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CHAPTER THREE

FUNDAMENTALS OF METAL CUTTING

CONTENTS

2.1 Geometry of single point tool:

The chip removal process may be performed by cutting tools of definite geometry. These cutting tools can be classified as single point cutting tool, used in lathe, planer and, slotter and multi point cutting tool used in milling, drilling and broaching.

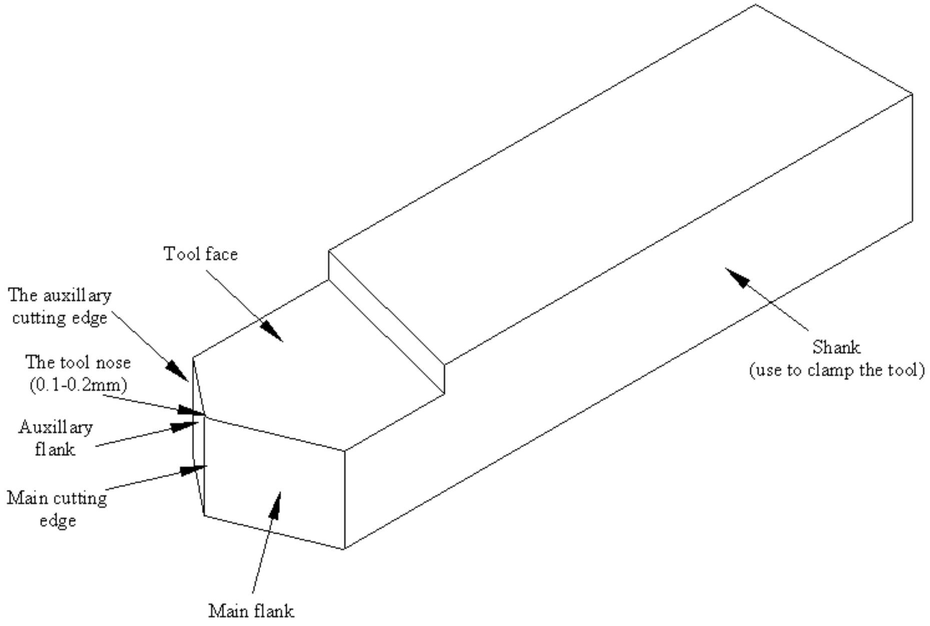
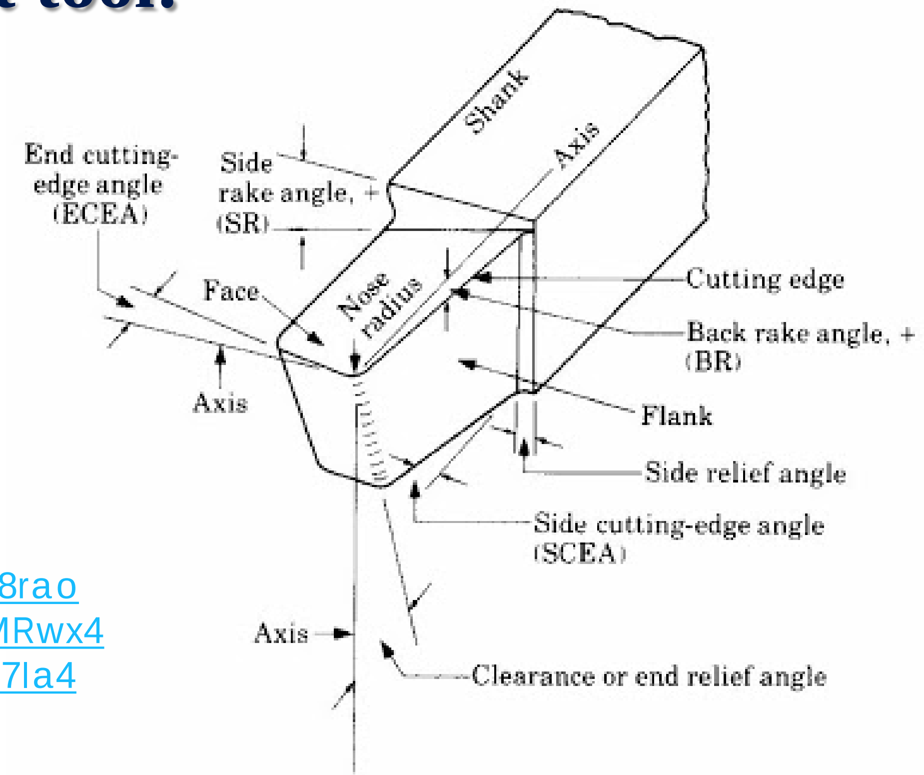
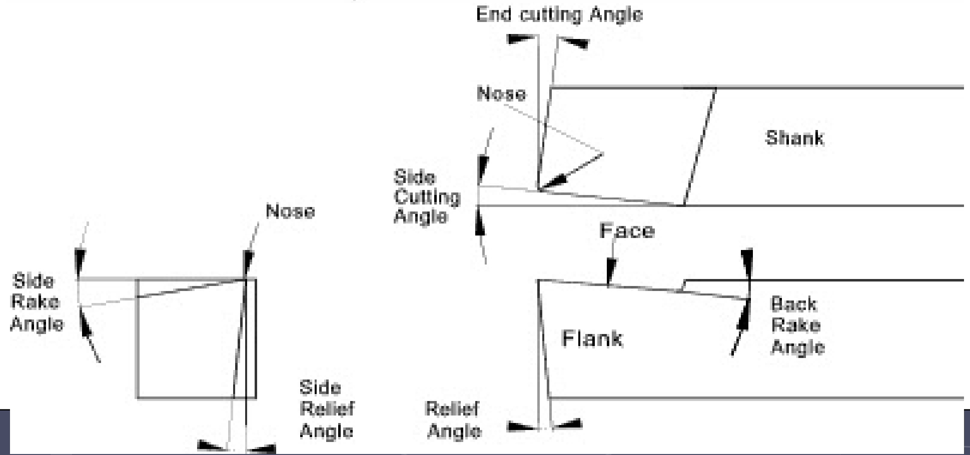


Figure 2.1: Nomenclature of a single point cutting tool

2.1 Geometry of single point tool:

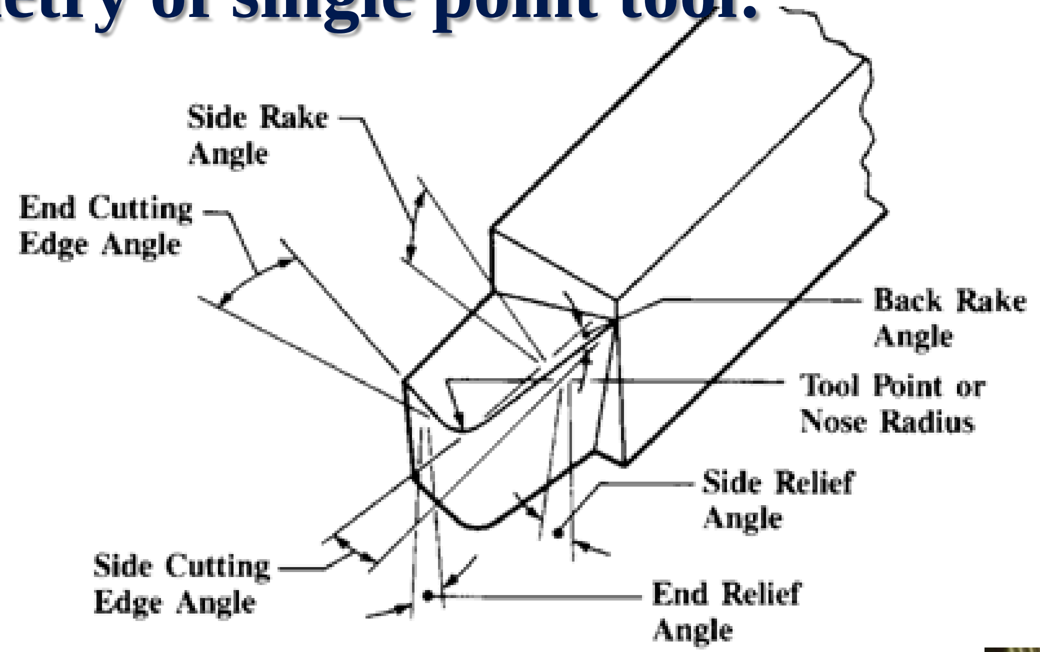


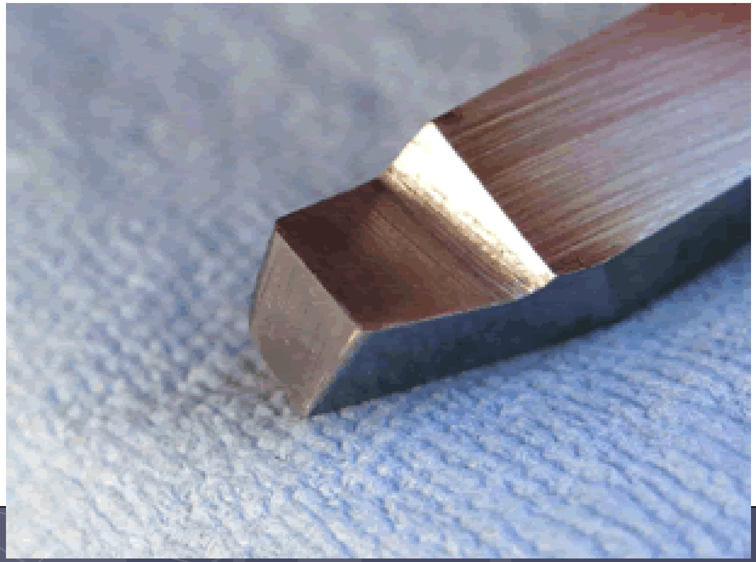


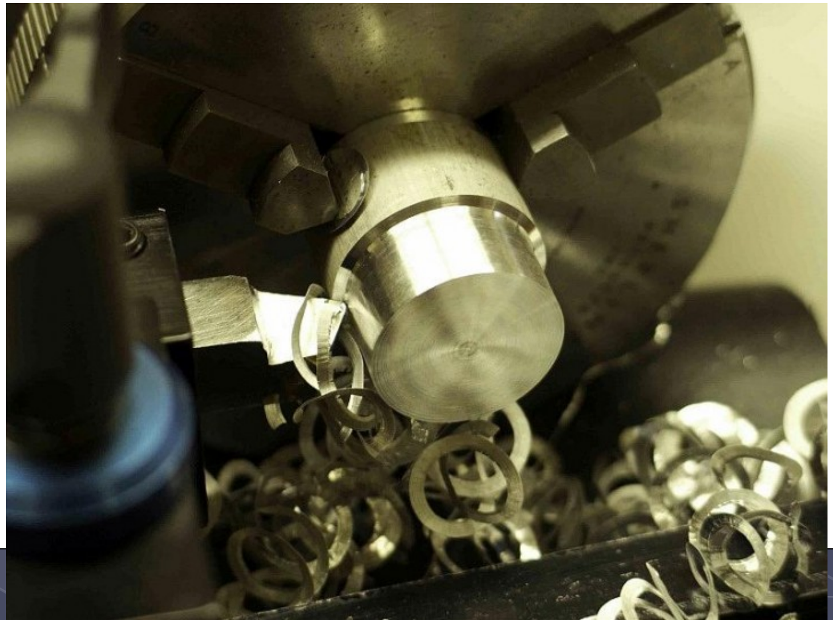
Useful links:

1. https://www.youtube.com/watch?v=Mn9jpqI8rao
2. https://www.youtube.com/watch?v=bUrp8JMRwx4
3. https://www.youtube.com/watch?v=J63dZsw7Ia4

2.1 Geometry of single point tool:

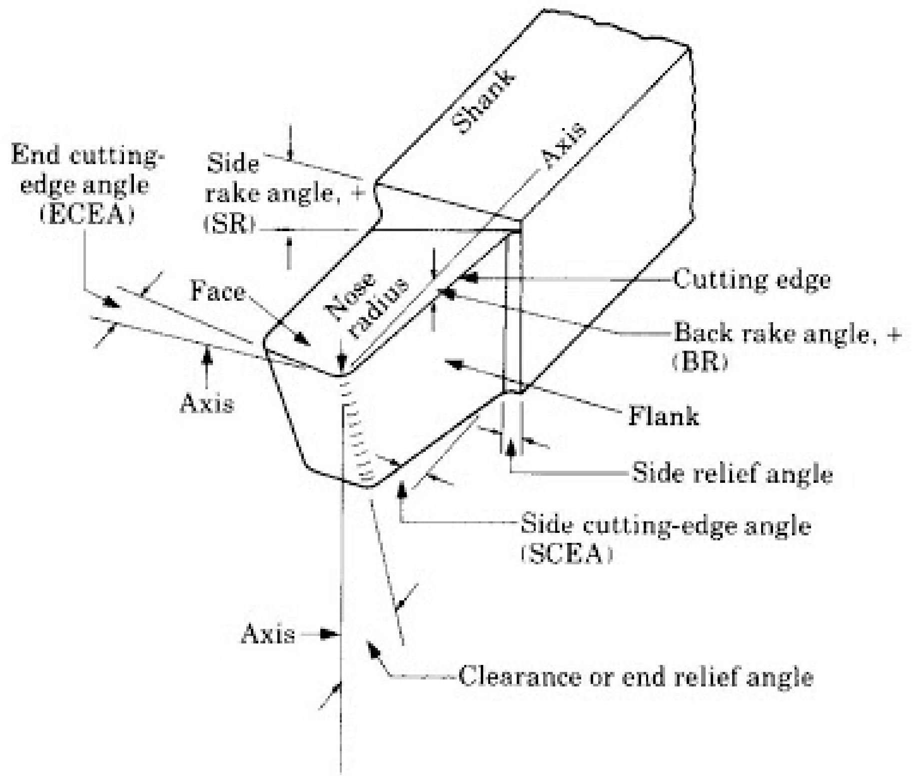




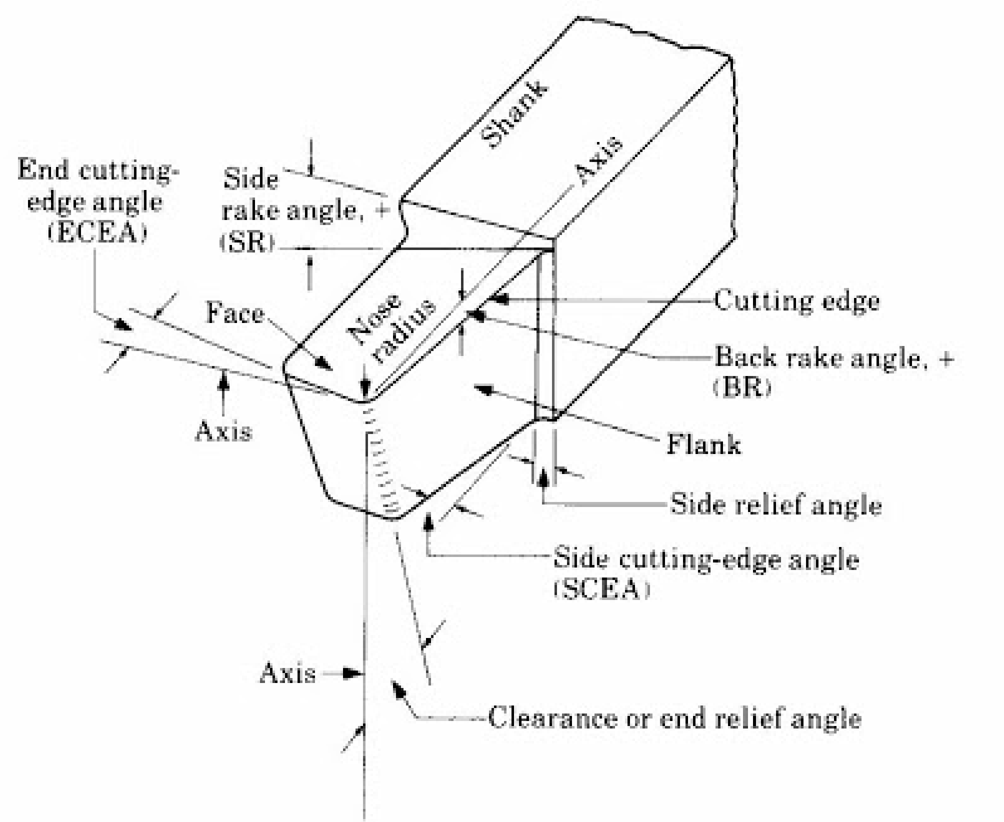


2.1 Geometry of single point tool:

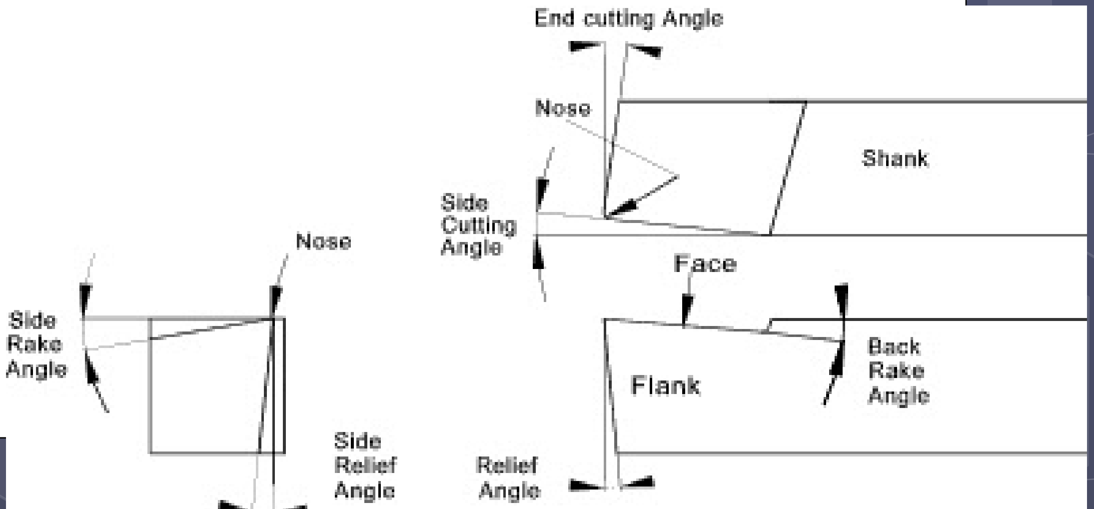
Shank: the shank is used as a tool holder. It is a main body of the tool. It is generally gripped in the tool frame.
Flank: It is a surface of the cutting edge or the surface adjacent to the cutting edge of the tool.
Face*:* It is the surface of the tool where the chip slides along the top of this surface.
Base*:* Base is a bearing surface of the tool. This base is held in a tool holder or it is directly clamped in the tool post.
Heel: Heel is an intersection to the flank and base of the cutting tool. It is a curved portion at the bottom of the tool.
Nose: This is a point where the base cutting edge and the side cutting edge gets intersected.
Cutting edges: It is a face edge on the face of the tool that removes the material from the work piece. There are two cutting edges as side cutting edge and end cutting edge, where the side cutting edge is major cutting edge and the end cutting edge is minor cutting edge.
Tool angles: Tool angle splay a vital role in the tool cutting action. The tool that comes with proper angles will reduce failures as tool breaking due to high work forces on the work piece. The metal cutting is done more efficiently with generation of little heat.
Noise radius: The nose radius will provide long life and also good surface finish with it sharp point on the nose. It has high stress and leaves in its path of cut. Longer nose radius will give raise to chatter.



2.1 Geometry of single point tool:



Side cutting edge angle:
It is the angle in between the side cutting edge and the side of the tool shank. This angle is also referred as lead angle.
End cutting edge angle:
End cutting edge angle is in between the perpendicular line of the tool shank and the end cutting edge.
Side relief angle:
The portion of side flank that is immediate below to the side cutting edge and the base perpendicular line of the cutting tool.
End relief angle:
Relief angle is in between the base perpendicular line and end flank.
Back rake angle:
The angle measured along the plane perpendicular through the side cutting edge in between the tool face and the perpendicular line to the base.
Side rake angle:
The angle in between the parallel line of the base and the face of the tool that is measured it the plane perpendicular to the side edge and base.



2.1.1 Right cut tool:

A right cut tool is the tool in which the main cutting edge faces the headstock of the lathe, when the tool is clamped and in this case the tool cuts from right to left.

2.1.2 Left cut tool:

In this case the main cutting edge faces the tailstock of the lathe and consequently the tool cuts from left to right as shown in figure 2.2.

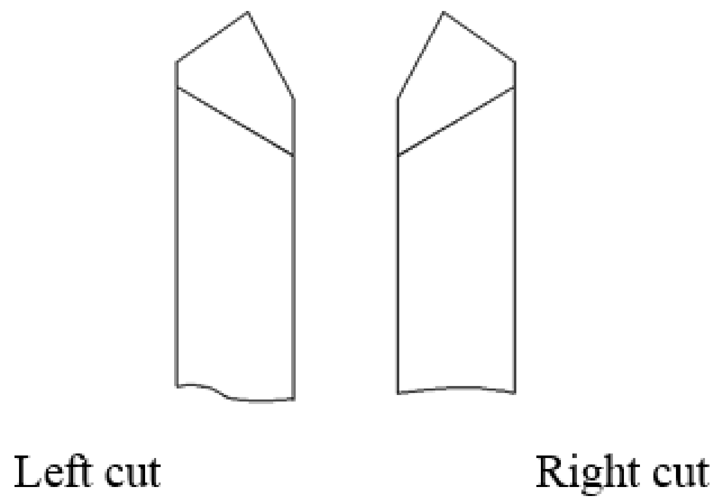


Figure 2.2: Two basic types of single point cutting tools

2.1.3 Tool planes:

To define the tool angles, some reference planes are suggested.

a-The basic plane:

Is the plane containing the tool base.

b-Auxiliary plane of main cutting edge:

Is the plane containing the main cutting edge and perpendicular to the basic plane.

c- Auxiliary plane perpendicular to the projection of main cutting edge:

It is the plane perpendicular to the projection of the main cutting edge and both planes mentioned above.

2.2 Tool angles:

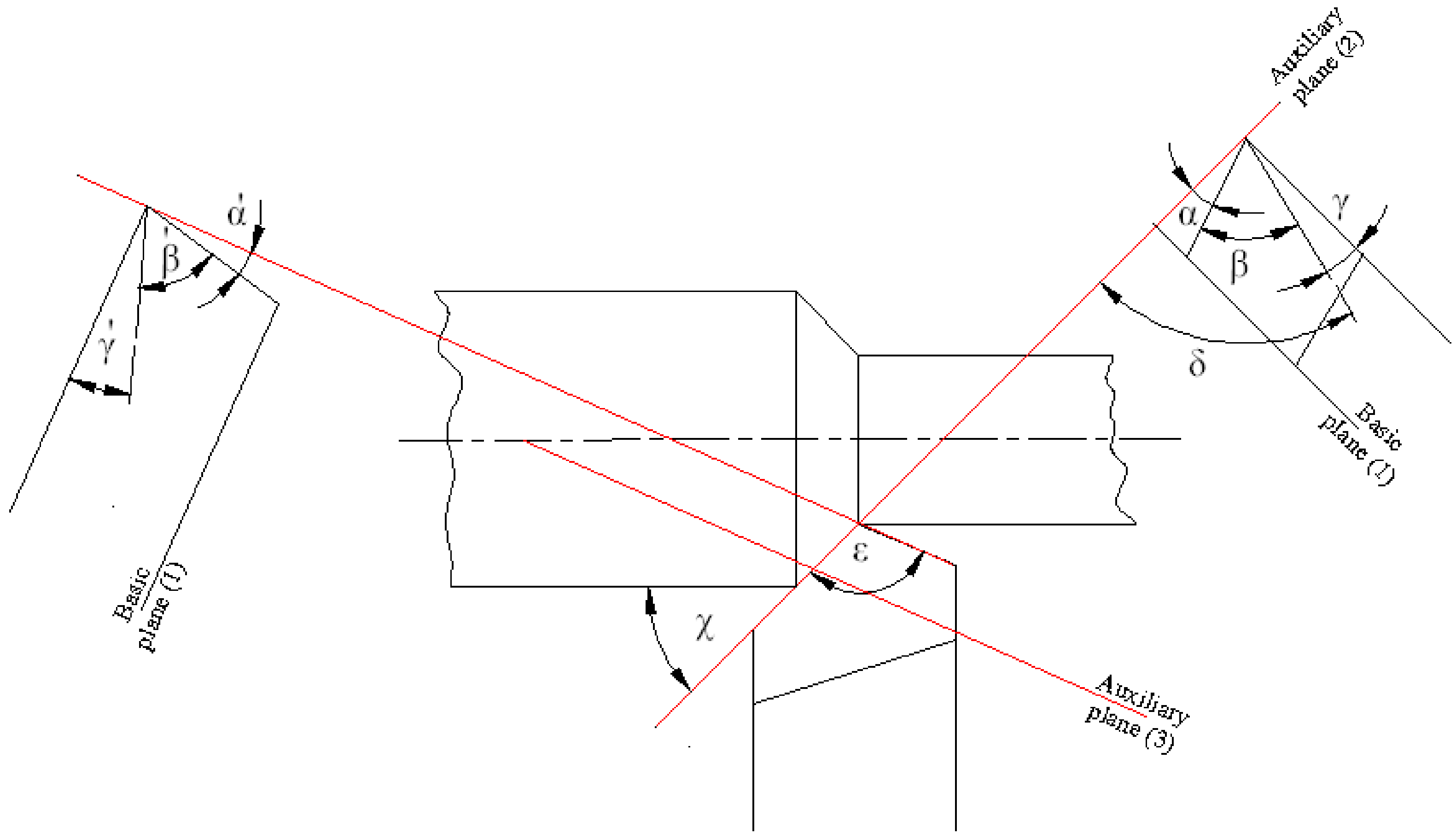


Figure 2.4: Single point cutting tool angles

2.2.1 Clearance angle α: It is the angle between the main flank and the auxiliary plane z, measured in the auxiliary plane c.

2.2.2 Wedge angle β: It is the angle between the tool face and the main flank, measured in the auxiliary plane c.

2.2.3 Rake angle γ: It is the angle between the tool face and a plane passing through the point of the intersection of the main cutting edge with auxiliary plane c and parallel to the basic plane a, it also measured in the auxiliary plane c.

2.2.4 Cutting angle δ: It is the sum of the clearance angle and wedge angle.

$$\delta = \alpha + \beta$$

According to the figure.

$$\alpha + \beta + \gamma = 90^\circ$$

2.2.5 Auxiliary angles

In addition to the above mentioned main angles, the single point tool has auxiliary angles, α’β’γ’

2.2.6 Nose angle ε

It is the angle included between the projections of the main and auxiliary cutting edges on the basic plane.

$$\alpha' + \beta' + \gamma' = 90^\circ$$

2.2.7 Setting angles χ

Generally the tool angles are chosen with respect to:

1. The material to be machined, negative rake for hard and brittle materials and positive for ductile materials.
2. The tool material.
3. The machining method.

2.3 Requirements of tool materials:

1. High hardness and high hot hardness
2. High wear resistance
3. High strength and toughness (impact resistance)
4. High thermal conductivity
5. Low cost

2.4 Common tool materials

1. **Tool carbon steels** (It contain 0.6 – 1.4 percent carbon and low percentages of Mn, Si, S, P, and heat treated, it withstand temperatures < 250°C)
2. **Alloy tool steels** (The cutting performance of steel can be improved by adding alloying elements such as chromium (Cr), vanadium (V), molybdenum (Mo) and tungsten (Tn). When these steels properly heat treated, they can work at temperatures up to 300°C.)
3. **High speed steels** (It contain 8 – 19% tungsten and 3.8 – 4.6% chromium. They can withstand temperatures up to 600°C)
4. **Cemented carbides**

2.4.4.1 Straight tungsten cemented carbide:

2.4.4.2 Titanium -Tungsten cemented carbides:

2.4.4.3 Titanium – Tantalum – Tungsten cemented carbides:

2.4.5 Ceramic tool materials

Ceramic materials are made by compacting followed by sintering of aluminum oxides at high temperature (1700°C). They are enable to machine all materials at very high cutting speeds with higher surface finish and no coolant is required.

2.4.6 Diamonds

Diamonds are the hardest materials; they can work up to 1500°C. It is found in nature or synthetically produced from ordinary graphite by subjecting it to extremely high pressures and temperatures.

2.4.7 Cubic Boron Nitride (CBN)

Cubic Boron Nitride is the hardest known material next to diamond. It is ment to transform the crystal structure of carbon from hexagonal to cubic.

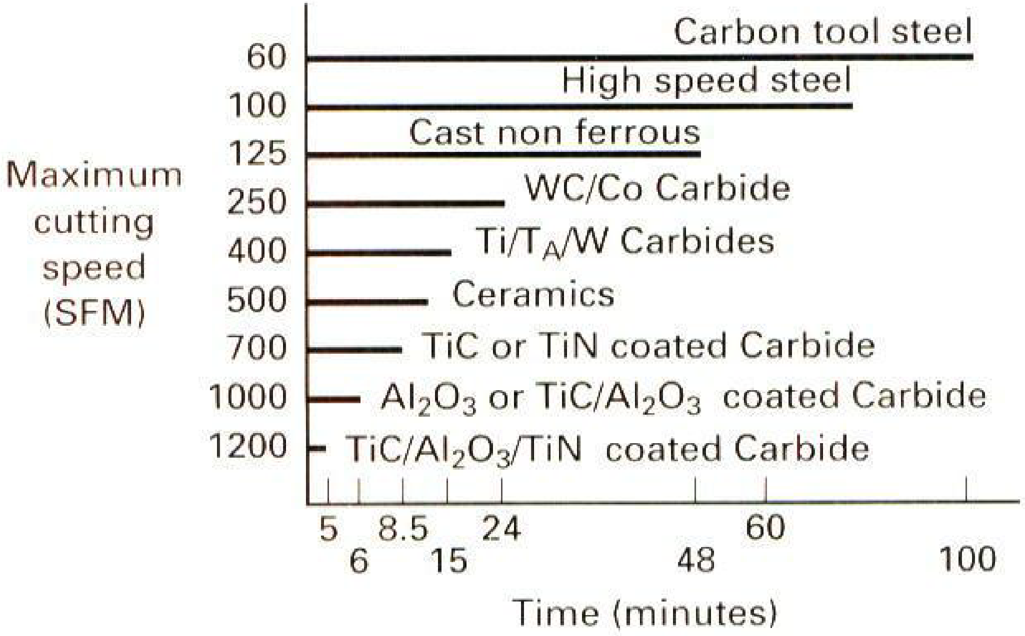


Figure 2.5: Improvement in cutting tool materials have reduced machining time

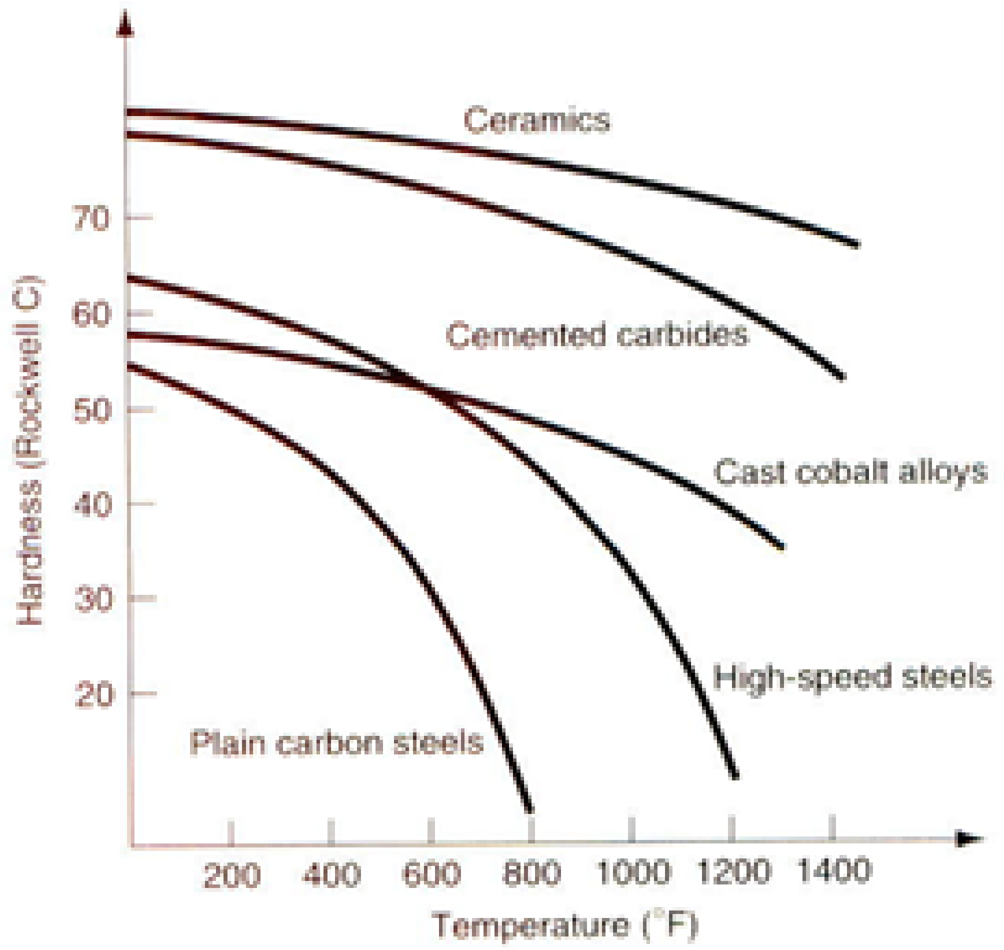


Figure 2.6: Typical hot hardness relationship for selected tool materials. Plain carbon steel shows a rapid loss of hardness as temperature increases, while cemented carbide and ceramics are significantly harder at elevated temperatures.

2.5 Methods of fixation of sintered carbides, ceramics & diamond tools

The cutting tools made from sintered carbides, ceramic and diamonds are available in the form of tips (inserts).

2.5.1 Mechanical clamping

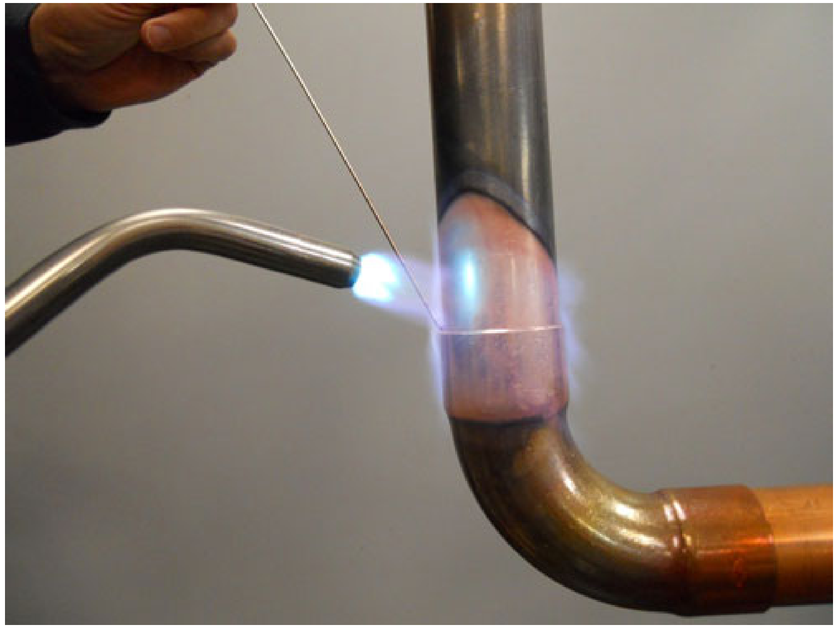
Mechanical clamping is used for cemented carbides, ceramics, and other hard materials. In this method the cemented carbide, ceramic, and diamond inserts clamped mechanically with the tool shank.

2.5.2 Brazing

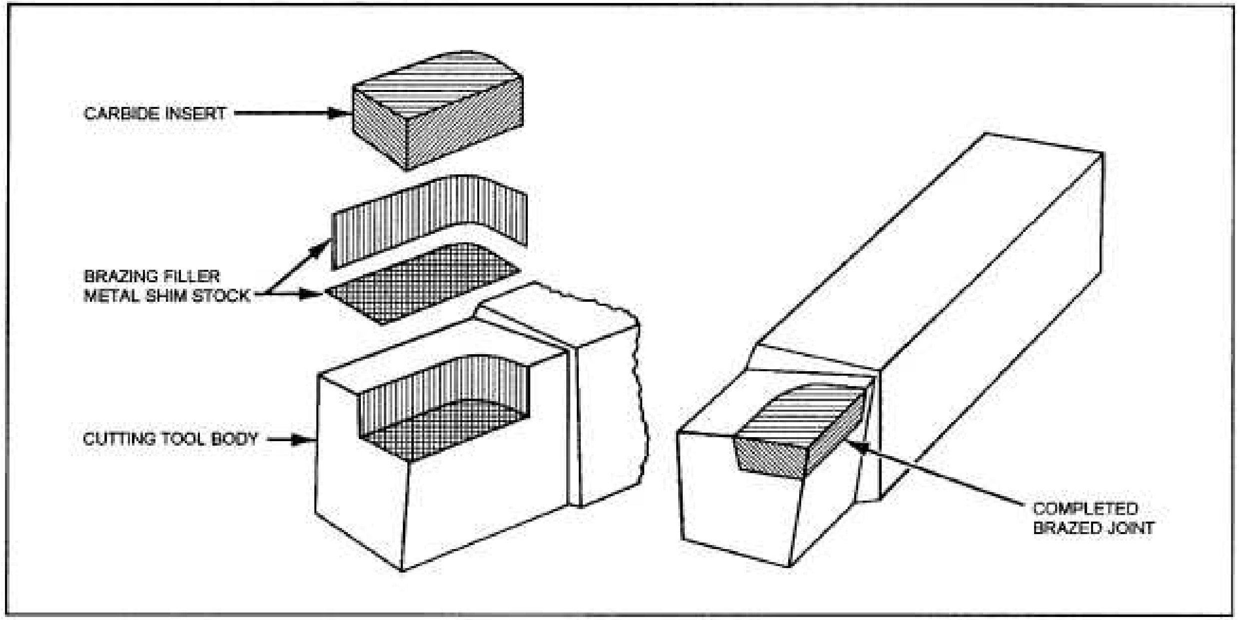
In this method of fixation, the tool bits are bonded with the shank by applying soldering materials.

2.5 Methods of fixation of sintered carbides, ceramics & diamond tools

Brazing is a metal-joining process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, the filler metal having a lower melting point than the adjoining metal.



2.5 Methods of fixation of sintered carbides, ceramics & diamond tools



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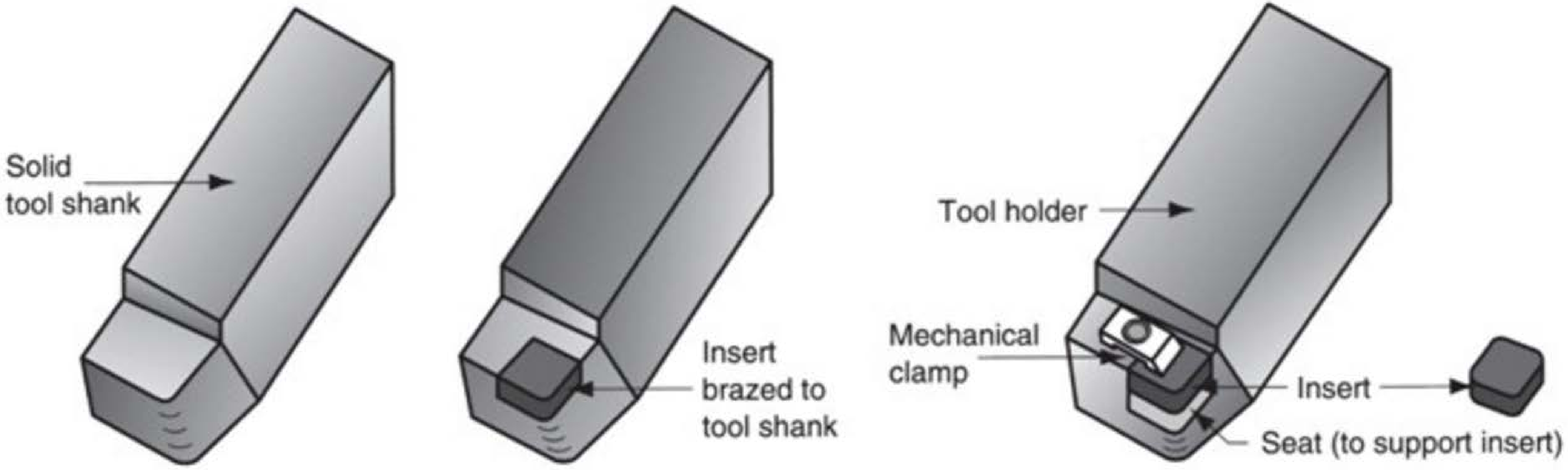

(a) Solid tool (b) Brazed insert (c) Mechanically clamped insert

2.6 Disadvantages of mechanical clamping

- Mechanical clamping of cutting inserts does not always ensure a contact stiffness that is sufficiently high to prevent vibrations which develop in machining.
- These vibrations shorten the life of the insert and often produce machined surfaces with poor finish.
- The clamping arrangement is often of comparatively large size, which in many cases limits the cutting parameters of the tool such as depth of cut, width of cut.

2.7 Disadvantages of brazing

- Micro cracks are often produced due to the high temperature of the brazing operation. The proportion of rejects due to cracks in tips is 10 – 40%.
- High skills is required for brazing.
- Difficulty in changing the worn insert.

Useful links

- https://www.youtube.com/watch?v=vAo0xmDQ-kI&feature=youtu.be
- https://youtu.be/Za0t2Rfjewg
- https://youtu.be/w46cnvjIJzA