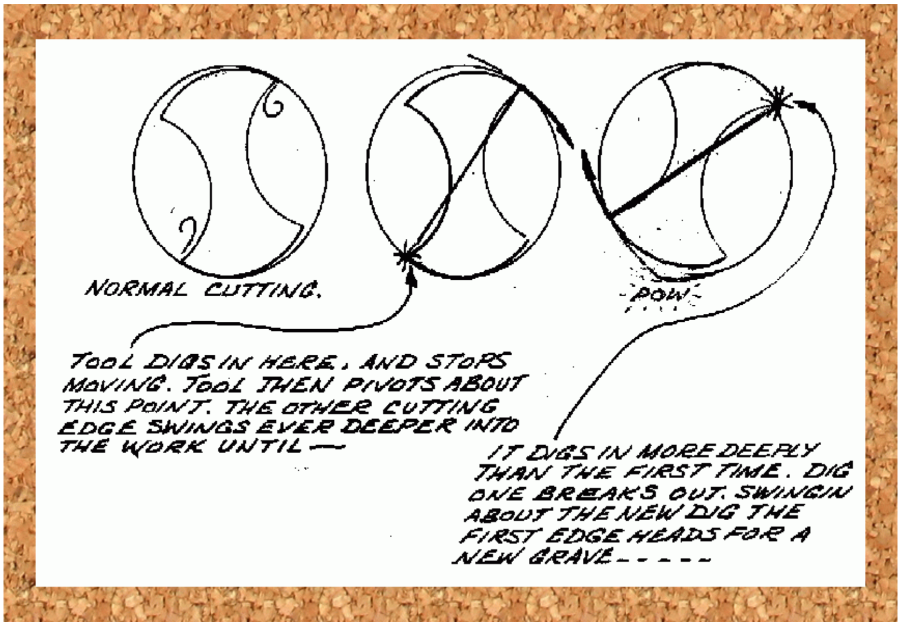


'Two flat' sharpening.

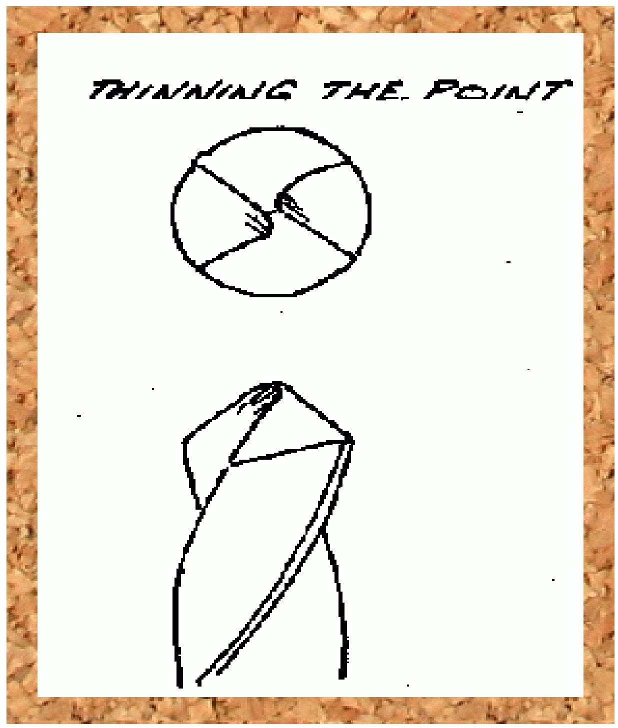
This is simple, does the job just as well and is easily learnt! Hold the drill in the start position as per sketch. Lightly touch the cutting edge to the grindstone. Look at the side of the drill. The front portion of the cutting edge is fine but the rear edge curves forward again. Not much use. See sketch. But if the drill is held in the finish position and again touched to the stone a second flat will appear and remove the recurved back edge.



Before getting into the subject of modified points, lets recap on the cutting action of the drill. The blunt ridge at the end of the web in the centre of the drill smears the metal outward into the area swept by the cutting edges. Thus there are two totally different cutting actions, the smearing action at the centre which cannot dig in and the cutting action of the edges themselves which can. The balance of the two actions is not too critical and for most applications the twist drill provides the rightproportions. Most of the time! When a drill misbehaves it is usually because we have upset the balance between the steadying action of the web and the dig inprone cutting edges.

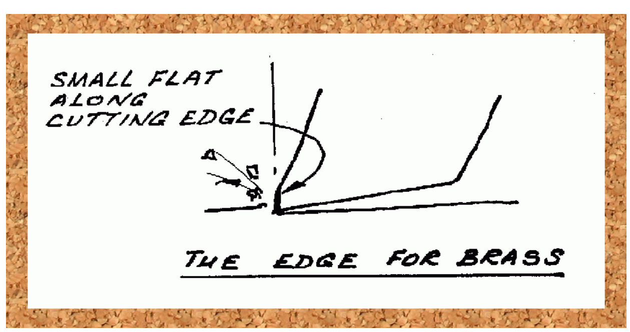


In the diagram, chatter process is shown. The important thing is that this can only occur at the cutting edges, the web smeary bit (hereafter called the ridge) is totally immune and actually has a steadying influence on the drill. Thus it is that when the drill breaks through thin sheet it removes the ridge area first and freed of its restraining influence goes into chatter mode. If drilling big holes in thin metal try drilling a piece of scrap first. If it chatters fold up a pad of paper about 20 mm sq. and about eight layers thick and put under the point of the drill. Keep the pilot hole fairly small and let the pad rotate with the drill. Not infallible but usually has enough of a steadying influence back to subject. A similar action may occur when opening up an oversized pilot hole. With no steadying influence from the ridge the drill goes into chat mode and produces an interesting oversize hole with a slow helical pattern in it. More on that later, it can also occur when an oversized centre drill has been used before drilling in the lathe. The drill chatters about and produces an awful hole until the end of the pilot is reached.



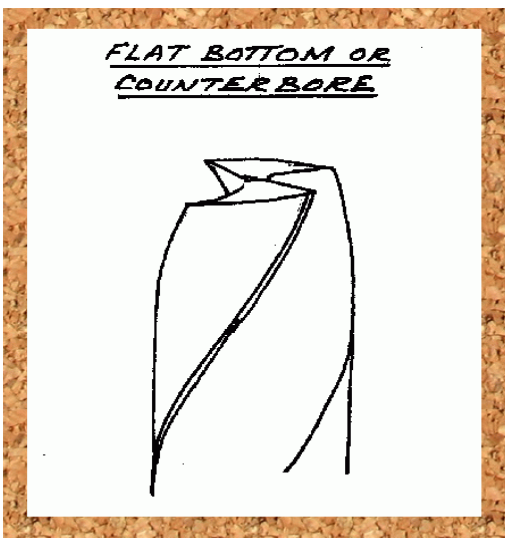
Having extolled the virtues of the ridge, let us look at the downside. It depends on considerable local pressure being applied to the point of the drill. If the drill is large the force required may be beyond the capacity of the drilling machine. In this case, the point may be thinned, so extending the cutting edges inward. See sketch.

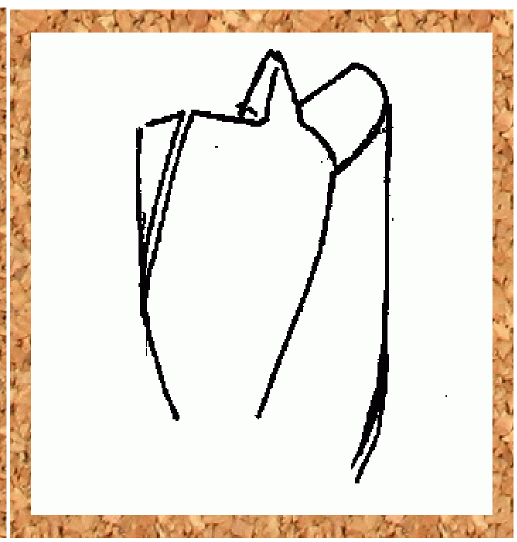
Using the corner of the wheel the flute area is extended forward locally in the shaded area.Tip for the idle, this modification can seriously reduce the amount of push required when drilling with a pistol drill.Such thinning of the point is often beneficial when drilling materials such as drawn bronze or stainless steel where there is a tendency for the material to work harden. Dropping the speed should be the first option however! For



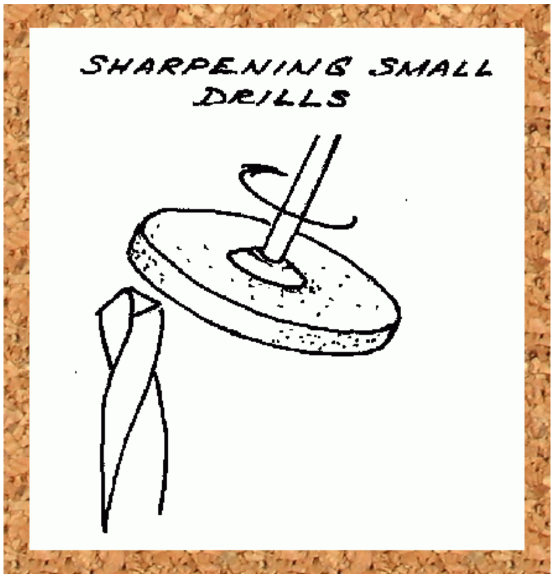
some materials, notably brass, the straight flute drill is a better option. The twist drill has a tendency to dig in and grab due to its excessive front rake. But we have lots of twist drills and straight flutes are expensive. The answer is to take a hand stone and just give the edge a couple of strokes parallel with the axis of the drill. See sketch.

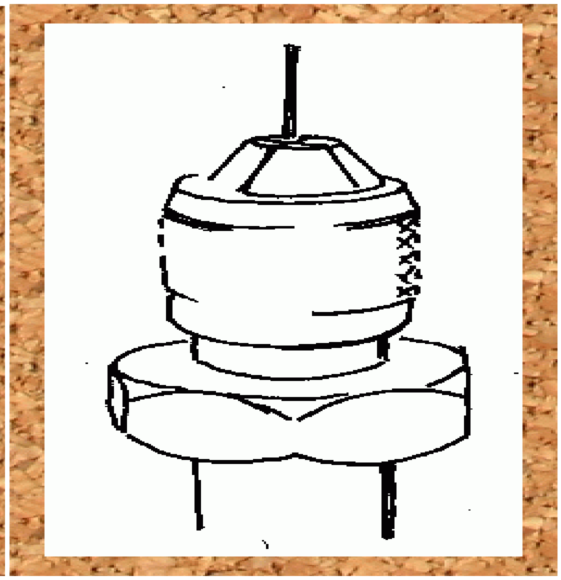
For the economically minded a small flat gives the option of later re-sharpening to standard form, per contra a touch with a stone in this fashion can often restore a tired drill. A few last points. A large drill will not start accurately from a tiny centre pop. When one considers the ridge shape and its action it is a wonder that there is any relationship between centre pop and drill position at all! Use a smaller drill with a diameter of around half to three quarters of the web thickness of the big drill to put in a short pilot hole and help it start in the right place. On really big drills the pilot drill may need a pilot- A full depth pilot hole is even better. Diameter as above will reduce the effort needed to push that ridge area into the metal while retaining enough support to stop it chattering. Incidentally the parallel shanks of large high speed steel drills are usually soft and can be turned down to suit ones chuck. Twist drills can be sharpened as in the sketch for drilling flat bottomed counter bores. Use an ordinary drill of the same size to remove the majority of the material and finish with the flat bottomed one. In the absence of a ridge area it depends on the wall of the hole to keep it on course. Sharpen against the corner of the stone.





A drill sharpened in a manner similar to the special twist drills for wood (see sketch) can be used for cutting holes in sheet. The action is rather like that of a fly cutter. Put in a pilot hole and cut about halfway through the sheet, turn over and complete the cut. Sharpen against the corner of the stone. It may be worth blunting the corners of the centre portion to improve stability. Small drills can be difficult to sharpen on the grindstone, mainly because ones hands prevent one seeing what is going on and also because the rate of metal removal is so fast that by the time vision is established one has gone too far! If the drill is held vertically in the left hand and a mini power drill armed with a small stone is held penholder fashion in the right it is a much simpler job. See the sketch. If the wrists can rest against something it is easier still.





Even in case of smaller drills below 1.5 mm it is difficult to see the cutting edges when sharpening. A pin chuck with a hex.nut secured to the body. If the drill is held vertically in this and the position of the nut/chuck noted when the cutting edge is in a convenient position it is a simple matter to rotate it through 180 degrees to get the second edge into a similar position. Application of the mini power drill or a hand held slip stone soon restores the edge.