Thapar Institute of Engineering & Technology, Patiala

Manufacturing Processes
UTA026

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THAPAR INSTITUTE
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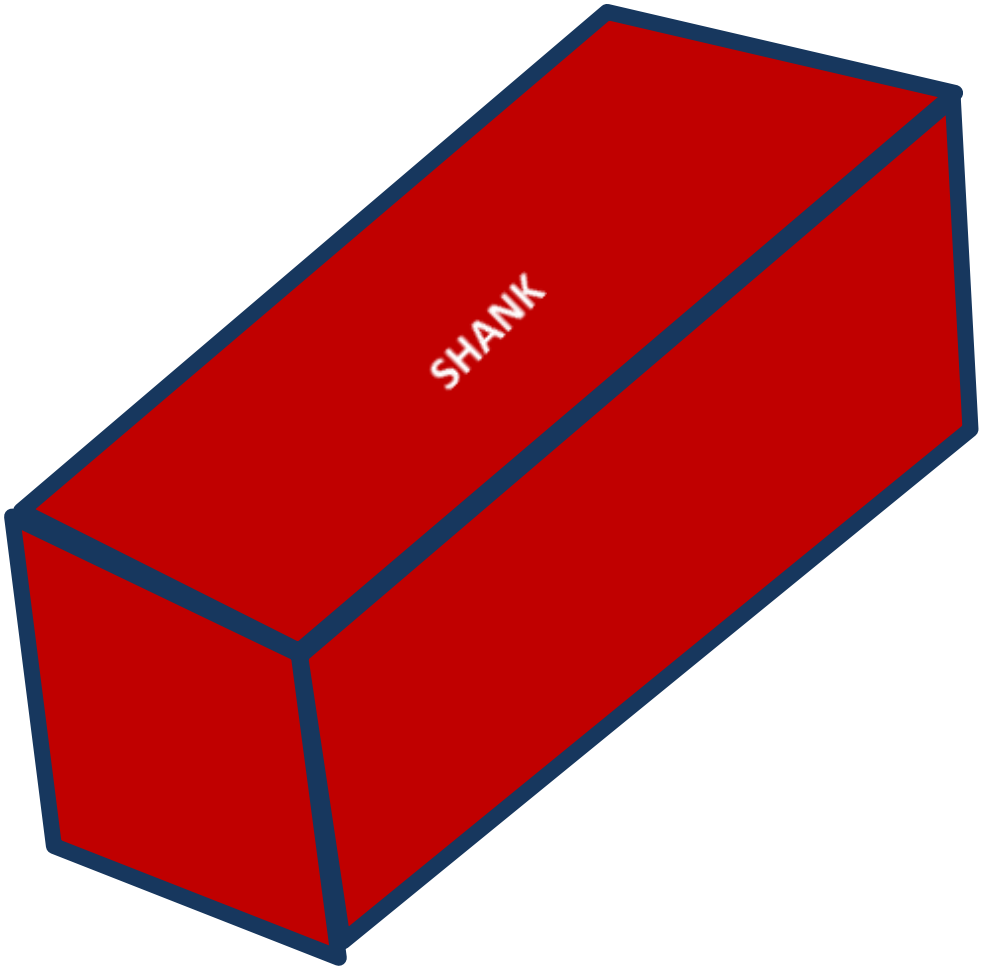
CUTTING TOOL

- A **CUTTING TOOL** has **one or more sharp cutting edges** and is made of a material that is **harder than the work material.**
- The **cutting edge** serves to **separate a chip** from the parent work material.

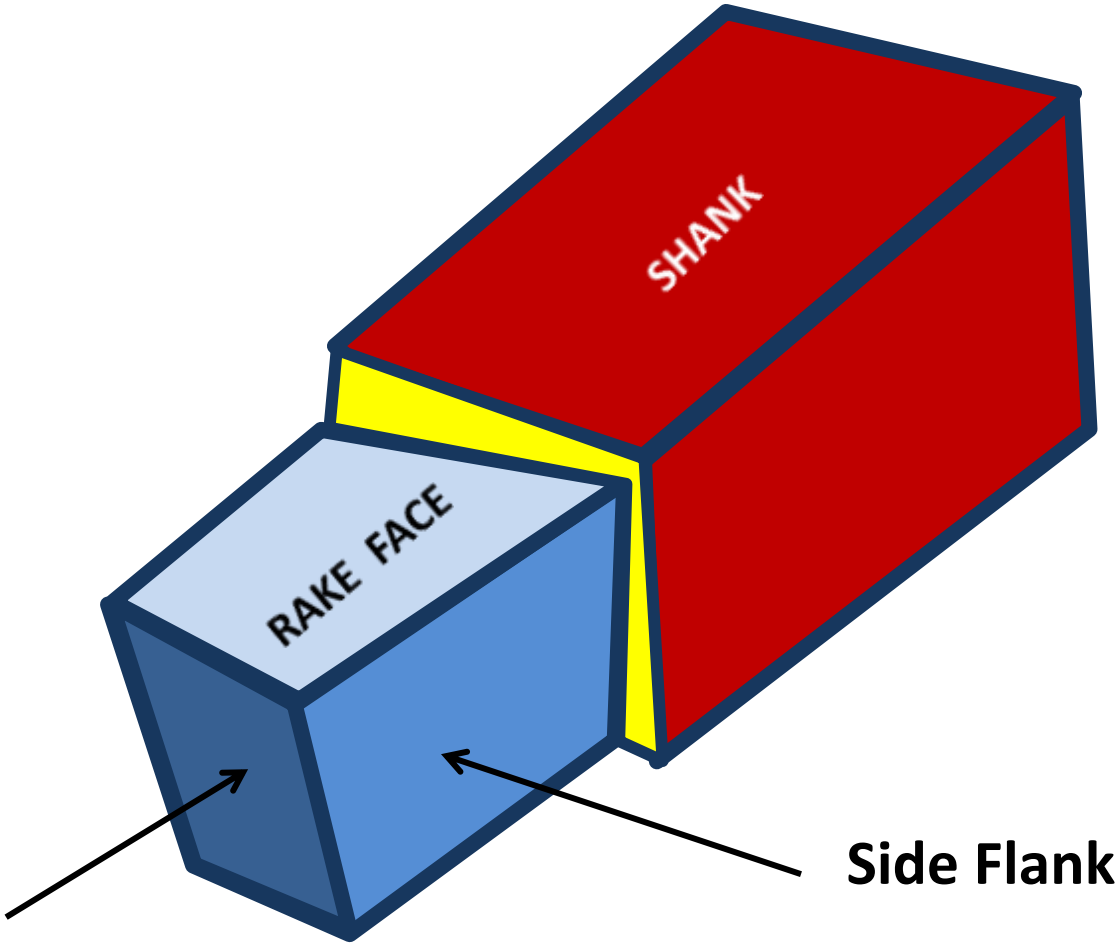
SINGLE POINT CUTTING TOOL

- A **SINGLE-POINT** tool has **one cutting edge** and is used for operations such as **turning**.
- In addition to the tool features shown in Figure, there is one tool point from which the name of this cutting tool is derived .
- During machining, the point of the tool penetrates below the original work surface of the part.
- The point is usually rounded to a certain radius, called the nose radius.

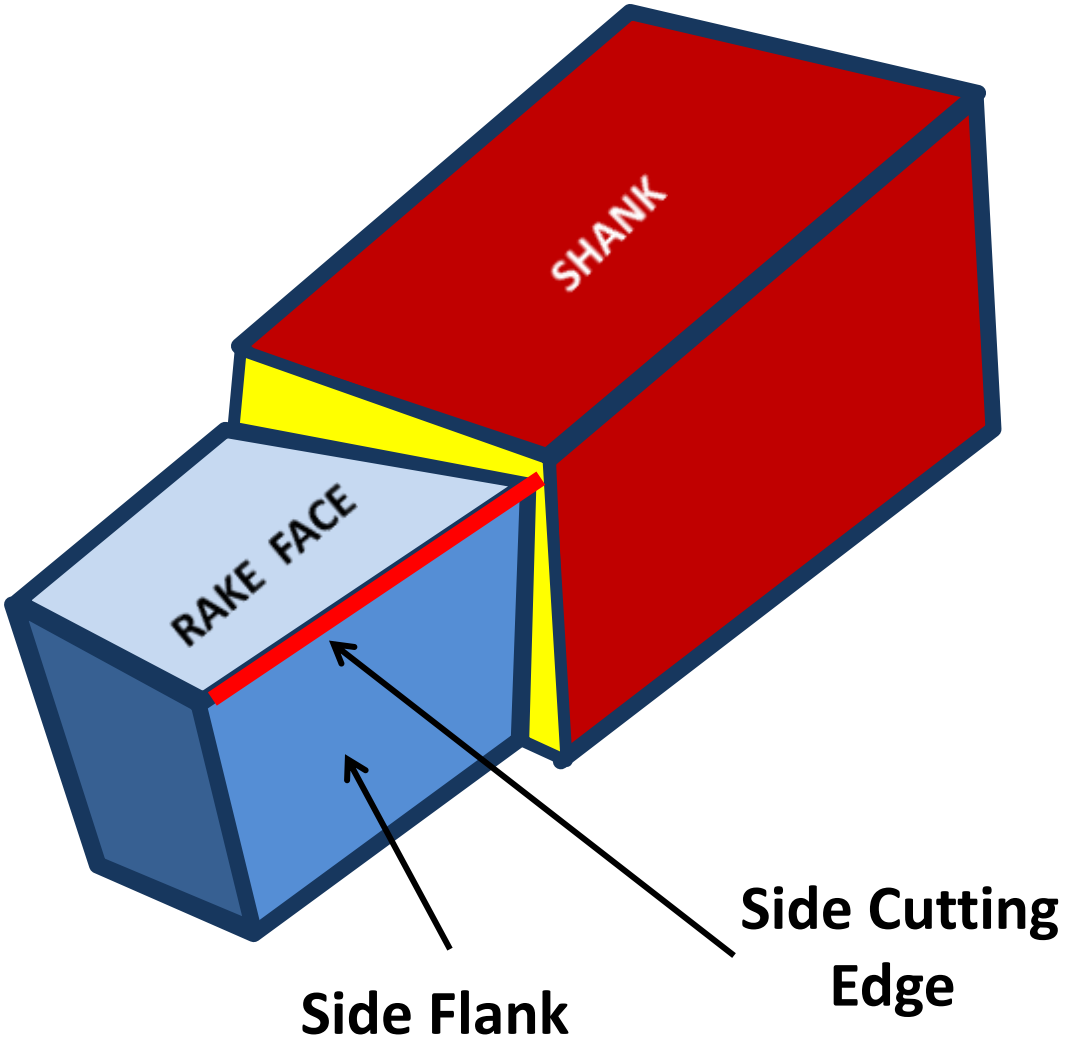
SINGLE POINT CUTTING TOOL 3-D VIEW



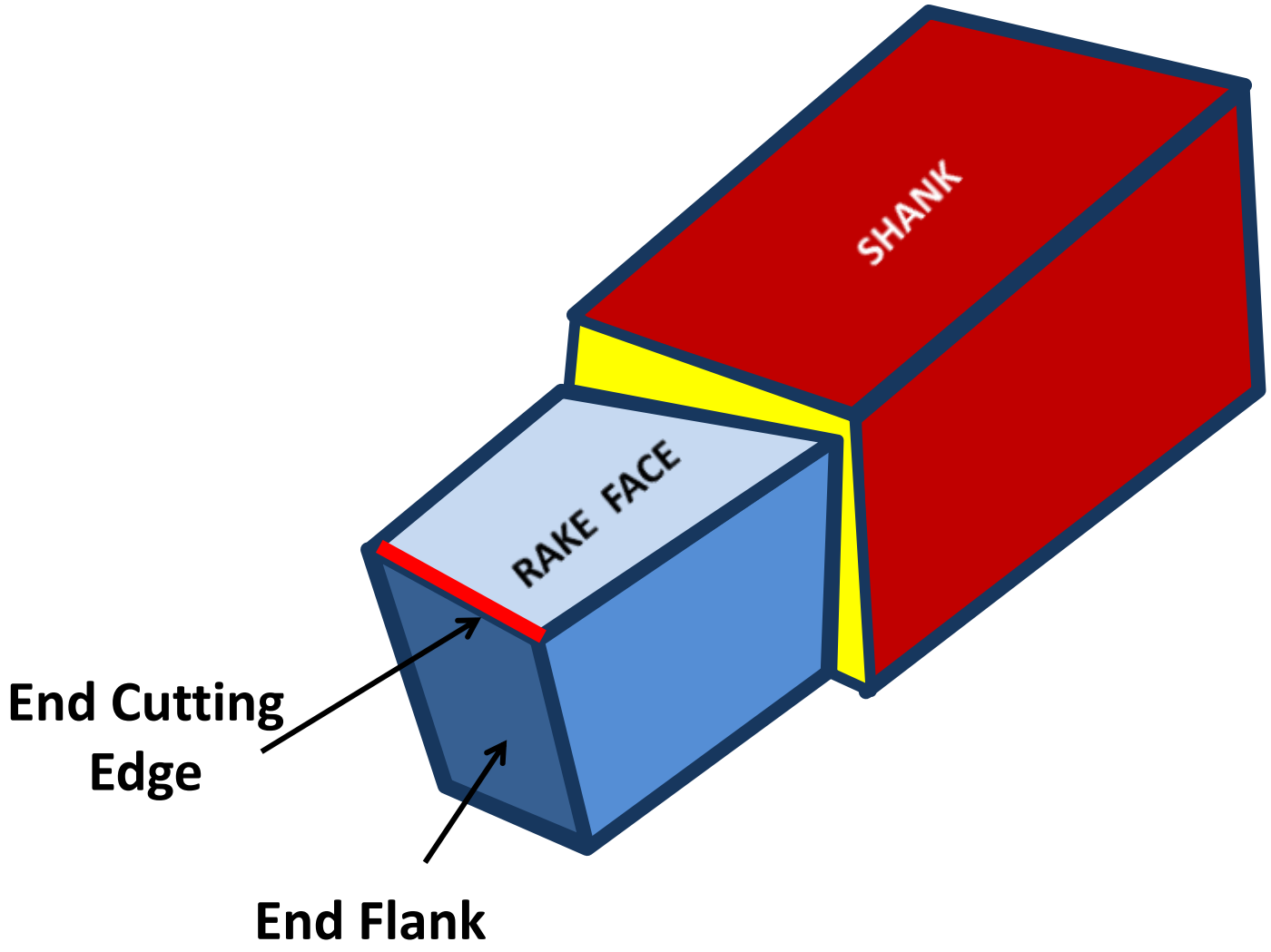
SINGLE POINT CUTTING TOOL 3-D VIEW



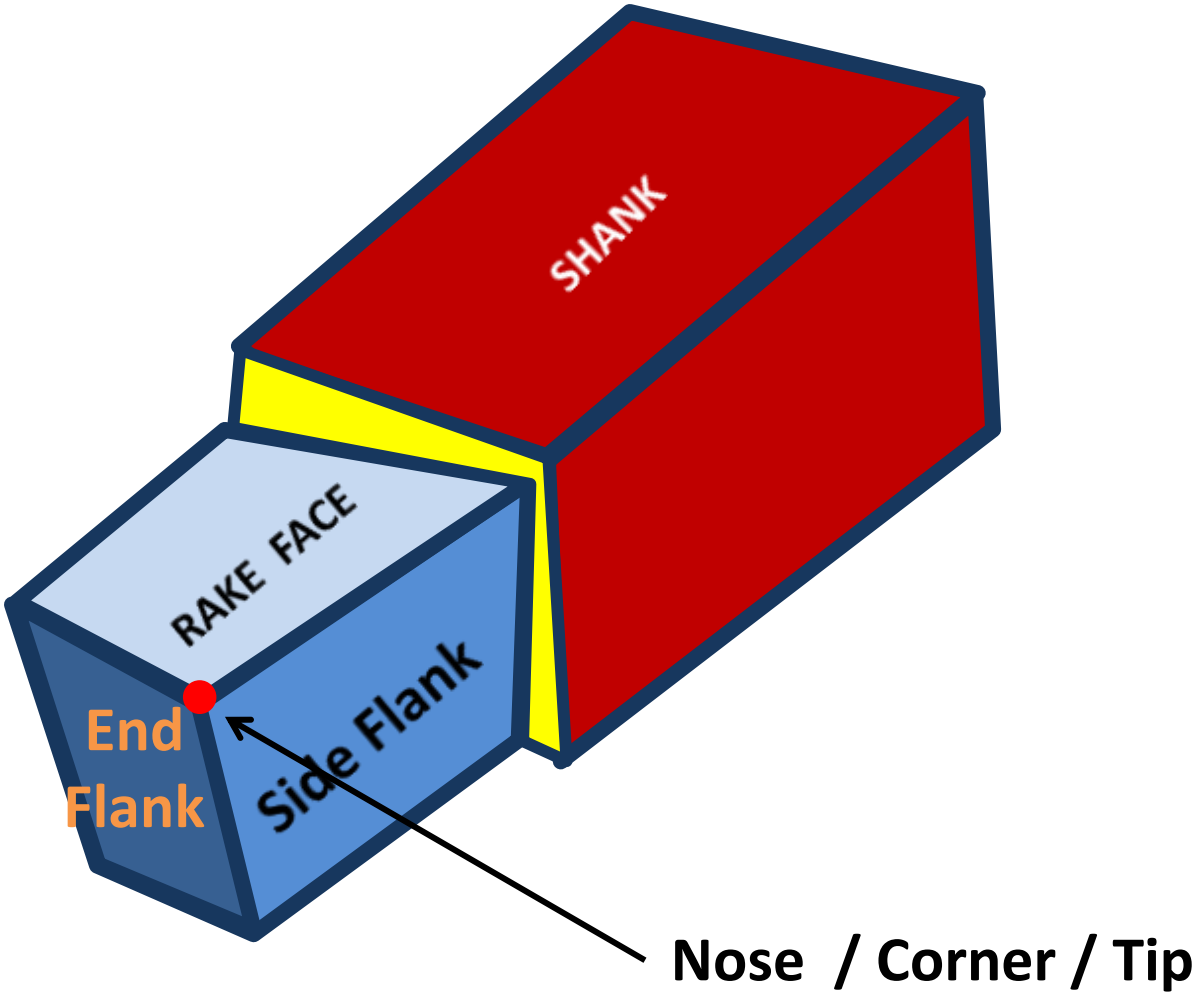
SINGLE POINT CUTTING TOOL 3-D VIEW



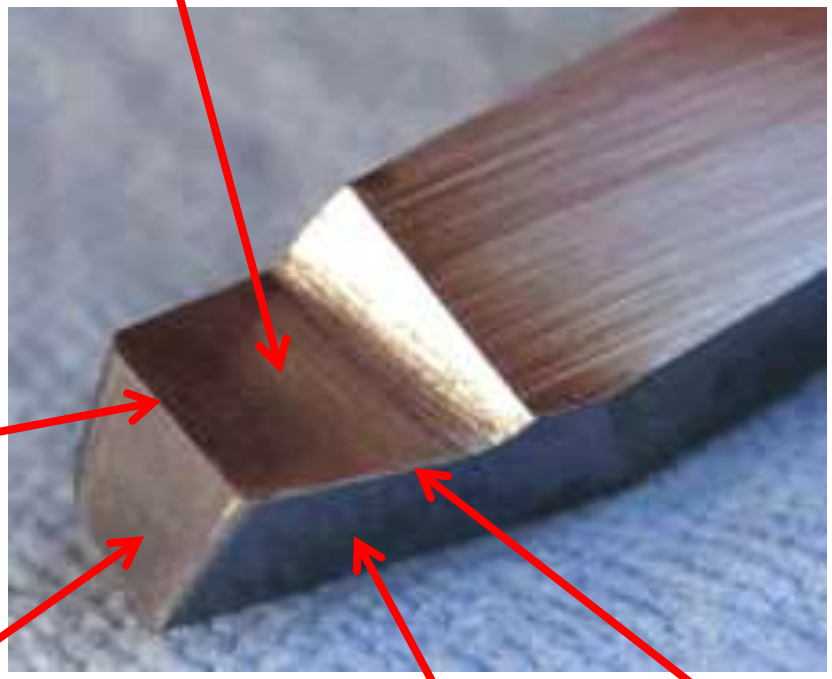
SINGLE POINT CUTTING TOOL 3-D VIEW



SINGLE POINT CUTTING TOOL 3-D VIEW

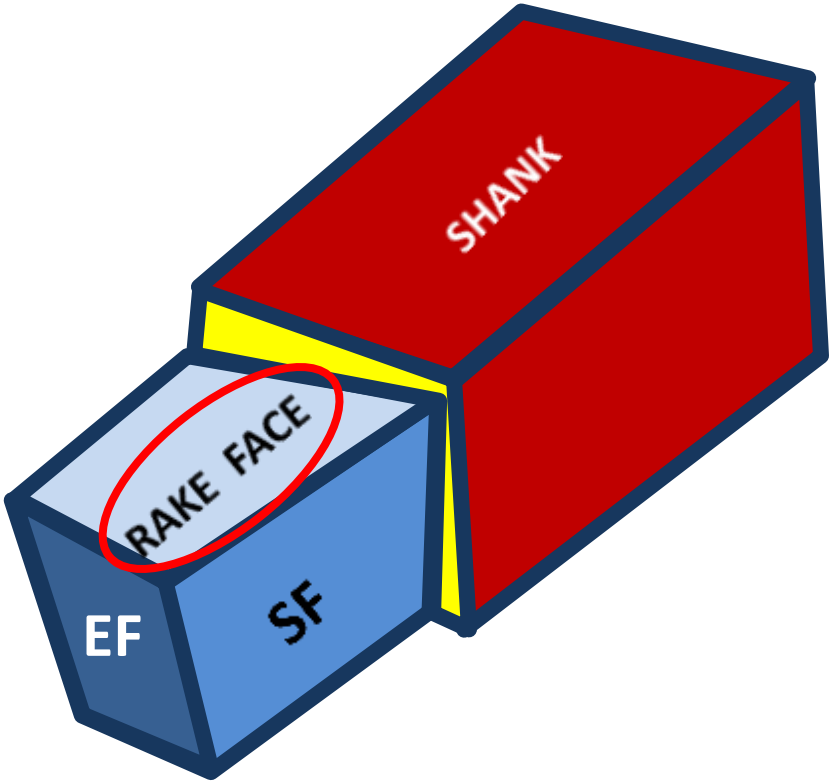


SINGLE POINT CUTTING TOOL PHOTOGRAPH



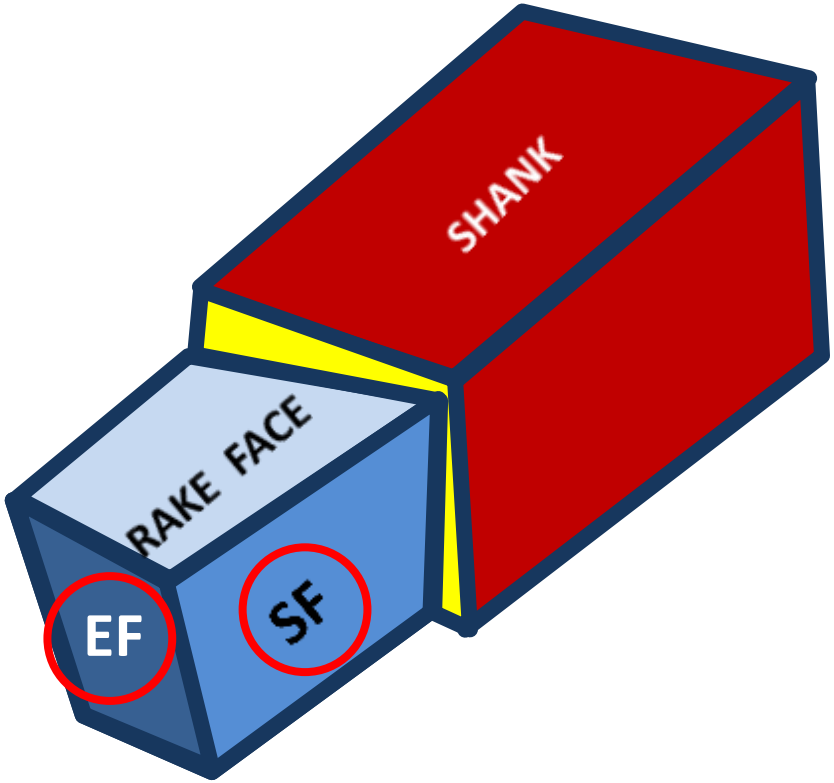
RAKE FACE

- Rake face is the surface over which the chip , formed in the cutting process, slides.



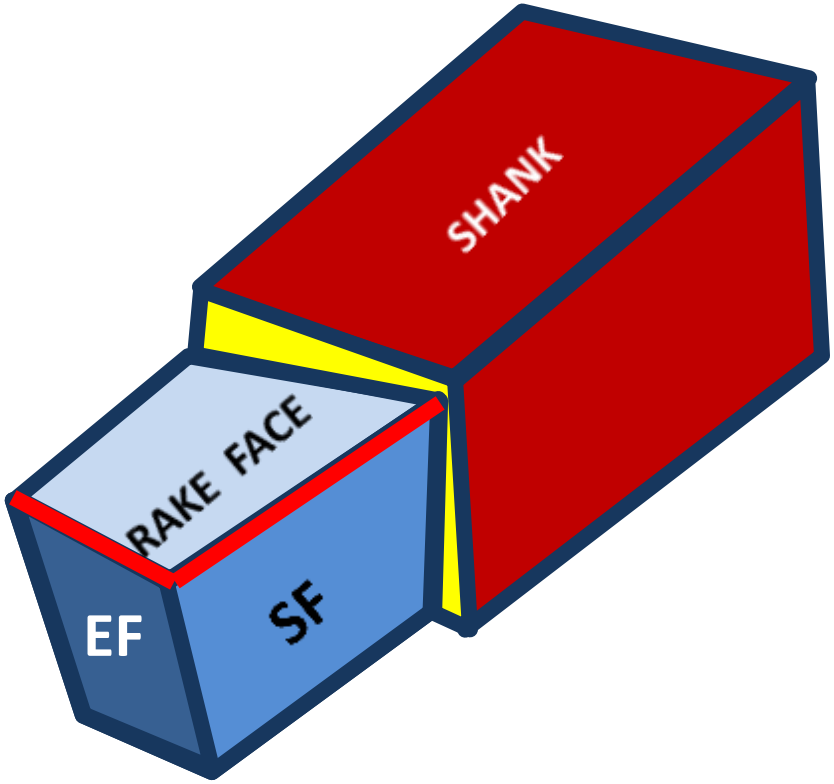
FLANK FACE

- Flank face is the surface(s) over which the surface, produced on the workpiece, passes.



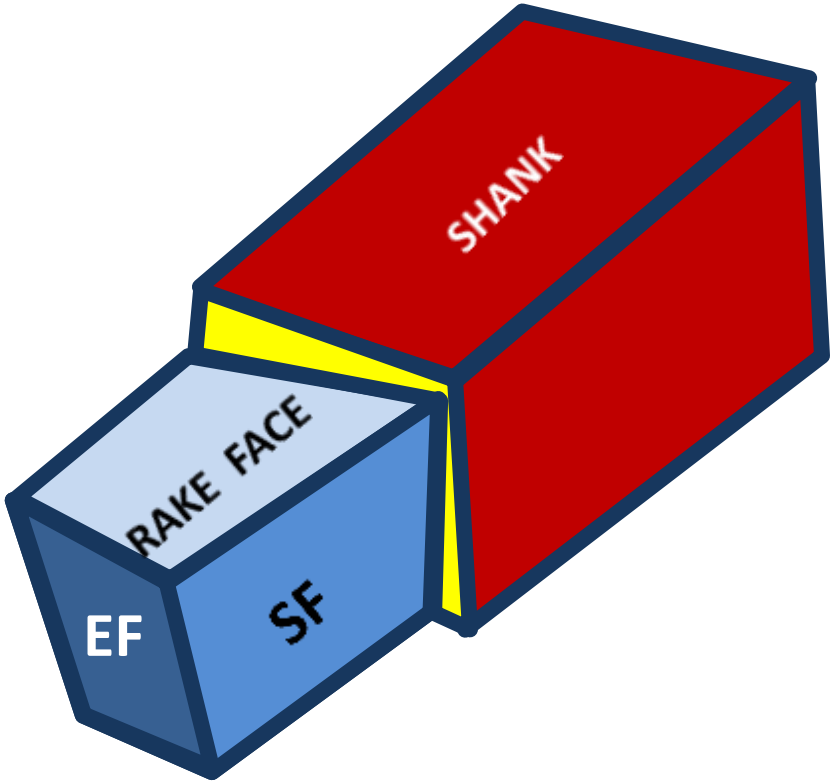
CUTTING EDGE

- Cutting edge is a theoretical line of intersection of the rake face and the flank surfaces.



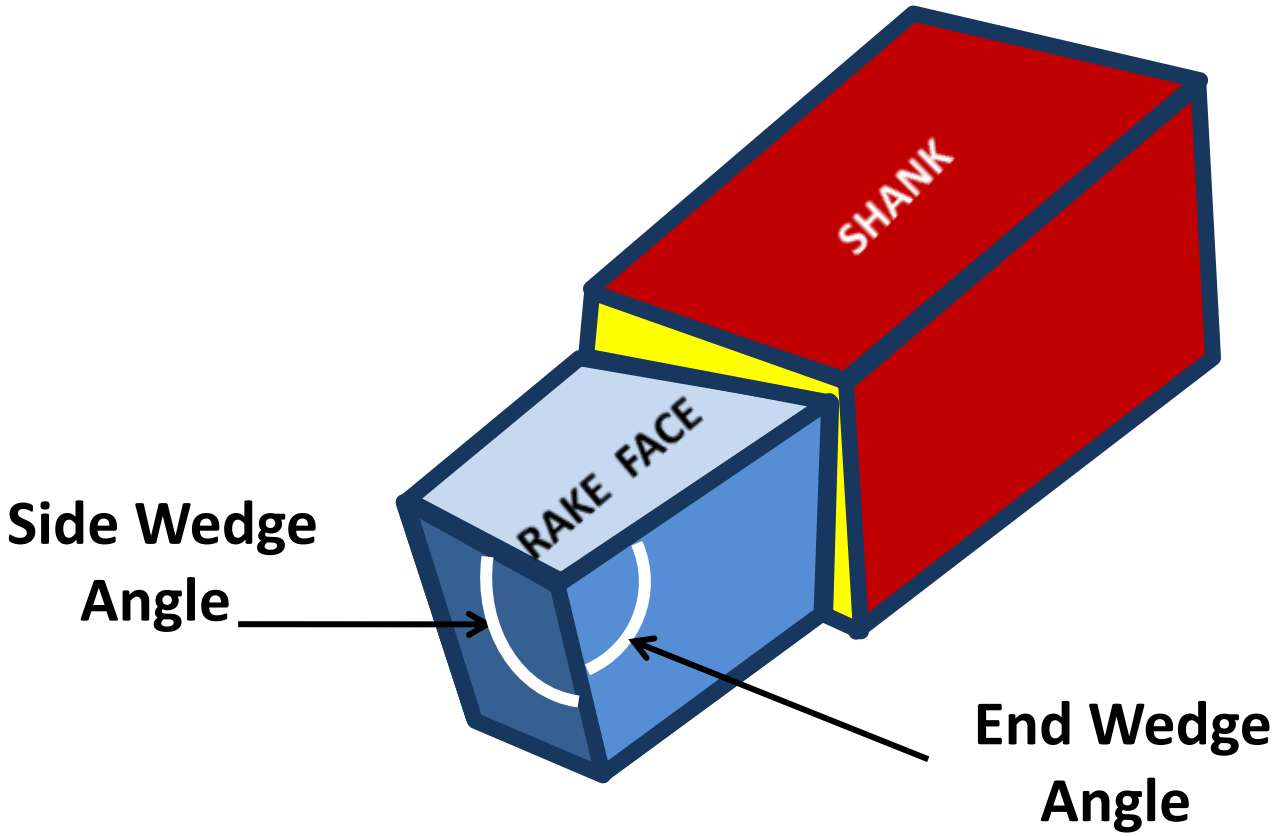
CUTTING WEDGE

- Cutting wedge is the tool body enclosed between the rake and the flank faces.



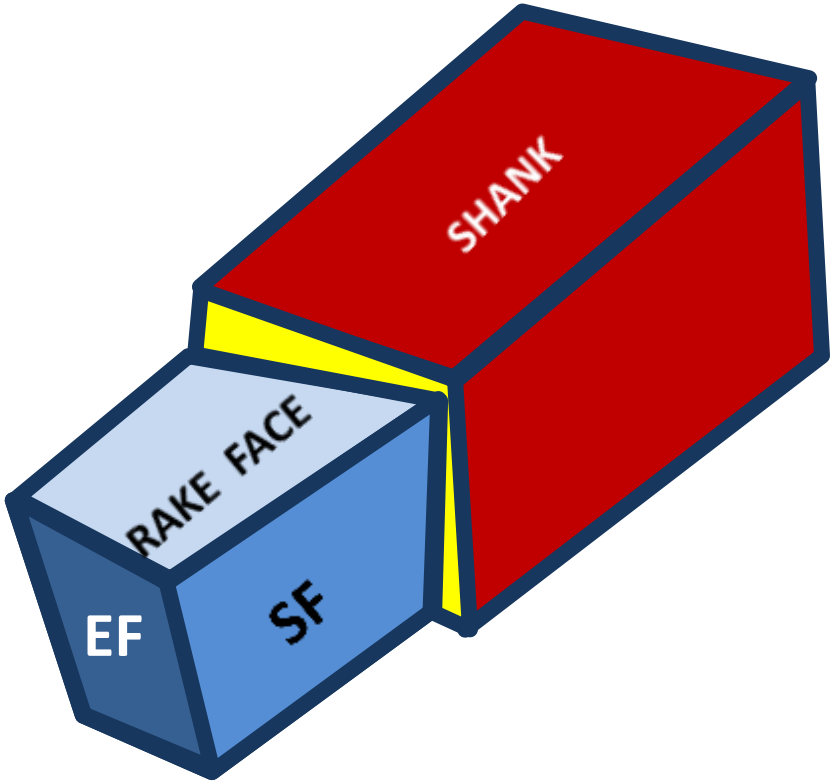
WEDGE ANGLE

- Wedge angle is defined as the angle between flank and rake face.

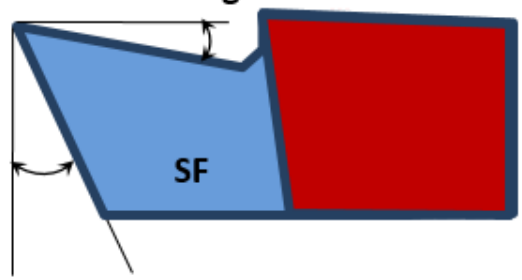


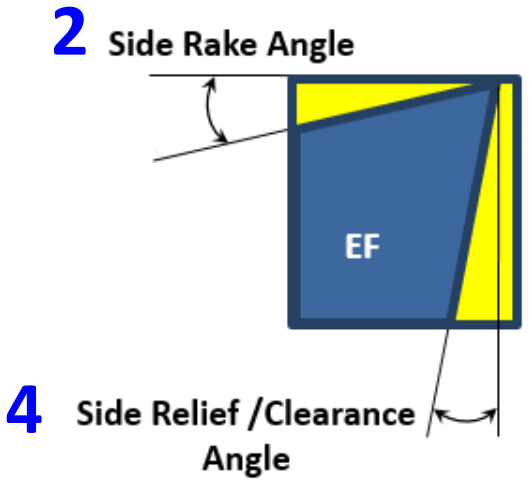
SHANK

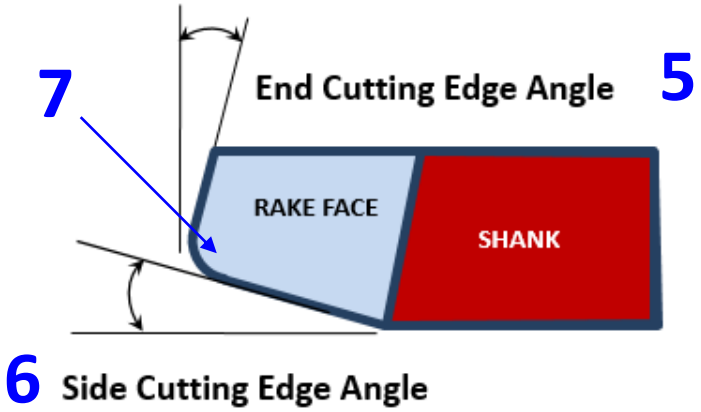
- Shank is the part of the tool by which it is held.



CUTTING TOOL ANGLES



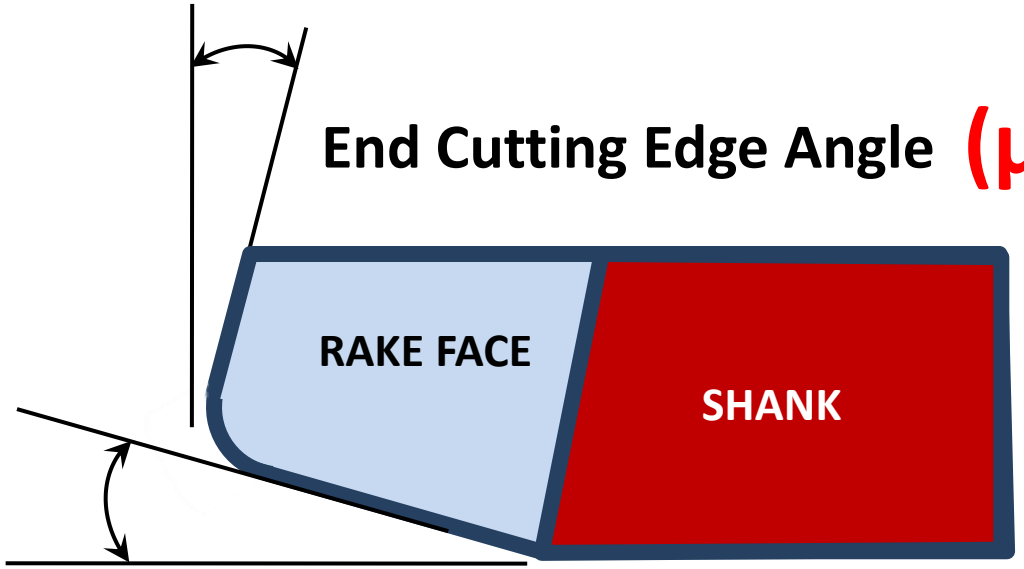


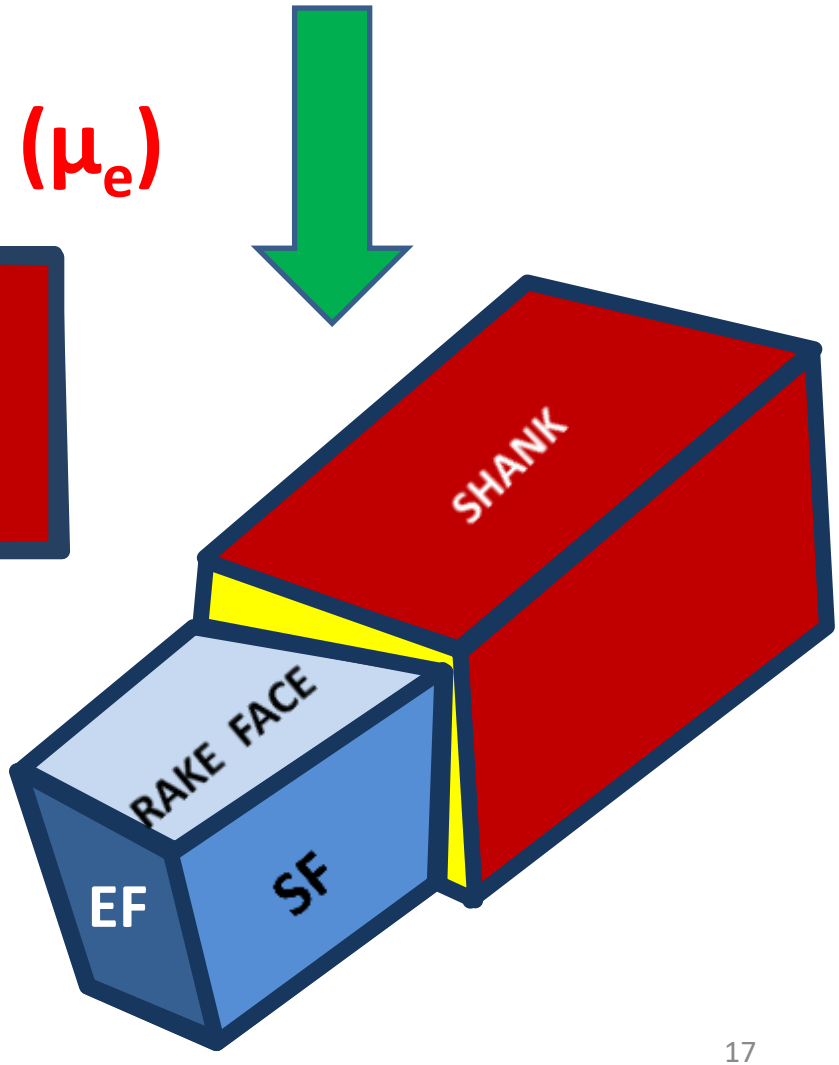


Tool signature 0-7-6-8-15-16-0.8

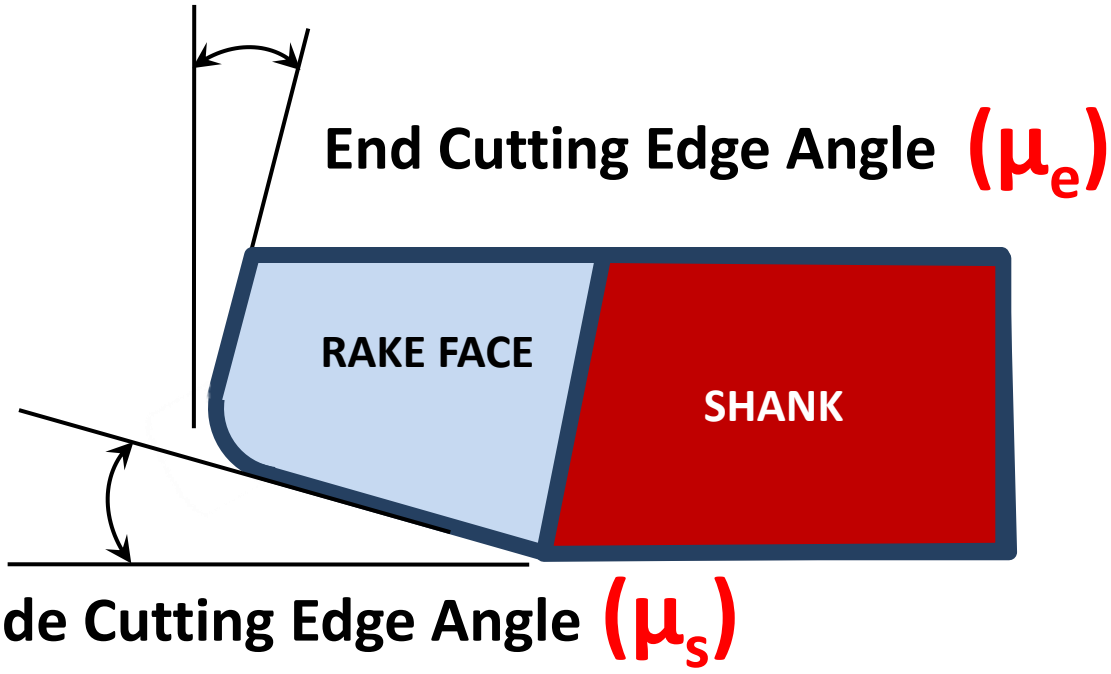
1. Back rake angle (**0°**)
2. Side rake angle (**7°**)
3. End relief angle (**6°**)
4. Side relief angle (**8°**)
5. End cutting edge angle (**15°**)
6. Side cutting edge angle (**16°**)
7. Nose radius (**0.8 mm**)

CUTTING TOOL ANGLES



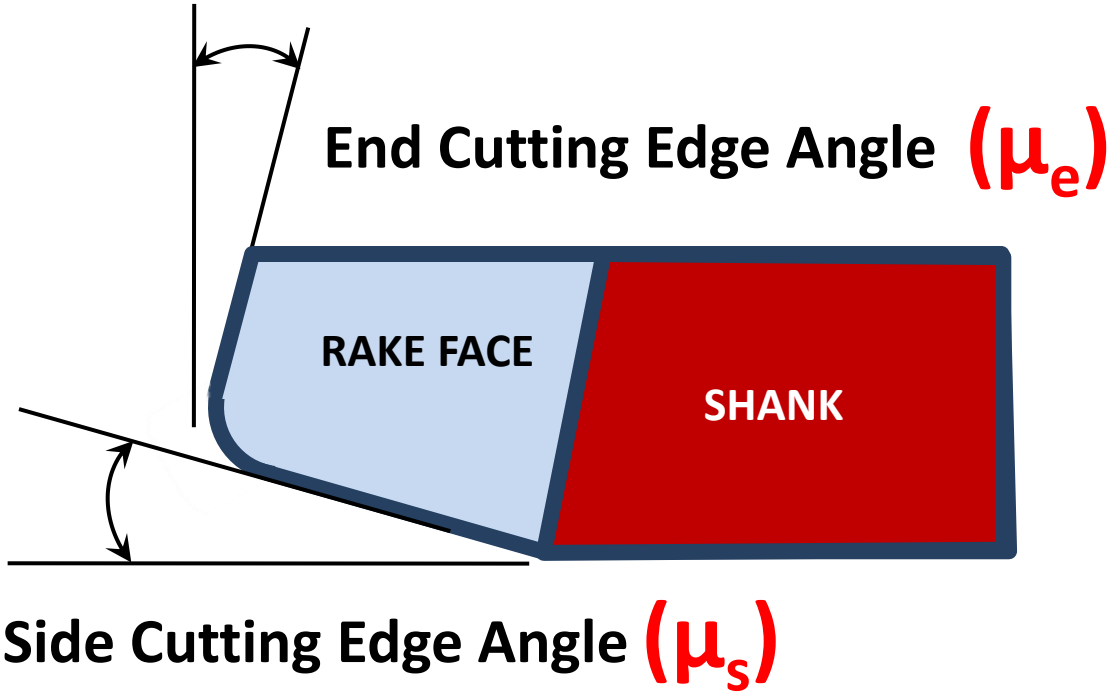


SIDE CUTTING EDGE ANGLE(μ_s)



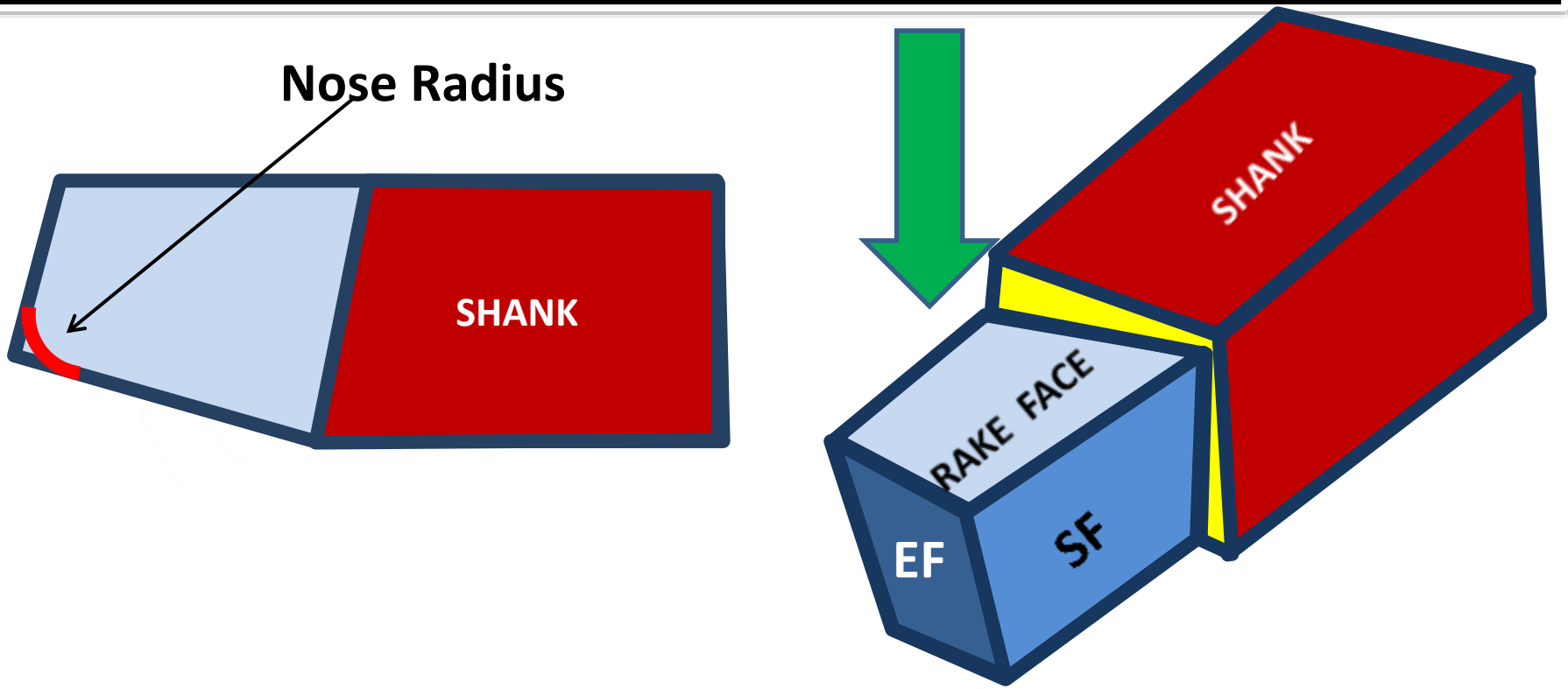
- Side cutting angles may vary from **10° to 20°**, depending on the material cut.
- If this angle is too large (**over 30°**), the tool will tend to **chatter**.

END CUTTING EDGE ANGLE(μ_s)



- End cutting edge angle may vary from **5° to 30°**, depending on the type of cut and finish desired.

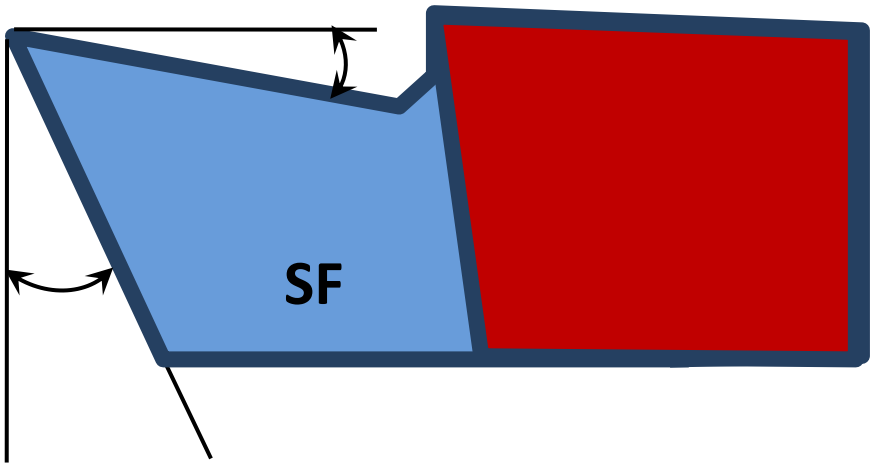
NOSE RADIUS



- The nose is the part of the tool bit which forms the corner between the side cutting edge and the end cutting edge.
- The **nose radius** is the rounded end of the tool bit.

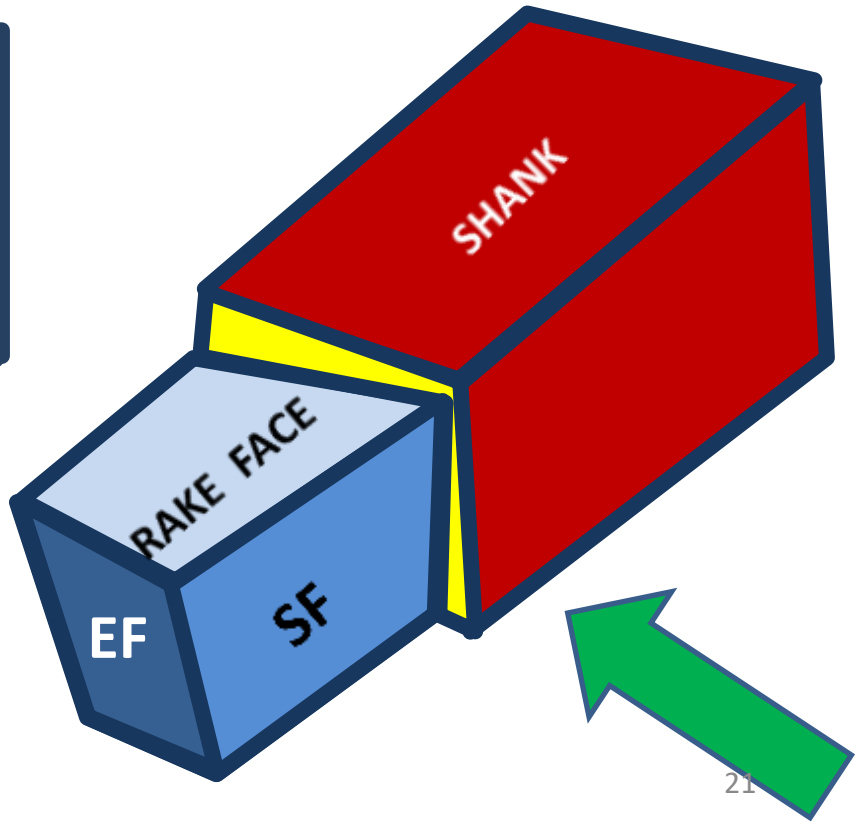
CUTTING TOOL ANGLES

Back Rake Angle (α_b)

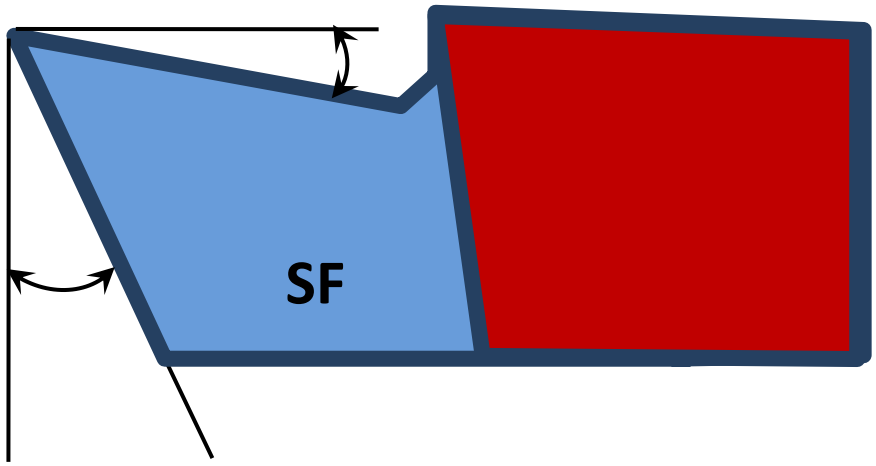


End Relief /Clearance Angle

(β_e)



END RELIEF (CLEARANCE) ANGLE(β_e)

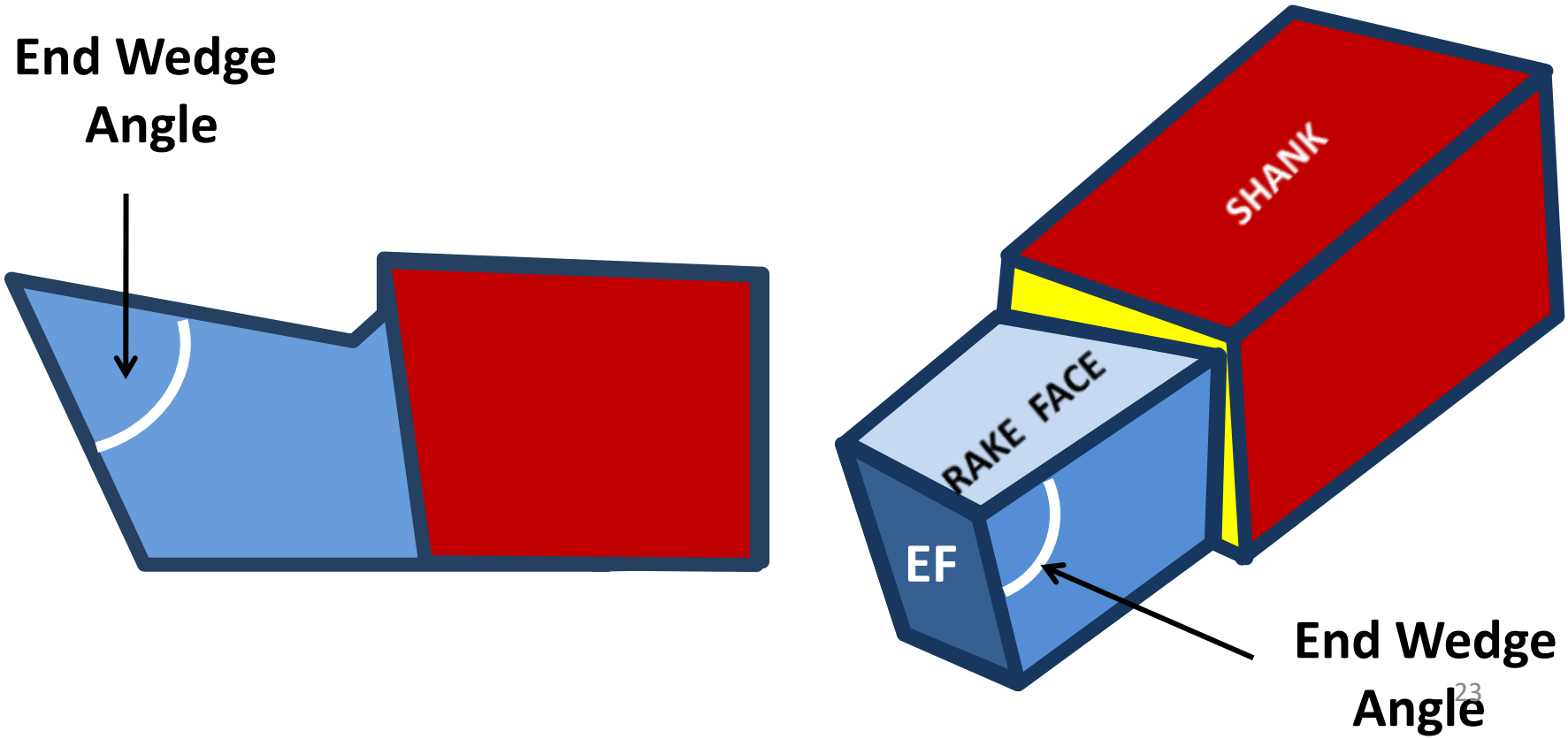


End Relief /Clearance Angle (β_e)

- ***End relief (clearance) angle*** is the angle ground below the nose of the tool, which permits the cutting tool to be fed into the work.
- It is generally **10° to 15°** for general-purpose tools .

END WEDGE ANGLE (γ_e)

- End wedge angle is defined as the angle between end flank and rake face.

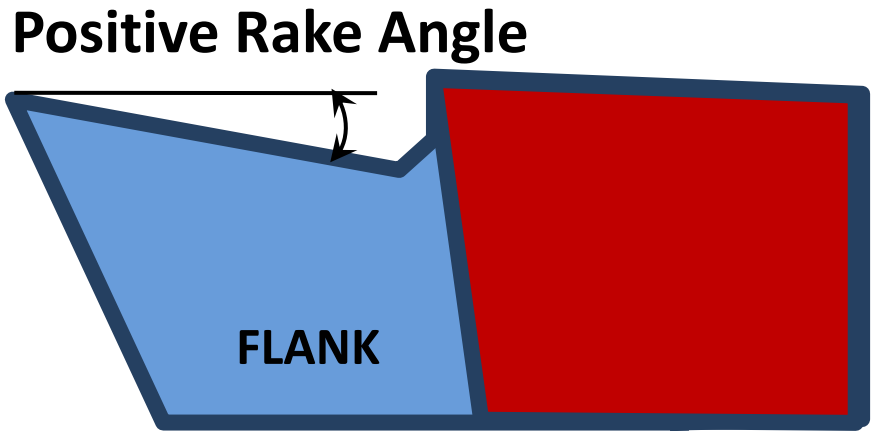


BACK (TOP) RAKE ANGLE (α_b)

- The ***back (top) rake angle*** is the backward slope of the tool face away from the nose.
- The back rake angle is generally about 20°.
- Back rake permits the chips to flow away from the point of the cutting tool.
- Two types of back or top rake angles are provided on cutting tools and are always found on the top of the tool bit.

POSITIVE RAKE

- ***Positive rake***, where the point of the cutting tool and the cutting edge contact metal first and the chip moves *down the face* of the toolbit.



POSITIVE RAKE

- Generally, ***positive rake angles***:
  - ***Make the tool*** more sharp and pointed. This reduces the strength of the tool, as the small 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.
  - Are suitable for ***lower cutting speeds***.
  - Are suitable for ***ductile materials***.

POSITIVE RAKE

- ***High-speed steel-cutting*** tools are almost always ground with positive rake angles.
- ***HSS has good strength and toughness***, so that the thinner cross section of the tool created by high positive rake angles does not usually cause a problem with tool breakage.

POSITIVE RAKE

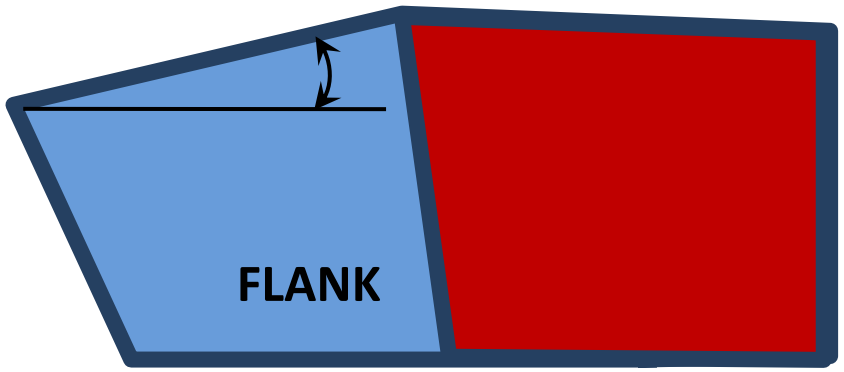
NOTE

Because there is less strength at the point of positive rake angle tools than with negative-rake tools, tool failure is more likely with large positive rake angles at high cutting speeds or with intermittent cuts.

NEGATIVE RAKE

- ***Negative rake***, where the face of the cutting tool contacts the metal first and the chip is forced *up the face* of the toolbit.

Negative Rake Angle



NEGATIVE RAKE

- Negative rake angles are generally preferred for ***ceramic, diamond, and cubic boron nitride tools (Brittle in nature).***
- As a group, these materials have ***higher hardness and lower toughness.***
- In other sense these materials are ***strong in compression but*** are relatively ***weak in tension*** because of their brittle nature.

NEGATIVE RAKE

- Cemented carbides, for example, are used with rake angles in the range from -5° to -10°.
- Ceramics have rake angles between -5° to -15 °.

NEGATIVE RAKE

- Negative rake angles also ***provide greater strength*** at the cutting edge and ***better heat conductivity.***
- ***The surface finish is usually poorer*** with negative rakes, ***although they can have good finish at higher speeds.***

NEGATIVE RAKE

- Generally, negative rake angles :
  - ***Make the tool more blunt,***
  - ***increasing the strength of the cutting edge***
  - ***Causes high compression***
  - ***Increase the cutting forces.***
  - ***Can increase friction, resulting in higher temperatures.***
  - ***Are suitable for higher cutting speeds.***
  - ***Are suitable for hard brittle materials.***

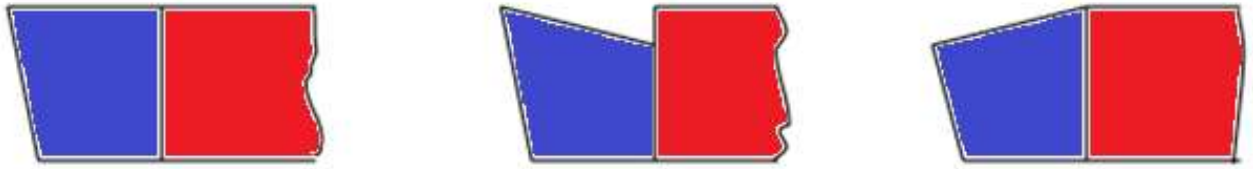
NEGATIVE RAKE

NOTE

- Negative-rake tools are most likely to produce a built-up edge with a rough continuous chip and a rough finish on the work, especially at lower cutting speeds and with soft ductile materials.
- ***Better finishes with negative rake can be obtained at high speeds with hard brittle materials.***

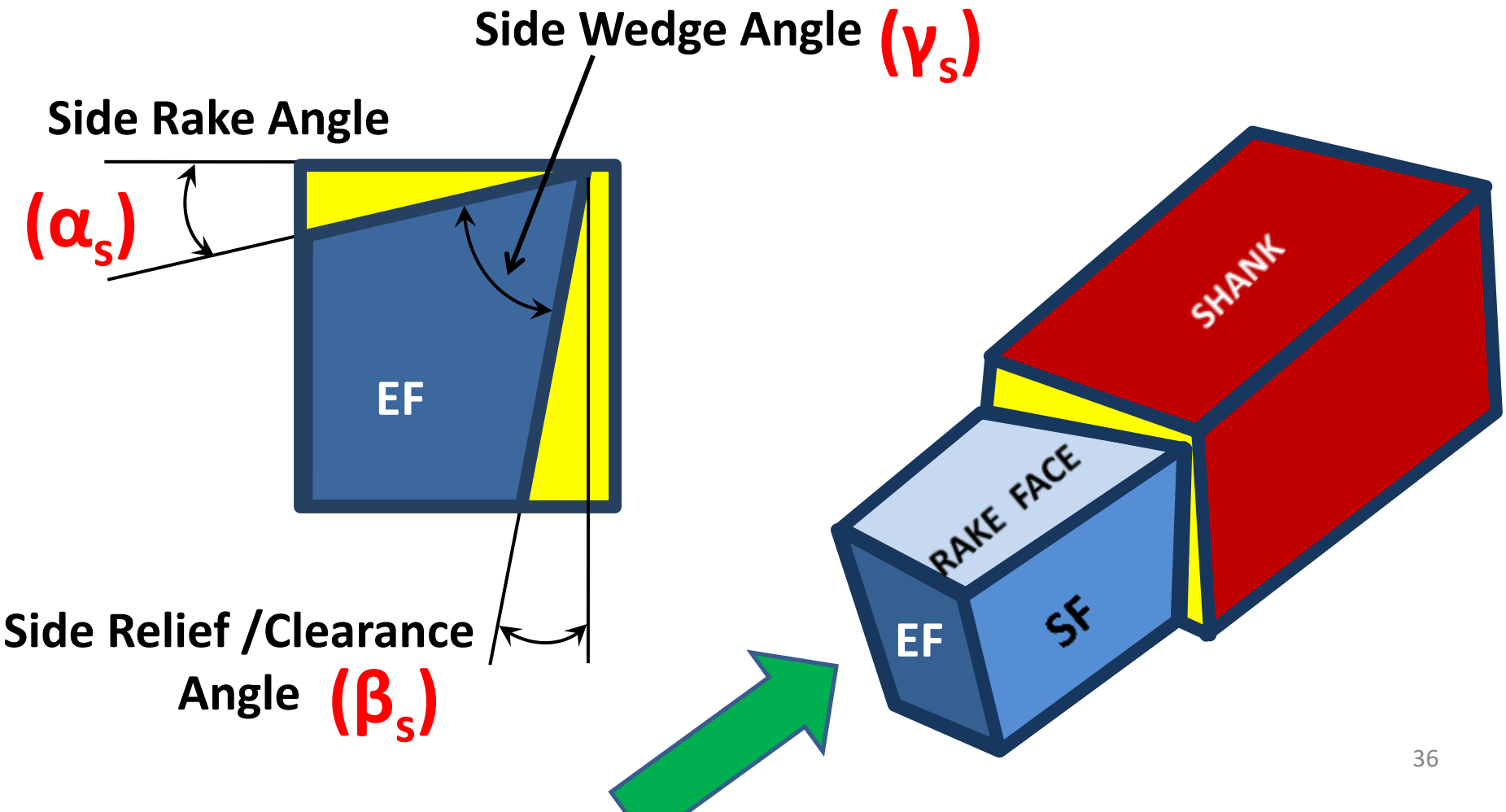
RAKE ANGLES

- The rake angle is always provided on the face or top side of the tool. With the tool tip at the center line of the workpiece, the rake angle is determined by the angle of the tool as it goes away from the workpiece center line location.

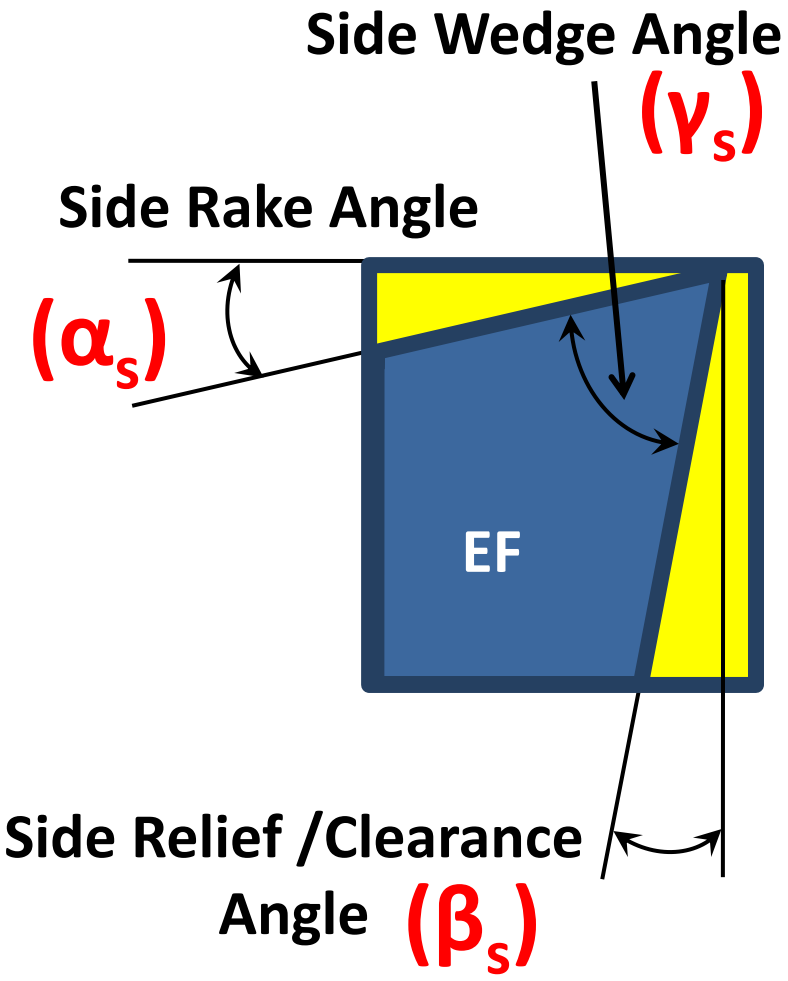


Zero rake Positive rake Negative rake

CUTTING TOOL ANGLES



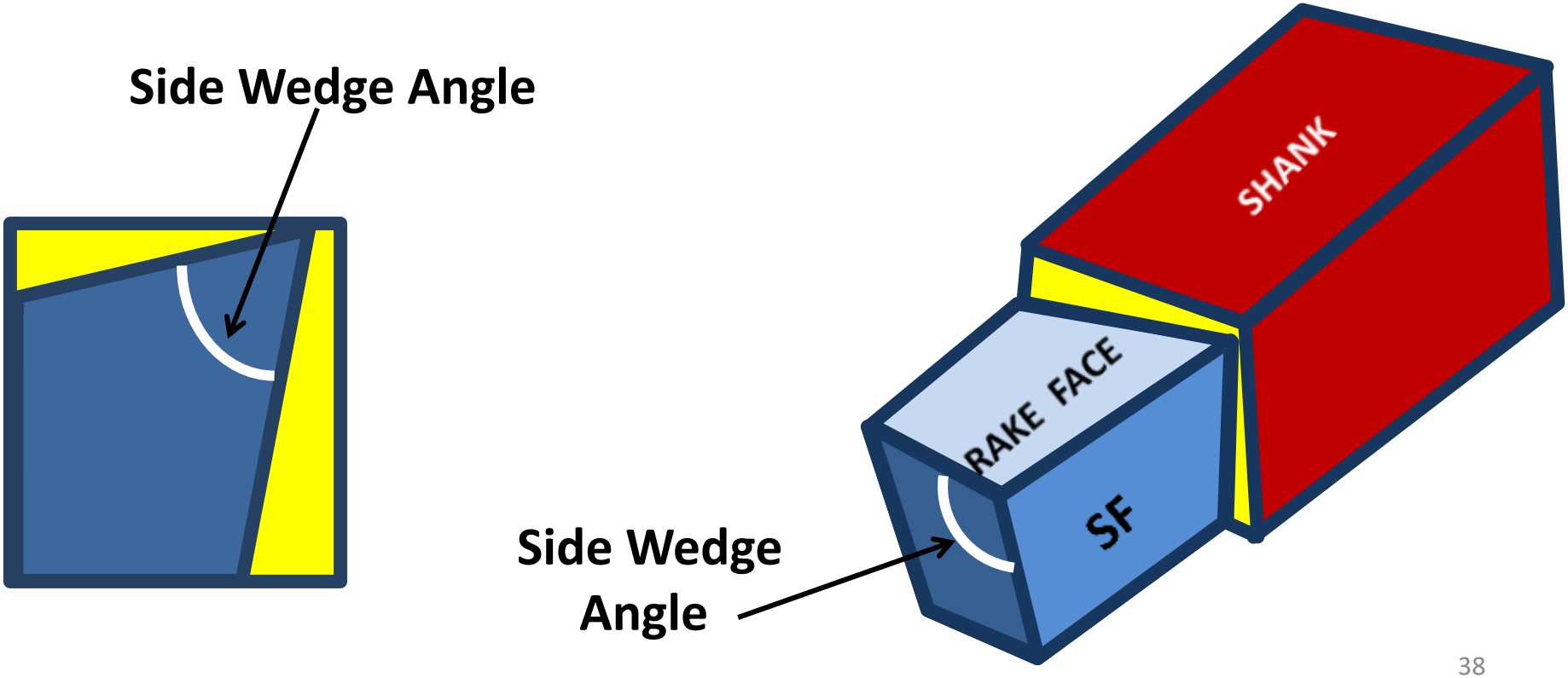
SIDE RELIEF (CLEARANCE) ANGLE (β_s)



- ***Side relief (clearance) angle*** is the angle ground on the flank of the tool below the cutting edge.
- This angle is generally 6° to 10°.

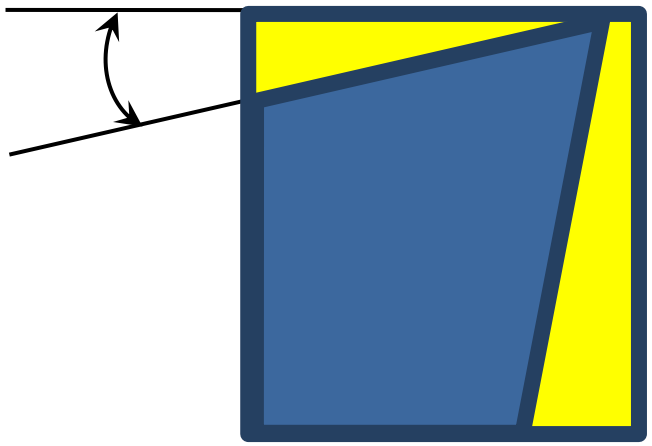
SIDE WEDGE ANGLE (γ_s)

- Side wedge angle is defined as the angle between side flank and rake face.

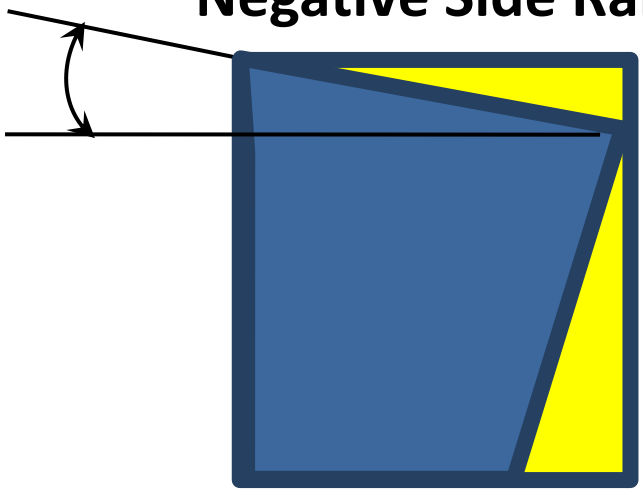


SIDE RAKE ANGLE (α_s)

Positive Side Rake Angle



Negative Side Rake Angle



- The ***side rake angle*** is the angle at which the face is ground away from the cutting edge.
- For general-purpose tool bits, the side rake is generally 14°.

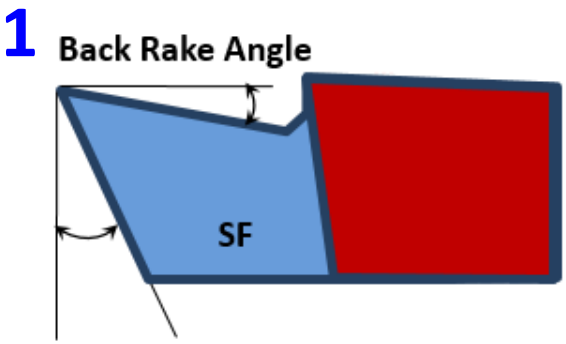
TOOL SIGNATURE

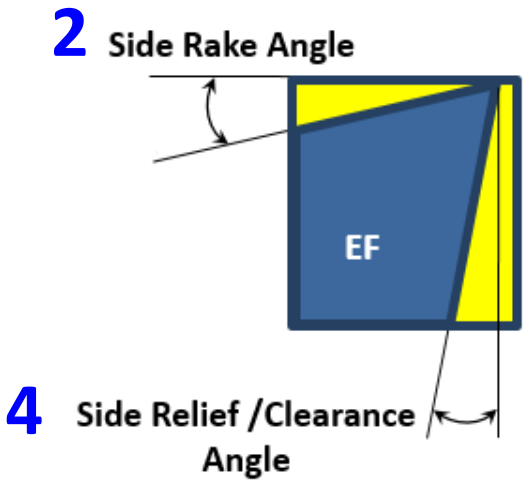
- Convenient **way to specify tool angles** by use of a standardized abbreviated system is known as tool signature or tool nomenclature.
- It indicates the angles that a tool utilizes during the cut.
- The **seven elements** that comprise the signature of a single point cutting tool can be stated in the following order:

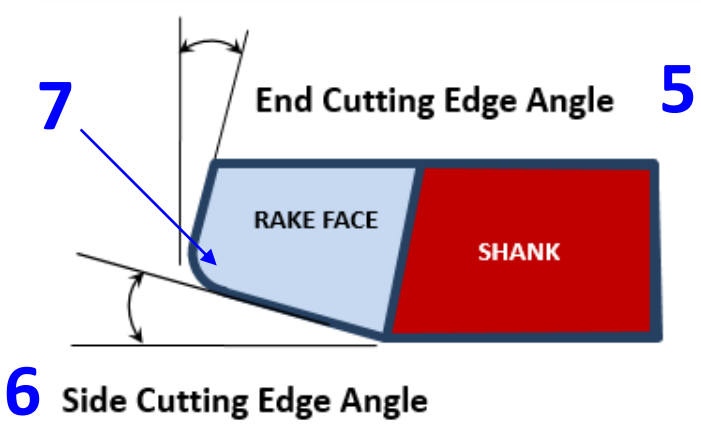
TOOL SIGNATURE

Tool signature 0-7-6-8-15-16-0.8

1. Back rake angle (**0°**)
2. Side rake angle (**7°**)
3. End relief angle (**6°**)
4. Side relief angle (**8°**)
5. End cutting edge angle (**15°**)
6. Side cutting edge angle (**16°**)
7. Nose radius (**0.8 mm**)







Tool signature 0-7-6-8-15-16-0.8

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7. Nose radius (**0.8 mm**)

References:

- M. P. Groover, Fundamentals Of Modern Manufacturing: Materials, Processes, and Systems, Wiley (2010), 4th edition.
- Degarmo, E. P., Kohser, Ronald A. and Black, J. T., Materials and Processes in Manufacturing, Prentice Hall of India (2008) 8th ed.
- Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, Dorling Kingsley (2006) 4th ed.