# MACHINING PROCESSES

# Machining – Purpose, Principle and Definition

## (a) Purpose of Machining

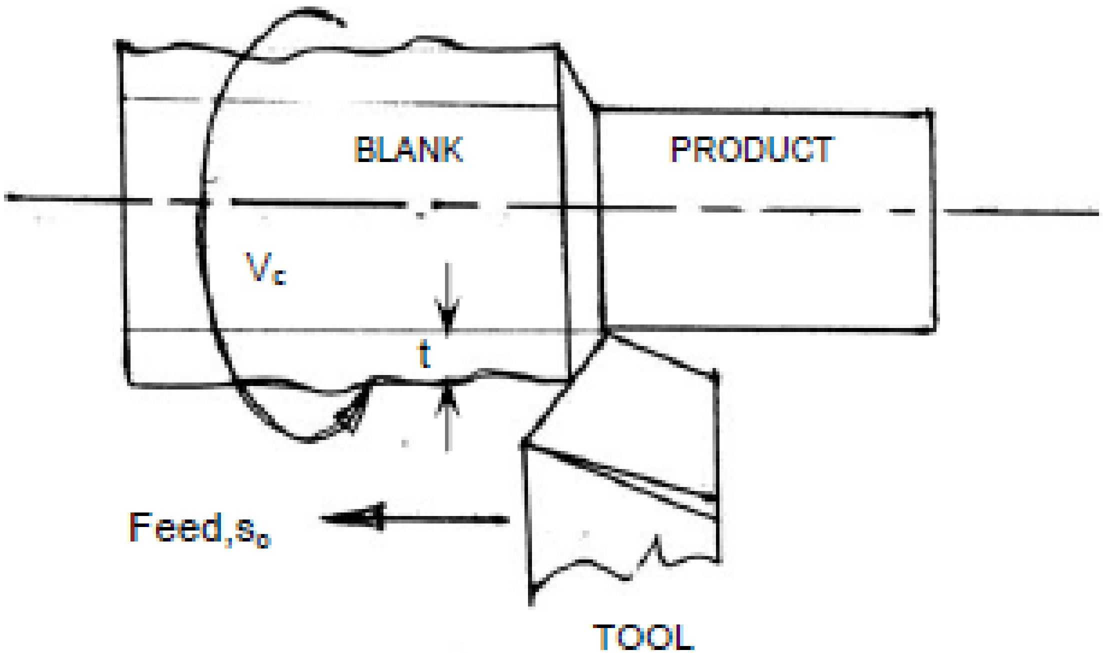
Most of the engineering components such as gears, bearings, clutches, tools, screws and nuts etc. need dimensional and form accuracy and good surface finish for serving their purposes.

Preforming like casting, forging etc. generally cannot provide the desired accuracy and finish. For that such preformed parts, called blanks, need semi-finishing and finishing and it is done by machining and grinding. Grinding is also basically a machining process.

- Machining to high accuracy and finish essentially enables a product
  - fulfill its functional requirements
  - improve its performance
  - prolong its service

**(b) Principle of Machining**

The basic principle of machining is typically illustrated in Fig.



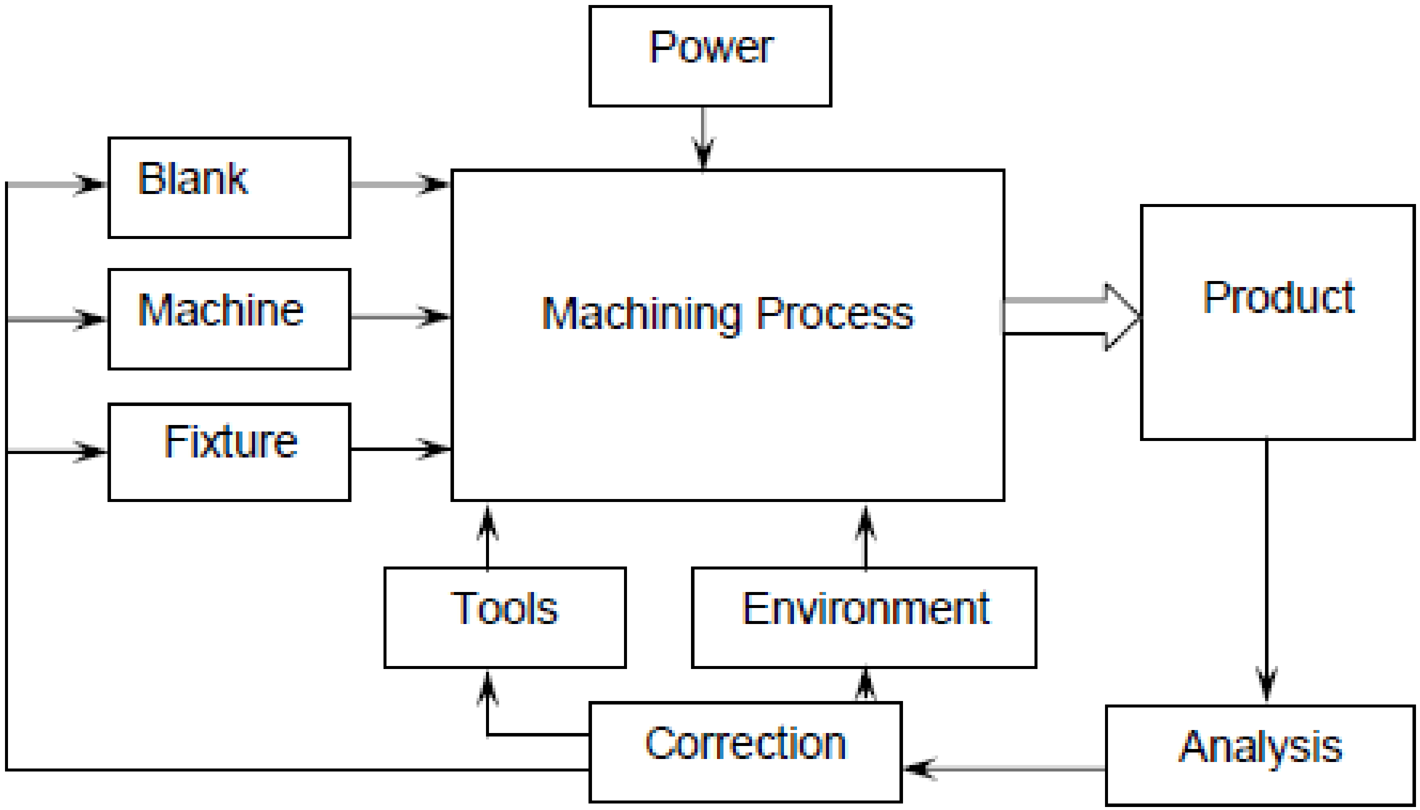

*Principle of machining (turning)*

A metal rod of irregular shape, size and surface is converted into a finished rod of desired dimension and surface by machining by proper relative motions of the tool-work pair.

**(c) Definition of Machining:** Machining is an essential process of finishing by which jobs are produced to the desired dimensions and surface finish by gradually removing the excess material from the preformed blank in the form of chips with the help of cutting tool(s) moved past the work surface(s).

## Machining requirements

The essential basic requirements for machining work are schematically illustrated in Fig.



- The blank and the cutting tool are properly mounted (in fixtures) and moved in a powerful device called machine tool enabling gradual removal of layer of material from the work surface resulting in its desired dimensions and surface finish.
- Additionally some environment called cutting fluid is generally used to ease machining by cooling and lubrication.

# Basic functions of Machine Tools

Machine Tools basically produce geometrical surfaces like flat, cylindrical or any contour on the preformed blanks by machining work with the help of cutting tools.

The physical functions of a Machine Tool in machining are:

- firmly holding the blank and the tool
- transmit motions to the tool and the blank
- provide power to the tool-work pair for the machining action.
- control of the machining parameters, i.e., speed, feed and depth of cut.

## Machine Tool - definition

A machine tool is a non-portable power operated and reasonably valued device or system of devices in which energy is expended to produce jobs of desired size, shape and surface finish by removing excess material from the preformed blanks in the form of chips with the help of cutting tools moved past the work surface(s).

Both material and geometry of the cutting tools play very important roles on their performances in achieving effectiveness, efficiency and overall economy of machining.

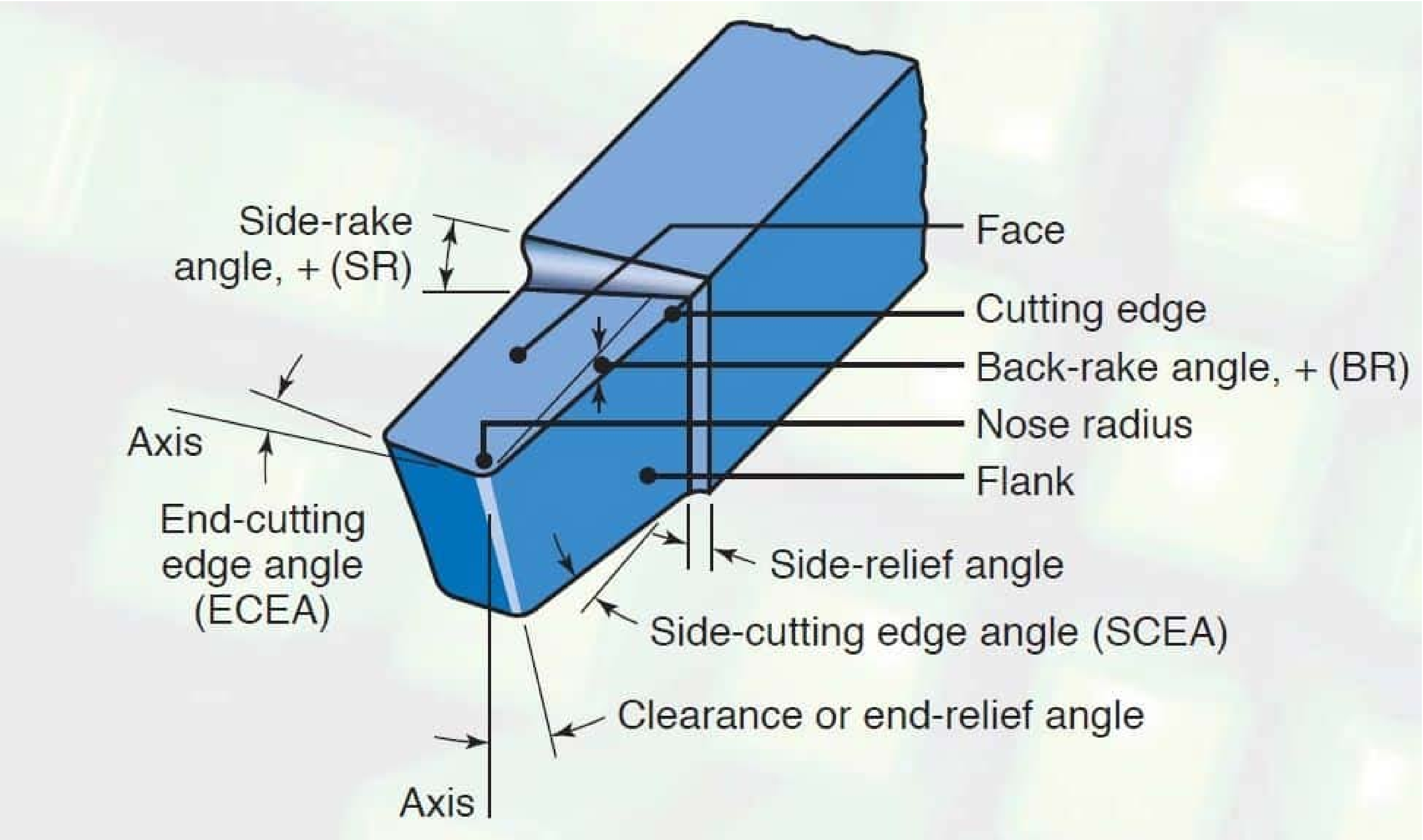
***<u>Cutting tools may be classified according to the number of major cutting edges (points) involved as follows:</u>***

- Single point: e.g., turning tools, shaping, planning and slotting tools and boring tools

- Double (two) point: e.g., drills

- Multipoint (more than two): e.g., milling cutters, broaching tools, hobs, gear shaping cutters etc.

# Single Point Cutting Tool

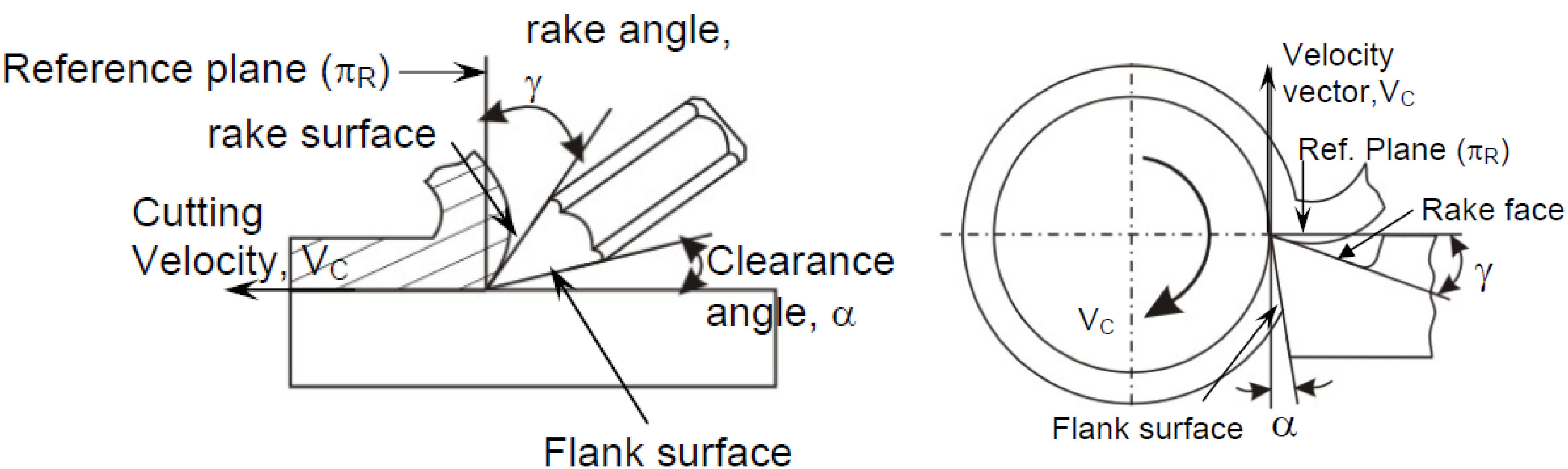


# Geometry of single point turning tools

**(i) Concept of rake and clearance angles of cutting tools.**

The word tool geometry is basically referred to some specific angles or slope of the salient faces and edges of the tools at their cutting point. Rake angle and clearance angle are the most significant for all the cutting tools.

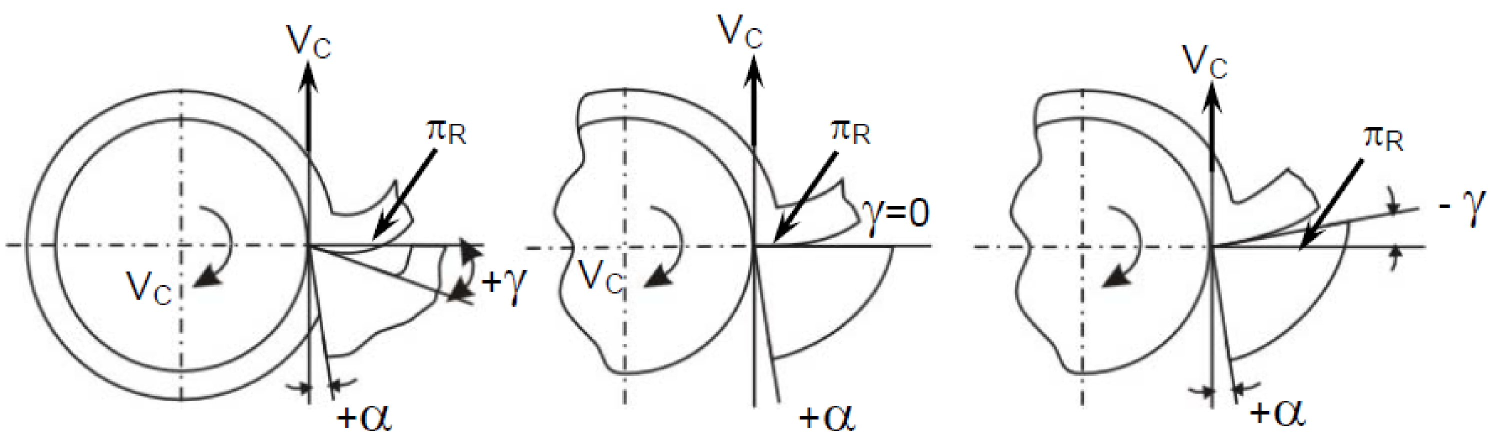
The concept of rake angle and clearance angle will be clear from some simple operations shown in Fig.



Definition –

- Rake angle (γ): Angle of inclination of rake surface from reference plane
- clearance angle (α): Angle of inclination of clearance or flank surface from the finished surface

Rake angle is provided for ease of chip flow and overall machining. Rake angle may be positive, or negative or even zero as shown in Fig.



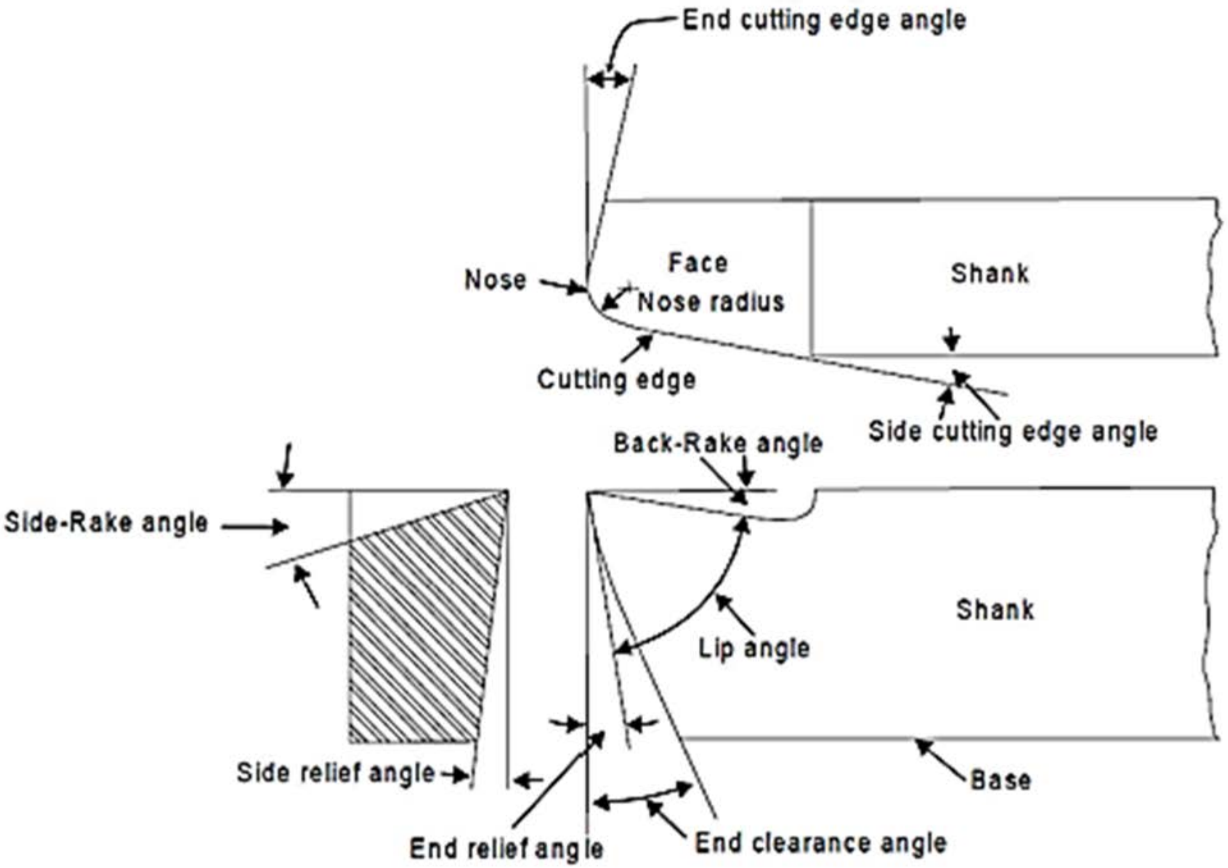

(a) positive rake (b) zero rake (c) negative rake

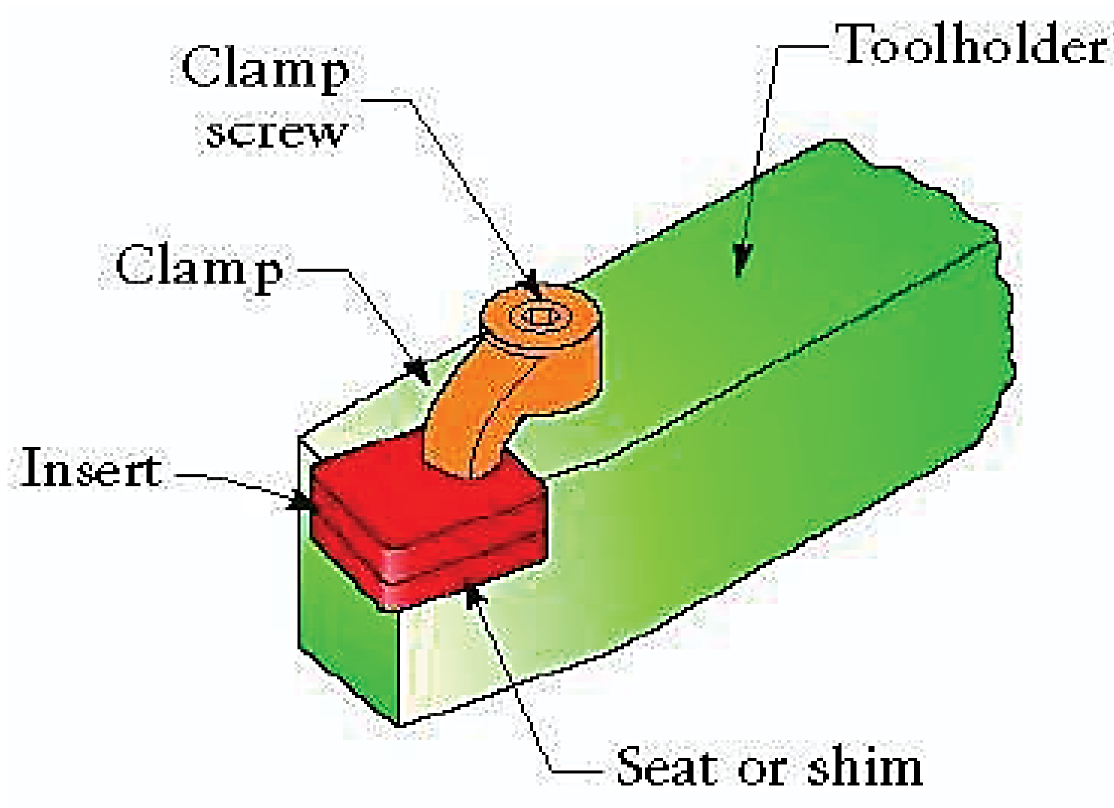
Relative advantages of such rake angles are:

- Positive rake – helps reduce cutting force and thus cutting power requirement.
- Negative rake – to increase edge-strength and life of the tool
- Zero rake – to simplify design and manufacture of the form tools.

Clearance angle is essentially provided to avoid rubbing of the tool (flank) with the machined surface which causes loss of energy and damages of both the tool and the job surface. Hence, clearance angle is a must and must be positive ($3^o \sim 15^o$ depending upon tool-work materials and type of the machining operations like turning, drilling, boring etc.)

# Tool Geometry

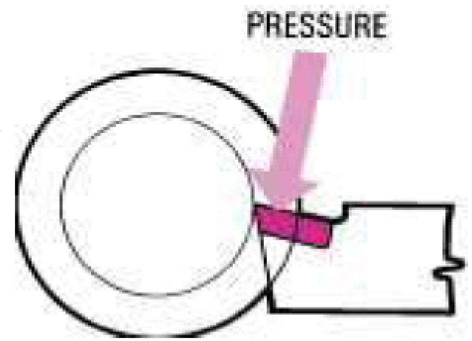



Toolholder
Clamp
screw
Clamp
Insert
Seat or shim

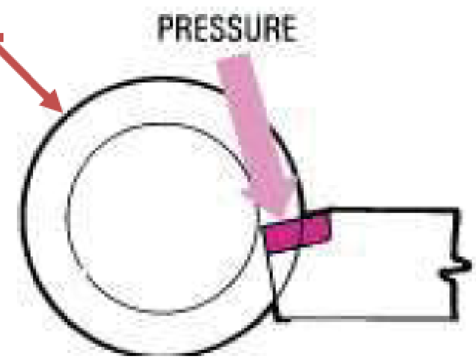
# Back Rake

Angle formed between top face of tool and top of tool shank. This angle helps in removing the chips away from the work piece.

- Positive
  - Top face slopes downward away from point
    *slope face is upward toward the nose*




- Negative
  - Top face slopes upward  away from point
    *slope face is downward toward the nose*




- Neutral

## Side rake angle

- It is the angle by which the face of the tool is inclined side ways.
- This angle of tool determines the thickness of the tool behind the side cutting edge.

## The Rake Angle:

- The rake angle is always at the topside of the tool.
- The side rake angle and the back rake angle combine to form the effective rake angle.
- This is also called true rake angle or resultant rake angle of the tool.
- The basic tool geometry is determined by the rake angle of the tool.

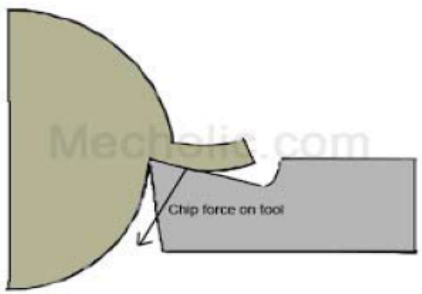
## Rake angle has two major effects during the metal cutting process.

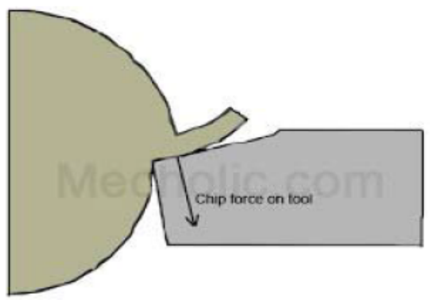
i. Its influence on tool strength. A tool with negative rake will withstand far more loading than a tool with positive rake.

ii. Its influence on cutting pressure. A tool with a positive rake angle reduces cutting forces by allowing the chips to flow more freely across the rake surface.

## Functions of rake angle:

- It allows the chip to flow in convenient direction.
- It reduces the cutting force required to shear the metal and consequently helps to increase the tool life and reduce the power consumption.
- It improves the surface finish.




**Generally, positive rake angles:**

- Make the tool more sharp and pointed.
- Reduces the strength of the tool, as the small included angle in the tip may cause it to chip away.
- Reduce cutting forces and power requirements.
- Helps in the formation of continuous chips in ductile materials.
- Can help avoid the formation of a built-up edge.

**Negative rake angles, by contrast:**

- Make the tool more blunt,
- Increasing the strength of the cutting edge.
- Increase the cutting forces.
- Can increase friction, resulting in higher temperatures.
- Can improve surface finish.

- A positive rake makes the tool tip comparatively sharper by reducing wedge angle, and thus shearing action occurs smoothly during machining.
- However, due to lower wedge angle, strength of tool tip reduces and consequently tool becomes vulnerable under severe cutting temperature and impact loading.

**Advantages of positive rake angle**

- ***Reduced shear strain***—Higher the value of positive rake angle lower will be the shear strain. Lower shear strain in machining indicates less energy requirement for shearing.
- ***Low power consumption***—Due to lower wedge angle and reduced shear strain, cutting or shearing occurs easily with minimum effort. Thus higher feed rate or depth of cut can be utilized without much problem to enhance material removal rate (MRR) and productivity.
- **Low cutting force**—Due to less shear deformation of chip, Chip Reduction Coefficient (CRC) also reduces. This results in lower cutting force, which consequently eliminates detrimental effects of high force.
- **Lower tendency of built-up edge formation**—Built-up edge, forms on the rake surface of the cutting tool, breaks down quickly and flow away with chip if tool with positive rake angle is used.

Lower cutting temperature—Although heat generation in machining depends greatly on other factors, positive rake angle contributes in reducing heat generation during machining. This protects both the tool and job from detrimental effects of the severe cutting temperature.

- Favourable for continuous chip formation—Since shear deformation is low, so positive rake angle offers favourable condition for continuous chip formation, whichndicates better machinability

Disadvantages of positive rake angle

- Weak tool tip—As positive rake angle indicates lower wedge angle, so strength of tool tip reduces. Capability of the cutting tool to withstand higher cutting force and absorbing larger heat during machining also reduces. Thus higher speed, feed and depth of cut may not be applied.
- Lower tool life—Tools with positive rake angle reaches their life time quickly due to gradual wear, especially flank wear.

## Negative Rake

To provide greater strength at the cutting edge and better heat conductivity, zero or negative rake angles employed on carbide, ceramic, polycrystalline diamond, and poly crystalline cubic boron nitride cutting tools.

- These materials tend to be brittle but their ability to hold their superior hardness at high temperature results in their selection for high speed and continuous machining operation.
- Negative rakes are recommended on tool which does not possess good toughness (low transverse rupture strength)
- Negative rakes increases tool forces but it is necessary to provide added support to the cutting edge.
- This is particularly important in making intermittent cuts and in absorbing the impact during the initial engagement of the tool and work.
- Negative rake causes high compression, tool forces and friction, resulting in highly deformed , hot chip.