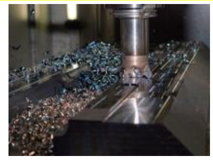
WHAT IS MACHINING?

- ❖Machining is a manufacturing process in which excess material is removed from parent material in the form of chips using suitably shaped tools called cutting tools in order to achieve desired size shape surface finish surface integrity of the intended product.
- ❖Machining is a finishing process which follows other manufacturing processes such as casting, forging, rolling extrusion etc.
- ❖Shearing and cutting are not machining as they do not involve chip formation.

1

MACHINE TOOLS



- ➢It is a machine in which machining can be done, e.g., Lathe, Shaping m/c, Drilling machine
- ➢All machines are not machine tools but all machine tools are machines.

- ➢ Forging m/c, moulding m/c, die casting m/c etc. are machines but not machine tools.

2

CUTTING TOOLS

- These are tools used for metal cutting They involve certain geometry, angles planes clearances etc.
- Broadly they can be classified into two groups- 1) Single point cutting tools and 2) Multi point cutting tools
- A single point cutting tool contains only one main cutting edge
- A double point cutting tool contains two cutting edges and multi-point cutting tool contains more than two main cutting edges
- Cutting tools can also be classified as Right Hand & Left Hand cutting tool

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Lathe tool (turning/facing) is a single point tool.

Drill bits are the example of double point cutting tools

Milling cutters are multi-point cutters

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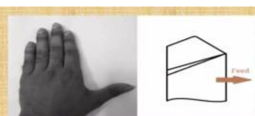
Right Handed Cutting Tool



Left Handed Cutting Tool

A right handed cutting tool, the common one, can remove material while moving leftward

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Differences Between Single And Multi-Point Cutting Tool

Sr. No.	Single Point Cutting Tool	Multi Point Cutting Tool
1.	In case of unplanned breakage of the cutting edge, the entire process needs to be paused until the tool is replaced by a new one.	In case of breakage of one tooth, the other tooth can continue cutting action without much problem.
2.	Design and fabrication of single point cutting tools are comparatively easy.	Design and fabrication of multi point cutting tools are quite difficult.
3.	Usually single point cutting tools are given low feed rate, so Material Removal Rate (MRR) and thus productivity are comparatively low	Higher feed rate can be provided, which increases MRR and productivity. So machining operation with multi point cutting tool is more economic
4.	Turning tool, also known as Single Point Turning Tool (SPTT), is the perfect example of a single point tool. Apart from SPTT, shaping, planing, slotting, boring tools are also single point tool.	Milling cutters, hobs, broaching tools, grinding wheels, etc. are examples of multi point tools.

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Differences Between Single And Multi-Point Cutting Tool

Sr. No.	Single Point Cutting Tool	Multi Point Cutting Tool
5.	While machining with single point cutting tool, only one cutting edge continuously engage in material removal action.	While machining with multi point cutting tool, more than two cutting edges simultaneously engage in material removal action.
6.	Usually, these cutting tools have only one wedge shaped main cutting edge. However, insert based single point cutting tools may have multiple cutting edges present on a single tool, out of them only one will partake in cutting action at a pass. In the next pass, the previous cutting edge can be replaced by a new sharp one. So in any case, more than one cutting edge will not engage in cutting action at a time.	Multi point cutting tools may have only few (about 4) to hundreds of cutting edges. However, the number of cutting edges engage in cutting action at a time depends on various factors, such as depth of cut, infeed, width, etc. By the by, all cutting edges successively engage in cutting action in a single pass.
7.	Chip load per tooth is usually high.	Due to presence of multiple teeth, chip load per tooth reduces.
8.	Since one cutting edge continuously remains in contact with the workpiece, so rate of rise in tool temperature is high.	Due to successive engagement of teeth, some amount of heat gets dissipated from the teeth when these are not in contact with the workpiece. Consequently rate of rise in tool temperature is low.

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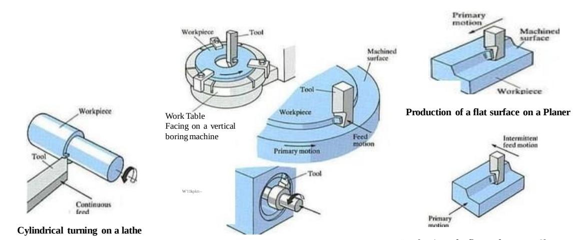
Single Point Cutting Tool

- Removal of the metal from the workpiece by means of cutting tools which have one major cutting edge.



Cylindrical turning on a lathe

Internal boring on a horizontal boring machine

Production of a flat surface on a Planer

Production of a flat surface on a Shaper

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Single Point Cutting Tool

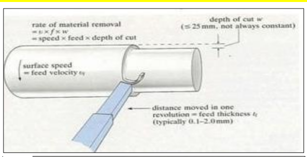
A *chip of material* is removed from the surface of the workpiece.

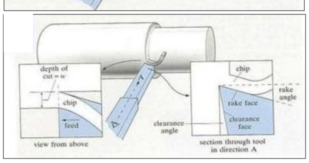
Principal parameters:
- the cutting speed, ***v***
- the depth of cut, ***w or d***
- the feed, ***f***.

Time requires to turn a cylindrical surface of length L_w,

$$t = \frac{L_w}{f n_w}$$

Where n_w is the number of revolutions of the workpiece per second.





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Single Point Cutting Tool

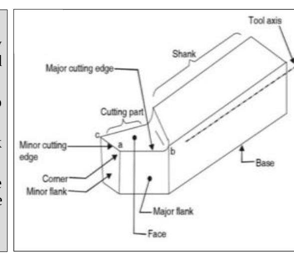
❖***Shank :-*** It is the main body of the tool.

❖***Flank :-*** The surface or surfaces below and adjacent to the cutting edge is called flank of the tool.

❖***Face :-*** The surface on which the chip slides is called the face of the tool.

❖***Heel :-*** It is the intersection of the flank and the base of the tool.

❖***Nose :-*** It is the point where the side cutting edge and end cutting edge intersect.



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Single Point Cutting Tool

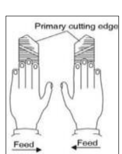
Cutting edge:- It is the edge on the face of the tool which removes of the material from the workpiece. The total cutting edge consists of side cutting edge (major cutting edge). end cutting edge (minor cutting edge and the nose).

A single point cutting tool may be either right-or left hand cut tool depending on the direction of feed. In a right cut tool, the side cutting edge is on the side of the thumb when the right hand is placed on the tool with the palm downward and the fingers pointed towards the tool nose.

Such a tool will cut when fed from right to left as in a lathe in which the tool moves from tale stock to headstock. A left-cut tool is one in which the side cutting edge is on the thumb side when the left hand is applied . Such a tool will cut when fed from left to right.

❖The various types of surfaces and planes in metal cutting arc explained below , in which the basic turning process is shown. The three types of surfaces are :

1. The work surface, from which the material is cut
2. The machined surface which is formed or generated after removing the chip.
3. The cutting surface which is formed by the side cutting edge of the tool.



Left and Right Cut Tools.

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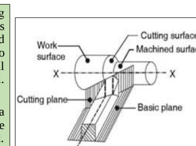
Single Point Cutting Tool

The references from which the tool angles are specified are the "cutting plane" and the "basic plane" or the "principal plane'. The cutting plane is the plane tangent to the cutting surface and passing through and containing the side cutting edge. The basic plane is the plane parallel to the longitudinal and cross feeds, that is, this plane lies along and normal to the longitudinal axis of the Guting surface. workpiece. In a lathe tool. the basic plane coincides with the base of the tool.

Designation of Cutting Tools. By designation or nomenclature of a cutting tool meant the designation of the shape of the cutting part of the tool. The two systems to designate the tool shape, which are widely used. Are

1. American Standards Association System (ASA) or American National Standards Institute (ANSI).
2. Orthogonal Rake System (ORS).



Principal Surfaces and Planes in Metal Cutting.

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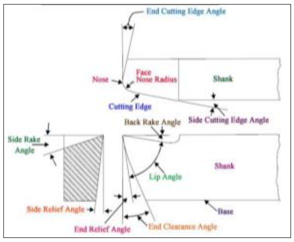
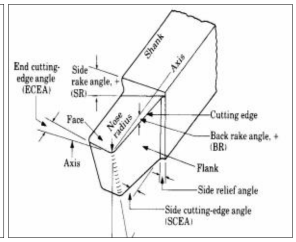
Angles in Single Point Cutting Tool





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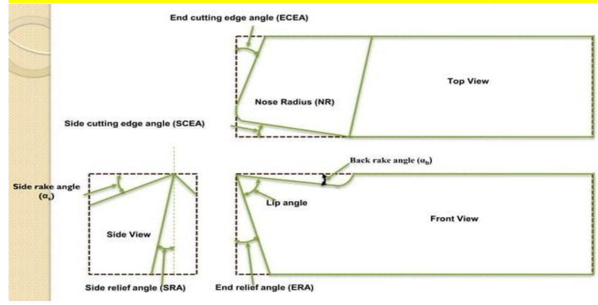
Importance of Angles in Single Point Cutting Tool



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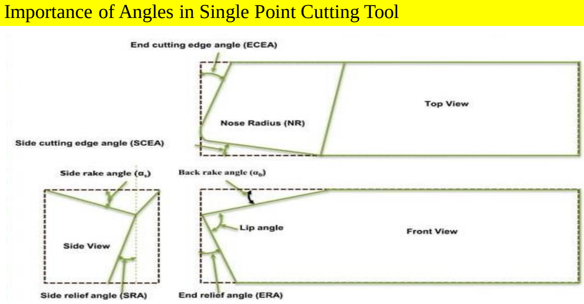
Importance of Angles in Single Point Cutting Tool



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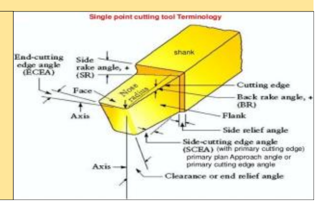
Rack Angle

- Side rake angle and Back rake angle combine to form the effective rake angle.
- It also called true rake angle.
- It has two major function.

1. Its influence on tool strength.
   -Negative rake angle increase strength
2. Its influence on cutting pressure.
   -Positive rake angle reduce cutting force by allowing chips to flow freely



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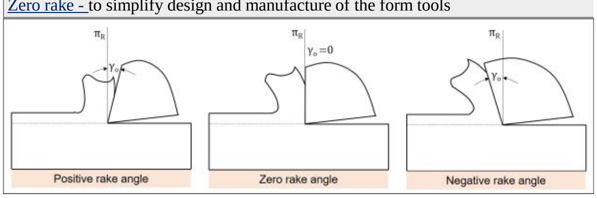
Rake angle is provided for ease of chip flow and overall machining.
Rake angle may be positive, or negative or even zero.
Positive rake - helps reduce cutting force and thus cutting power requirement.
Negative rake - to increase edge-strength and life of the tool (eg. carbide tools)
Zero rake - to simplify design and manufacture of the form tools



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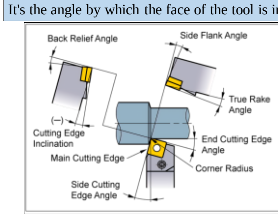
Back Rack Angle

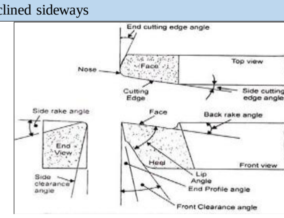
It's the angle between the face of the tool and line parallel to base of shank in a plane parallel to the side cutting edge

It affects the ability of the tool to shear the work and form a chip.

Side Rack Angle

It's the angle by which the face of the tool is inclined sideways





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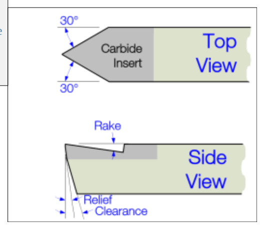
Relief Angle

- It minimize rubbing contact between machined surface.
- It helps to eliminate tool brakeage and increase tool life.
- Small angle for machining hard material
- It prevents side flank of tool fro1n rubbing against the work.
- Increase tool life for same depth of cut cutting force distributed on wide su1face.
- It prevents side flank of tool from rubbing against the work.
- It dissipated heat quickly for having wider cutting edge.



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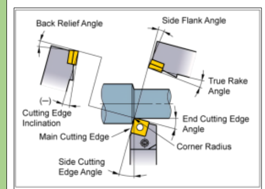
Side Cutting Edge Angle

- The following are the advantages of increasing this angle:
- It increases tool life as, for the same depth of cut; the cutting force is distributed on a wider surface.
- It diminishes the chip thickness for the same amount of feed and permits greater cutting speed.
- It dissipates heat quickly for having wider cutting edge.
- The side cutting edge angle of the tool has practically no effect on the value of cutting force or power consumed for a given depth of cut & feed.
- Large side cutting edge angles are likely to cause the tool to chatter.



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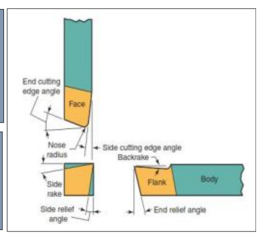
End Cutting Edge Angle

- It prevents front cutting edge of tool from rubbing against the work.
- Large end cutting edge angle unnecessarily weakens of tool.
- 8-15 degrees.

Nose Radius

- Grater nose radius provide better surface finish.
- All finish tool have grater nose radius than rough tool.
- Accumulated heat is less than pointed tool.
- which permits higher speed Increase tool life.



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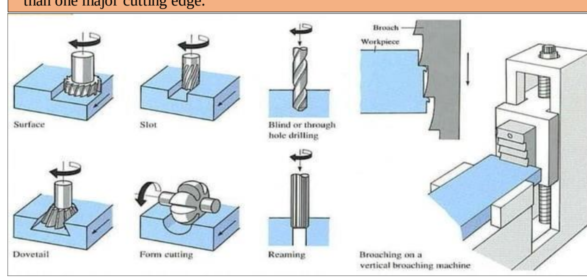
Multi-point cutting tool

- Removal of the metal from the workpiece by means of cutting tools which have more than one major cutting edge.



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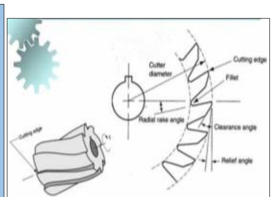
Multi-point cutting tool

- Multiple-point cutting tools comprise a series of single-point tools mounted in or integral with a holder or body and operated in such a manner that all the teeth (tools) follow essentially the same path across the workpiece.
- The cutting edges may be straight or in the form of various contours to be reproduced on the workpiece. Multiple-point tools may be either linear travel or rotary. With linear travel tools, the relative motion between the tool and workpiece is along a straight-line path.
- The teeth of rotary cutting tools revolve about the tool axis. The relative motion between the workpiece and a rotary cutting tool may be either axial or in a plane normal to the tool axis.
- In some cases, a combination of the two motions is used. Certain form-generating tools involve a combination of linear travel and rotary motions.



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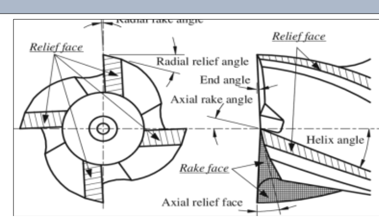
- Whether a cutting tool is single-point or one component of a milling cutter, various angles must provide the most efficient cutting action.
- Theoretical considerations may dictate larger angles, but actual cutting experience may dictate smaller angles for greater tool strength without chatter.
- Advantages from increasing any angle always must be considered together with its effect on tool strength.



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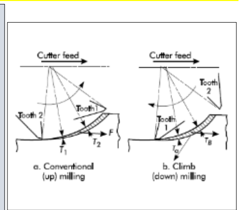
Cutting Processes in Multi-point Cutting tool

- ➢Cutting processes for multiple-point tools are similar to those for single-point tools. Linear travel tools produce a series of chips similar to those produced by single-point tools on planning cuts.
- ➢Milling cutters produce chips that vary in thickness because of the nature of the tooth path. The chips produced by axial-feed tools tend to be conical because varying diameters across the cutting-edge cause different portions of the cutting edge to travel discrete distances.
- ➢Aside from these differences, studies have shown no fundamental difference between the metal-formation processes involved in forming chips using these tools or single-point tools on turning or planning cuts.



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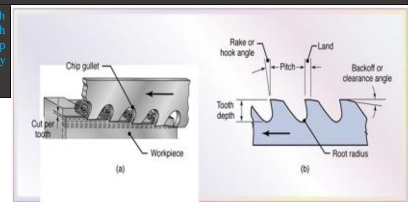
Broaches

- The most common multiple-point, linear travel tool is the broach. Broaches are used for producing either external or internal surfaces.
- The surfaces produced may be flat, circular, or of an intricate profile, as viewed in a section normal to tool travel. A broach is essentially a series of single-point tools following each other in the axial direction along a tool body or holder.
- Successive teeth vary in size or shape in such a manner that each following tooth will cut a chip of the proper thickness.
- The spacing and shape of broach teeth are determined by the length of the workpiece and the chip thickness per tooth, as well as by the type of chips formed.



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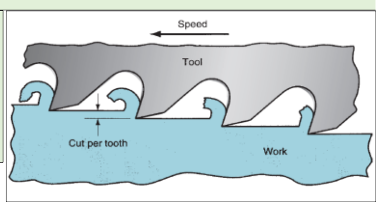
- The chip space between the broach teeth must be sufficient to take care of the volume of chips generated. Broach teeth are provided with rake and relief angles in the same manner as other cutting tools.
- Standard broaching nomenclature designates the rake angle as the face angle and the relief clearance as the back-off angle.
- Broaches are commonly made of HSS as solid units, but carbide-tipped and inserted-blade broaches are sometimes economical.

- This is particularly true in the case of surface broaches, which are better adapted to mounting carbide indexable inserts.
- Broaches can be used to cut helical internal forms if the broaching machine is equipped to rotate the broach at the proper lead rate as it passes through the work.



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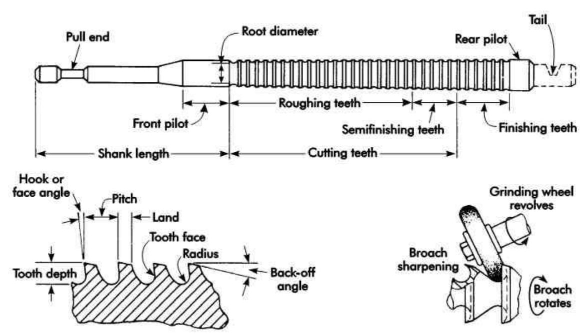

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The procedure for broaching with keyway sets or individual keyway broaches is as follows:

- ➢Select the right bushing for the bore (sizes are plainly marked) and insert in the bore of work.
- ➢Insert broach (which is also plainly marked for size) for the desired width of the keyway into the bushing slot and check alignment.
- ➢Place this assembly in the press.
- ➢Lubricate.
- ➢Push broach through.
- ➢Clean broach.
- ➢Insert shims as required to obtain the exact keyway depth.

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Drills and Related Tools

- The production, enlargement, or recontouring of a hole takes place in drilling and its related processes. Either a rotating cutter and fixed workpiece, or a rotating workpiece and fixed cutter, can be used to produce a chip that is formed and removed from the workpiece.

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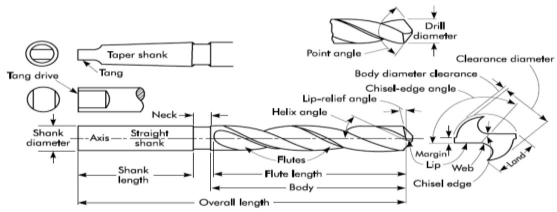
Twist Drills

- In its most basic form, a twist drill is made from a round bar of tool material. It has a pair of helical flutes that form the cutting surfaces and act as chip conveyors. Relief is provided behind the two cutting edges or lips. The intersection of the two relief surfaces across the web between the two flutes is known as the *chisel edge.*
- The lands between the flutes are cut away to a narrow margin to reduce the area of contact between the lands and the wall of the hole and/or guide bushing. The metal cut away forms the margin known as the *body diameter clearance.*



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Reamers and Core Drills

- Twist drills produce holes; core drills and reamers are hole-enlarging and finishing tools. The cutting ends of these tools have relieved chamfers that extend to a small enough diameter to permit their entry into the hole being enlarged or finished.
- Core drills are designed principally to enlarge existing holes, and provide a greater degree of accuracy and better finish than a two-fluted twist drill. These tools usually have three or four moderately deep helical flutes. The lands between the flutes are given body diameter clearance to produce a margin similar to that on a twist drill.
- Reamers are designed principally for hole sizing where only a moderate amount of stock is to be removed from the hole walls. The stock is removed by a larger number of flutes than are common with drills.
- Reamed holes usually have superior accuracy and finish. Because of the greater number of flutes and cutting edges, the margins on reamers are much narrower than those on twist drills and core drills, which minimizes galling of the margins.
- Reamers have little or no starting taper, which improves their ability to accept guidance from bushings. The flutes on reamers may be either straight or helical, depending on the type of work to be finished.
- Solid, HSS construction of reamers is most common, but carbide-tipped and solid carbide reamers are available in certain sizes and styles.

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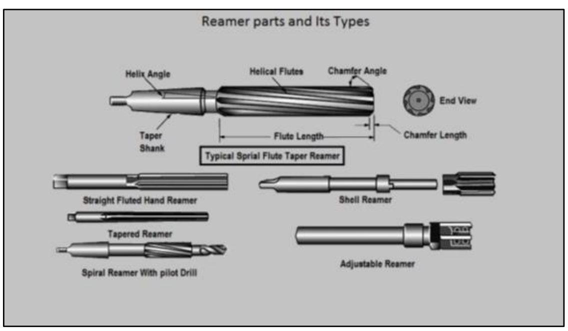

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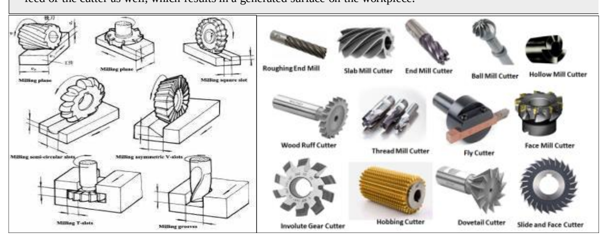
Milling Cutters

- *Milling cutters* are cylindrical cutting tools with cutting teeth spaced around the periphery.
- *Figure* showed the basic tooth angles of a solid plain milling cutter.
- A workpiece is traversed under the cutter in such a manner that the feed of the workpiece is measured in a plane perpendicular to the cutter axis. The workpiece is plunged radially into the cutter, and sometimes there is an axial feed of the cutter as well, which results in a generated surface on the workpiece.



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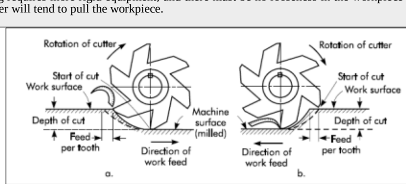
- Milling-cutter teeth intermittently engage the workpiece, and chip thickness is determined by the motion of the workpiece, number of teeth in the cutter, rotational speed of the cutter, cutter lead angle, and overhang of the cutter on the workpiece.
- There are two modes of operation for milling cutters. In conventional (up) milling, the workpiece motion opposes the rotation of the cutter, while in climb (down) milling, the rotational and feed motions are in the same direction.
- Climb milling is preferred wherever it can be used, since it provides a more favorable metal-cutting action and generally yields a better surface finish.
- Climb milling requires more rigid equipment, and there must be no looseness in the workpiece feeding mechanism since the cutter will tend to pull the workpiece.



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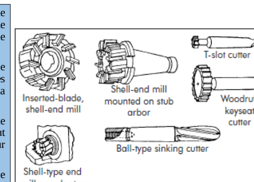
End Mills

- End mills are shank-type milling cutters usually designed with some form of relieved end teeth. This construction enables them to do some end cutting, but the majority of the cutting takes place on the periphery.
- Indexable end mills generally use radius corner inserts, but can be furnished with parallel land wiper inserts for generating finishes down to 50µin. (1 µm). End mills are usually considered to be in a separate category from other milling cutters.
- High-speed-steel end mills have helical flutes with a flute helix angle between 20° and 40°. Flutes are usually several diameters long, but longer and shorter designs are available. Tools with two and four flutes are most common—larger sizes are available with more flutes.
- Most two flute end mills have end teeth that extend from the periphery to the center of the tool. This permits their use as drills to sink into depth before starting a cut.



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DESIGN OF FORMING TOOLS

INTRODUCTION

- Forming a tool or die or designing a forming tool is one of vital factor of tool engineering, which must be known by every design engineer. Forming a tool means giving a particular and useful shape with required dimensions to the part.
- The part formed by forming operation is generally takes the shape of the die or punch. In the forming operation, the metal flow is not uniform and localized to some extent, depending upon the shape of the Workpiece.
- Bending along a large radius in a straight line may also be referred to as a forming operation.
- It is difficult to distinguish between a bending and forming tools. Forming operation may be simple and extremely complicated.

PURPOSE OF FORMING TOOLS

- A form tool is defined as a cutting tool having one or more cutting edges with well defined profile or contour that is reproduced as the desired form on the workpiece surface.
- Forming tools serve a crucial role in various manufacturing processes, particularly in industries such as metalworking, plastic processing, and ceramics. The main purpose of forming tools is to shape and transform raw materials into desired products or components. These tools are designed to exert pressure or force on the material, causing it to undergo deformation and take on the desired shape. The specific purposes of forming tools include:
- Shaping: Forming tools are used to shape materials into specific geometries. For example, metal forming tools can bend, stretch, or compress metal sheets to create various components like car body panels or household appliances.
- Precision: Forming tools enable manufacturers to achieve precise and consistent shapes, ensuring uniformity and quality in the final products.
- Mass production: With the use of forming tools, manufacturers can produce large quantities of components rapidly and efficiently, allowing for cost-effective mass production.
- Waste reduction: Forming processes often generate less waste compared to other methods, making them more environmentally friendly and economically advantageous.
- Flexibility: Different types of forming tools can be used for a wide range of materials and applications, offering flexibility in manufacturing various products.

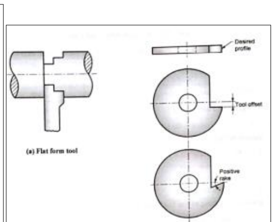
VARIOUS TYPES OF FORMING TOOLS

1. **Flat Form Tool**

   Straight and flat form tools have a square or rectangular cross-section with the form being along the side or end. These tools are similar in appearance to the turning tools. These are usually set centrally so that they will cut their contour which is identical to the desired contoured of the workpiece. A typical example of V-notch tool is shown in Figure. This type of tool is suitable for making deep straight-sided form grooves. The cutting is restricted type due to the mixed chip flow. Because of the existence of the good surface finish, this type of tool must be operated at very low cutting speed.

2. **Circular Form Tool**

   The circular form tool is circular in shape. It has depth x or projection of distance x produced all around the diameter in the form of annular grooves. The outside diameter of circular form tool is determined in accordance with the height of profile to be turned. The graphical method is recommended for this purpose. Circular form tool is shown in Figure



(a) Flat form tool

(b) Circular form tool