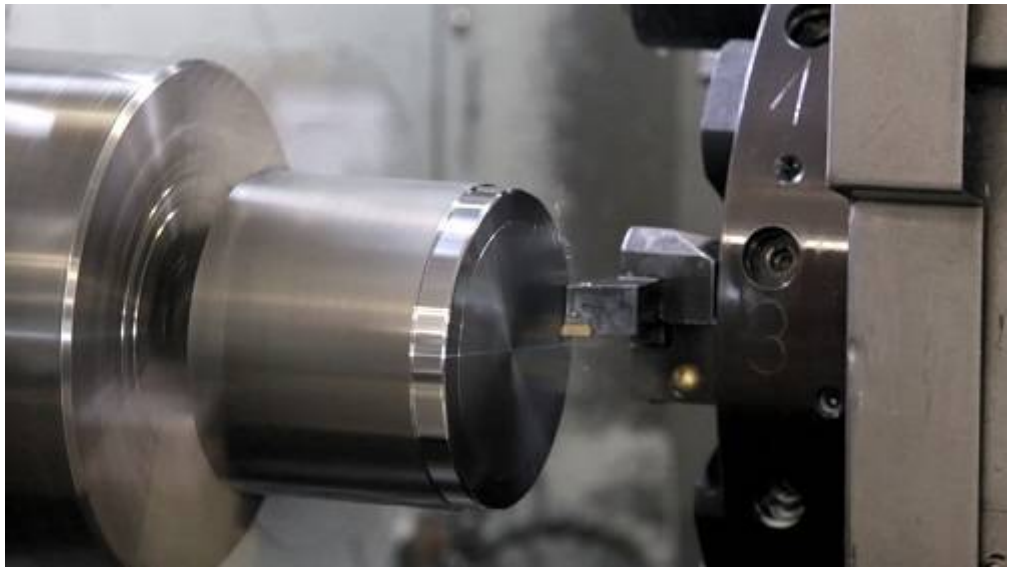
Metal Cutting and Machine Tool (MEL3132)



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Pic Source-Google images

CUTTING TOOL MATERIALS & CUTTING FLUIDS

Characteristics of Cutting Tool Material

1. Higher hardness than w/p
2. Hot hardness
3. Wear resistance
4. Toughness
5. Low friction
6. Better Thermal Characteristics

Types of Cutting Tool Materials

1. **Carbon Tool Steels**

- Plain carbon steels with C % between 0.6 and 1.5
- Very small additions of Mn, Si, W, Mo, Cr and V
- Hot hardness 200˚C
- Speed – 0.15 m/s
- Limited tool life
- Low cost
- Used for hand tool to machine wood, magnesium, brass, aluminium

Question ?

Assertion (A): Cutting tools made of high carbon steel have shorter tool life.

Reason(R): During machining, the tip of the cutting tool is heated to 600/700°C which cause the tool tip to lose its hardness.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

Types of Cutting Tool Materials

2. High Speed Steel

- Taylor and white developed at the start of 20th century
- Special alloy steel, contains elements like W, Mo, Cr, V, Co etc. upto 25 %
- Cutting speed 3 to 5 times higher (0.5 to 0.75 m/s)
- Highest toughness (used for interrupted cutting)
- W and Mo contribute more to hardness
- Addition of large amount of cobalt (2 to 15 %) and Vanadium (2 %) to increase hot hardness and wear resistance respectively
- Hot hardness 650˚C

Types of Cutting Tool Materials

- Good abrasion resistance
- 'T' Type and 'M' Type

Type	W	Cr	V	Mo	C
T1	18	4	1	0	0.7
M1	1.5	4	1	8	0.8

- Most commonly used HSS is better known by its composition is 18:4:1
- It is considered to be one of the best of all purpose tool steels.
- It is widely used for drills, lathe, planer and shaper tools, milling cutters, reamers, broaches, etc.

Question ?

The correct sequence of elements of 18-4-1 HSS tool is

(a) Cr, Ni, C

(b) Mo, Cr, V

(c) W, Cr, V

(d) Cu, Zn, Sn

Types of Cutting Tool Materials

3. Cast Cobalt alloys

- Cast cobalt alloys are cobalt-rich, chromium-tungsten-carbon cast alloys
- Properties and applications in between high-speed steel and cemented carbides
- 25 % higher cutting speed than HSS
- Used to machine plain carbon steels, alloy steels, nonferrous alloys, and cast iron

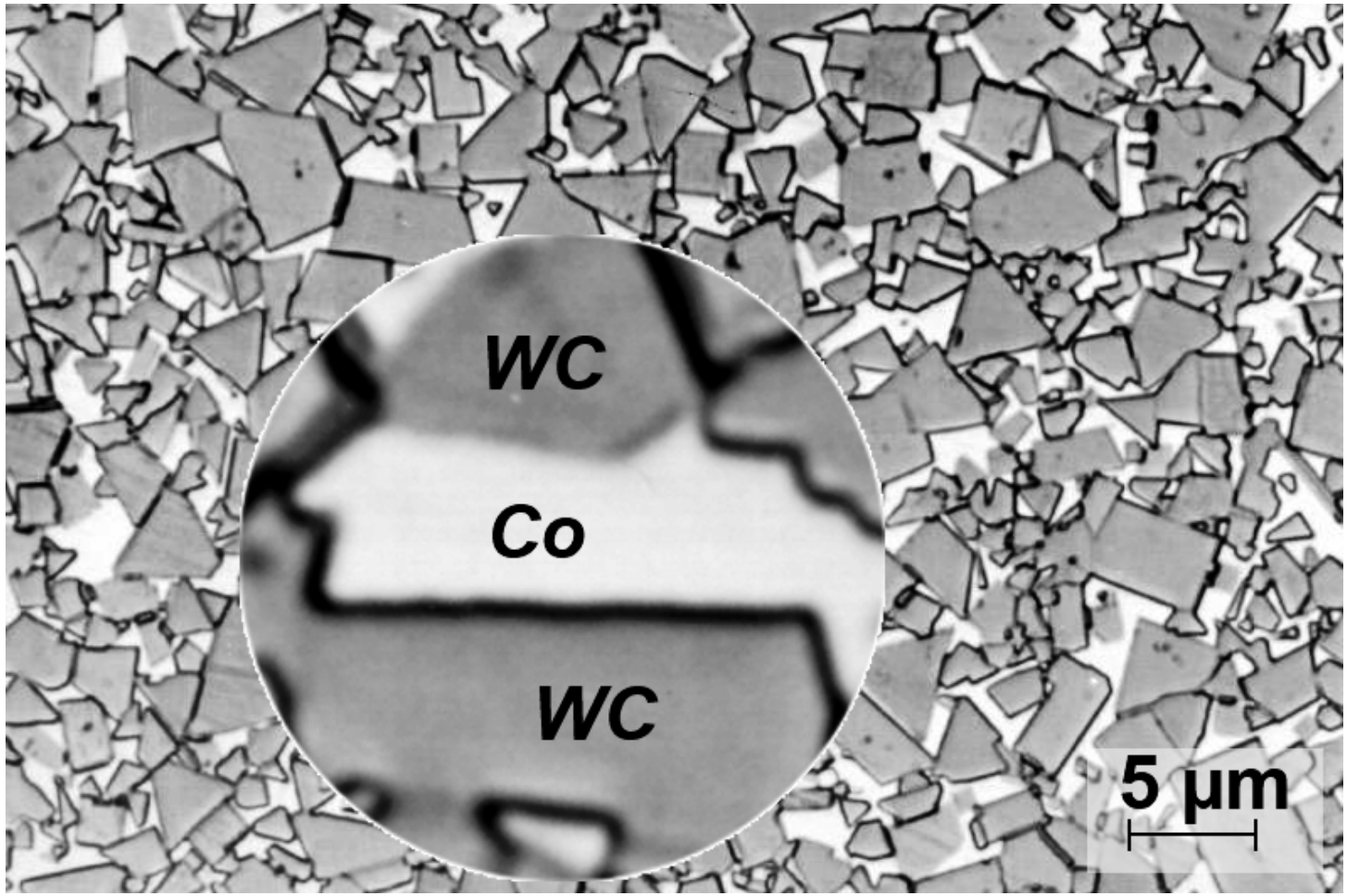
Composition

Cr	W	Mo	C	Mn	Si	Ni	Co
30	4.5	1.5	1.1	1	1.5	3	Rest

Types of Cutting Tool Materials

4. Cemented Carbides

- Best thing for metal cutting industry, 1926 Germany
- Tungsten carbide (hard metal) is a composite material fabricated by powder metallurgy, which consists of one or more hard material phases (e.g. tungsten carbide itself) and a binder metal surrounding the hard material grains (e.g. Co or Ni)
- 6 wt. % Co & 94 wt. % tungsten carbide
- High-performance properties that can be adjusted over a wide range make tungsten carbide the ideal material for a multitude of applications.
- Hot hardness – 1200 ˚C



Microstructure of Carbides (WC – Co)

Pic Source-Google images
(www.matmatch.com)

Types of Cutting Tool Materials

- Cutting speed 3 to 6 times (about 5 to 6 m/s) than HSS
- Increasing Co binder decreases hot hardness, wear resistance while increasing strength (Co-5 to 12%)
- Addition of TiC (5-25 wt.%) increases hot hardness, wear resistance but decreases strength
- Similarly, TaC increases hot hardness, decreases wear resistance and strength
- Tool inserts or tool bit is of tungsten carbide and tool holder shank is made from alloy steel to provide necessary strength and reduce tool cost

Lathe Turning Tool Holder Boring Bar CNC Tools Set With Carbide Inserts

Pic Source-Google images
(www.banggood.in)

Types of Cutting Tool Materials

Coated Carbides

- One or more thin layers of coating on carbide inserts to enhance tool life
- Tool life 2 to 3 times higher than carbides
- Coating thickness – 2.5 to 13 μm

TiC

Provides abrasion resistance

TiN

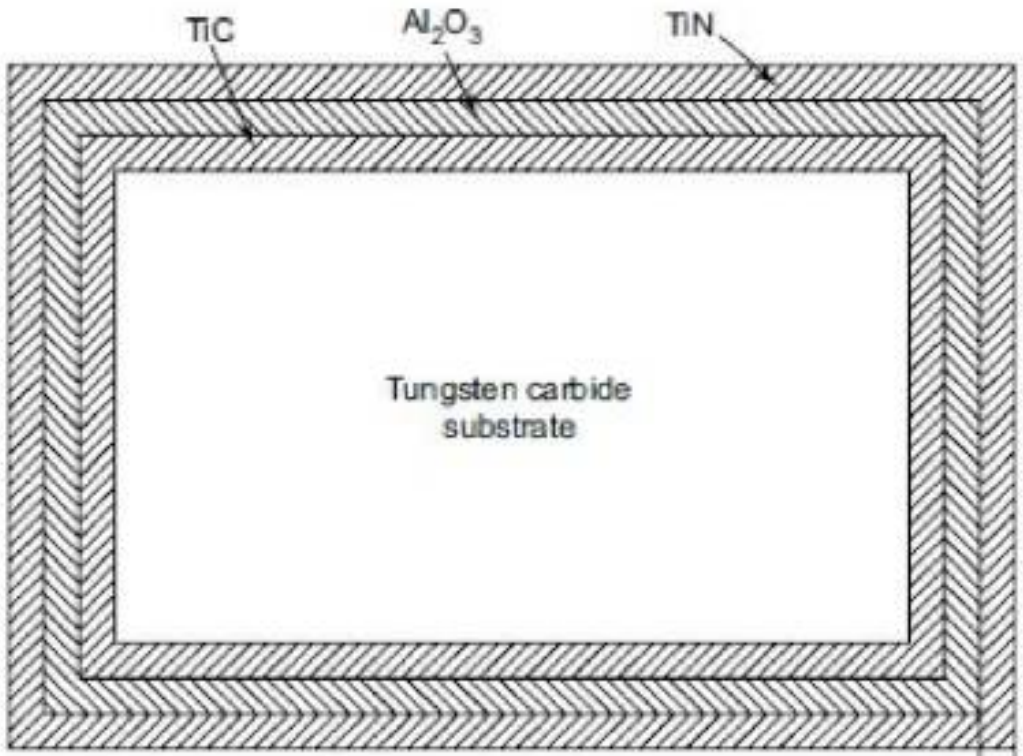
Prevents built up edge

Alumina (Al_2O_3)

Provide resistance to heat

Types of Cutting Tool Materials

Coated Carbides



Multicoated carbide tool

Pic Source-Google images (ebook-PN Rao, Manufacturing Technology Vol 2)

Types of Cutting Tool Materials

5. Ceramics

- Alumina **(Al_2O_3)** based high refractory materials introduced specifically for high speed machining of difficult to machine materials like Cast Iron (mirror finish), constructed mainly from Al_2O_3 , SiN
- SiC is also added
- Ability to withstand higher temperature (4000˚ F vs 1600˚F of carbides)
- Higher wear resistance, chemically more stable
- Cutting speed 10 m/s
- Not able to withstand thermal shocks very well, brittle, tendency to chipping

Types of Cutting Tool Materials

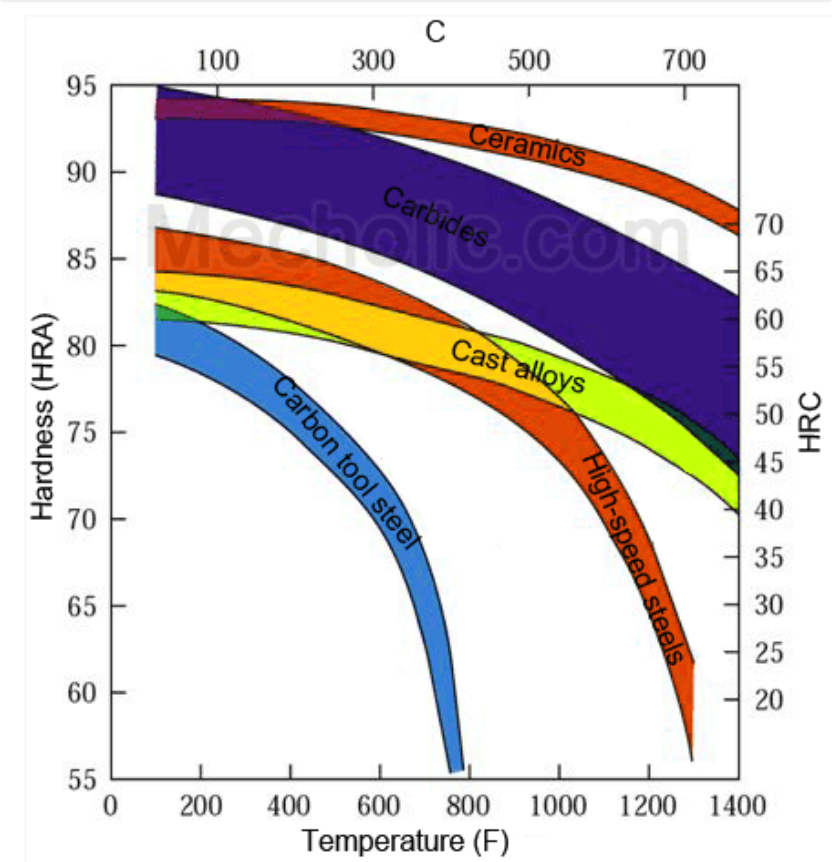
5. Ceramics Contd.

- ZrO_2 (2 to 5 wt%) to increase fracture toughness
- Not suitable for intermittent cutting
- Sometimes TiC, TiN, Ti diboride (TiB_2) added to enhance transverse rupture strength (flexural strength), hardness and thermal shock resistance
- Softening of w/p material allows deeper and cleaner cuts
- Ideal machining temperature for Ni alloys 2200˚ F can be accomodated by ceramics
- Other types

- Alumina - Ti diboride
- Alumina – Zirconia – Tungsten compound
- Silicon – Al-O-N complex compound

(Less harder than alumina but tougher)

Hot Hardness



Hot hardness of cutting tool material

Pic Source-Google images
(www.mecholic.com

Types of Cutting Tool Materials

6. Cubic Boron Nitride (CBN)

- Knoop Hardness – 4700 Kg/mm2
- Consists of elements Boron and Nitrogen
- CBN has no ‘C’ atoms making it suitable for machining steel
- Used for machining HSS, hardened steel over approx. 54 HRC hardness, Ni based special alloys

Types of Cutting Tool Materials

7. Diamond

- Knoop hardness – 8000 Kg/mm2
- High hradness, good thermal conductivity, low friction, good wear resistance
- High cost
- Allotropic transformation to graphite above 700 ˚C
- Difficulties in shaping it to suitable cutting tool form

Types-

- Natural Diamond- High tool life, impurities (unreliable)
- Polycrystalline Diamond (PCD) – formed in any given shape with substrate of cemented carbide

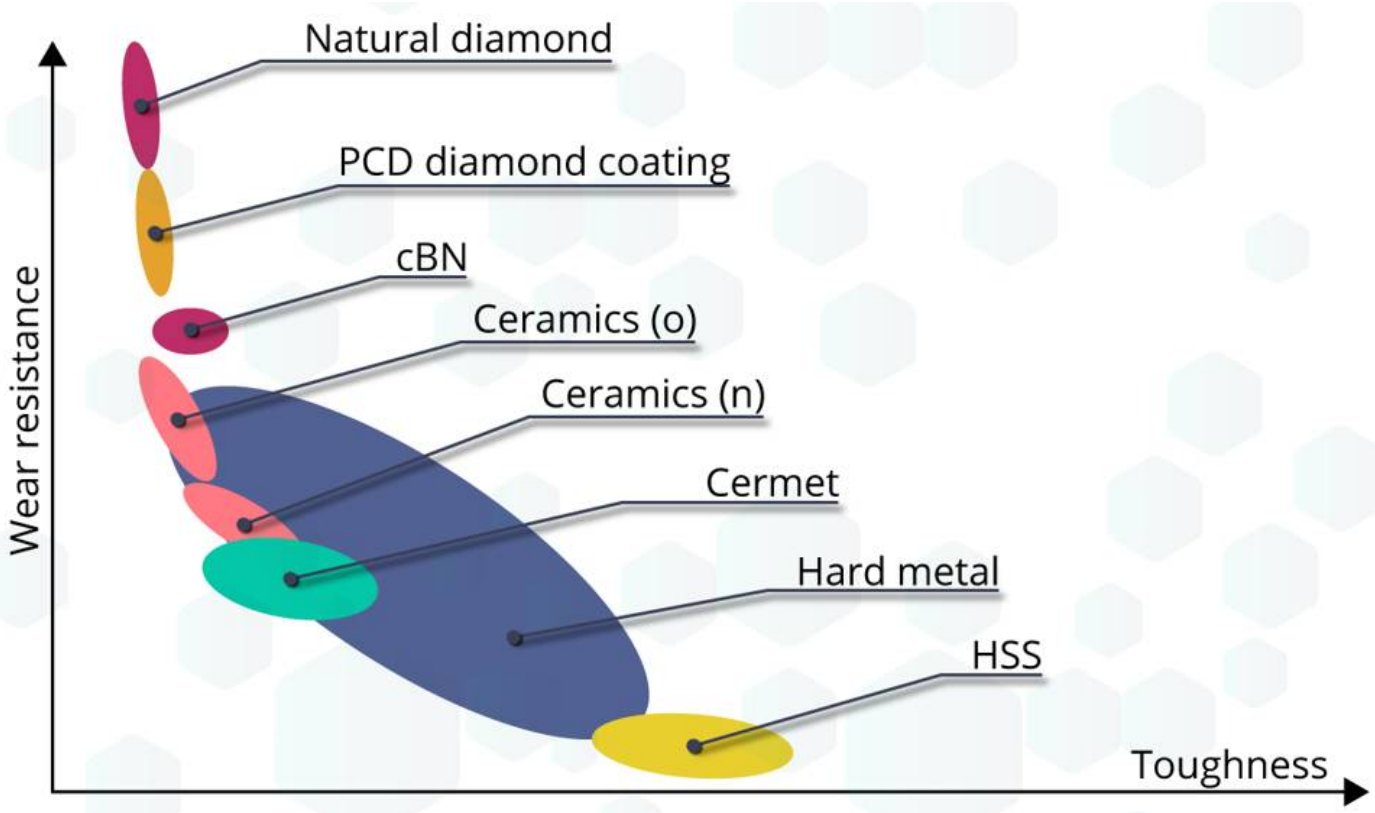
Types of Cutting Tool Materials

- Diamond can machine all carbide metal grades, ceramics
- Steel has high affinity to C, since diamond consists of pure C. So, not suitable for machining steel

  example-

  The high temperature produced in the grinding process cause the steel to extract C atoms from diamond, eroding the diamond grinding grit.

- Due to highest cost, justified only when machining hard materials (difficult to m/c with other tools) or where high accuracy and surface finish is desired
- -15˚ rake angle for hard materials
- 15 ˚ rake angle for soft materials



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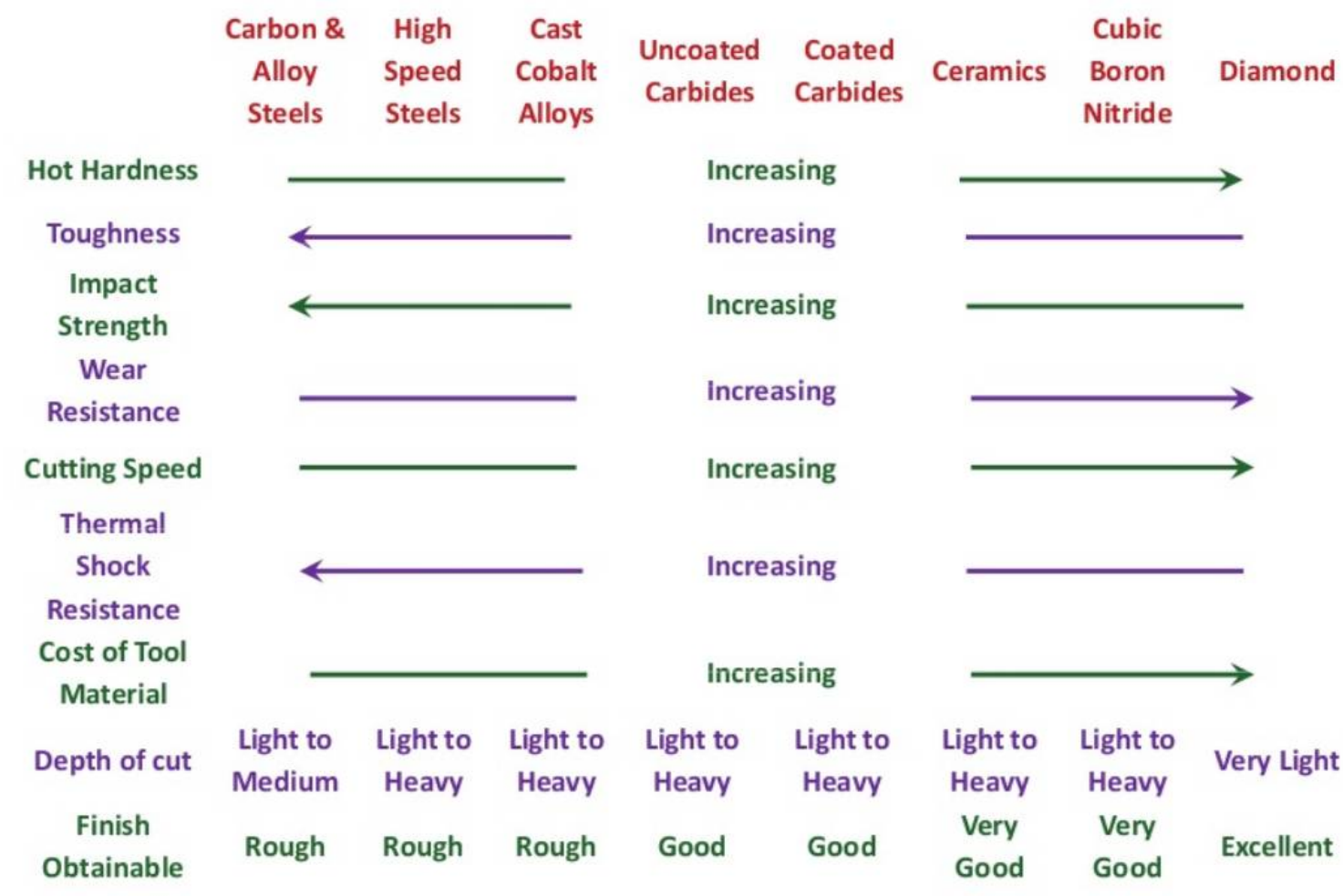
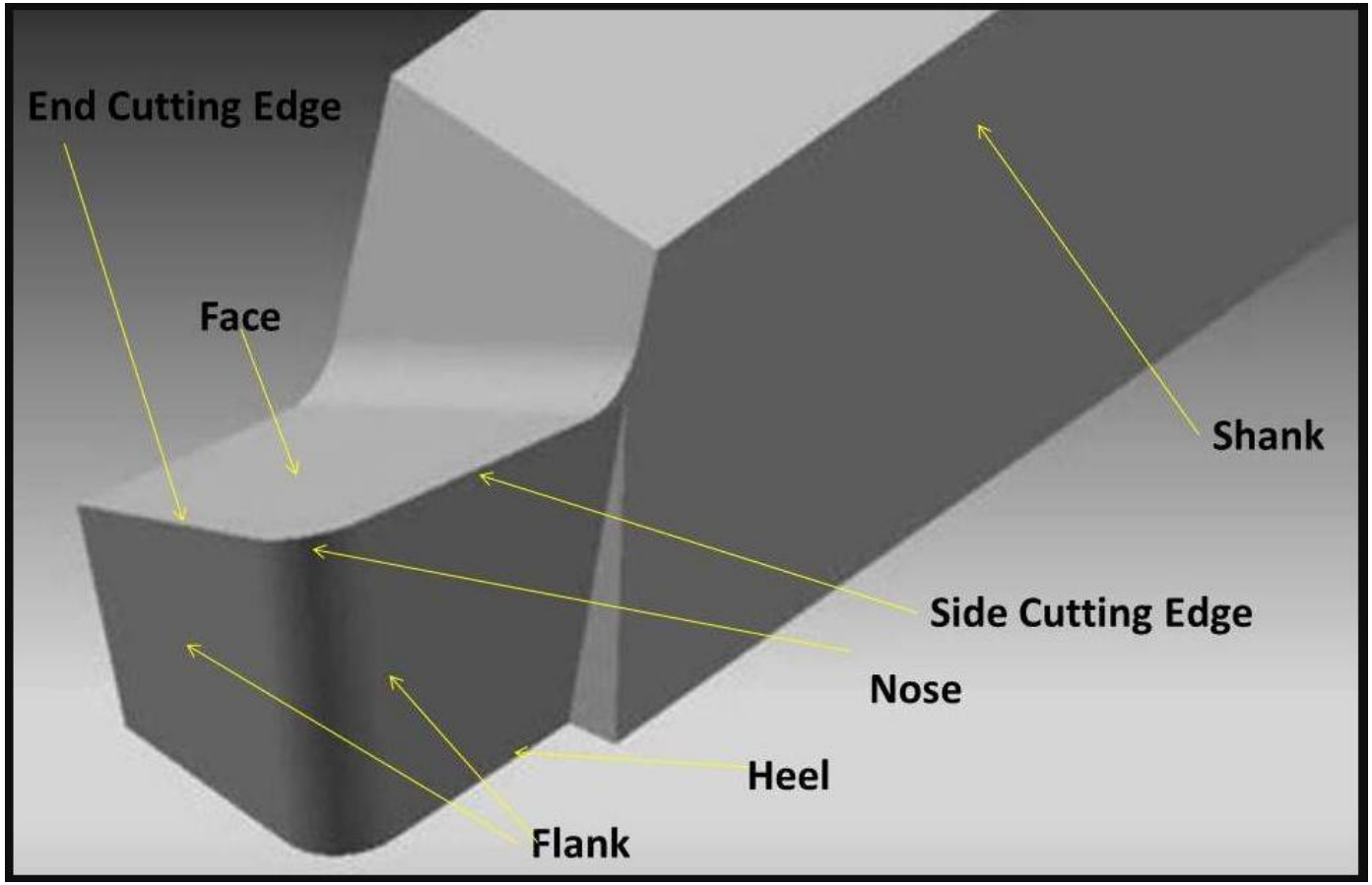
(matmatch.com)

General Properties of Tool Materials



Source- https://www.slideshare.net/rajguptanitw/cutting-tool-materials-60600192

Single Point Cutting Tool Geometry



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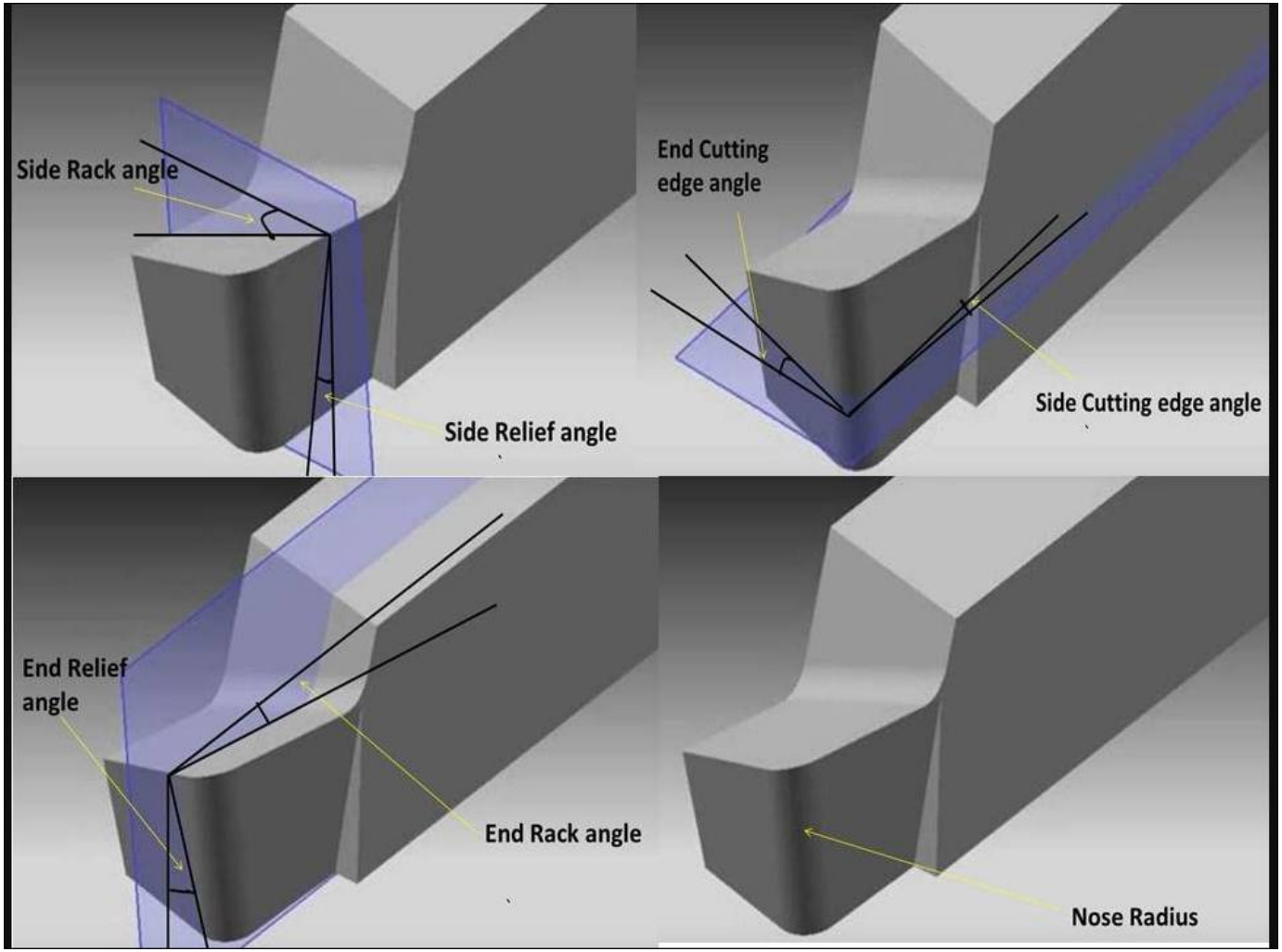
(https://www.mech4study.com)

Single Point Cutting Tool Geometry



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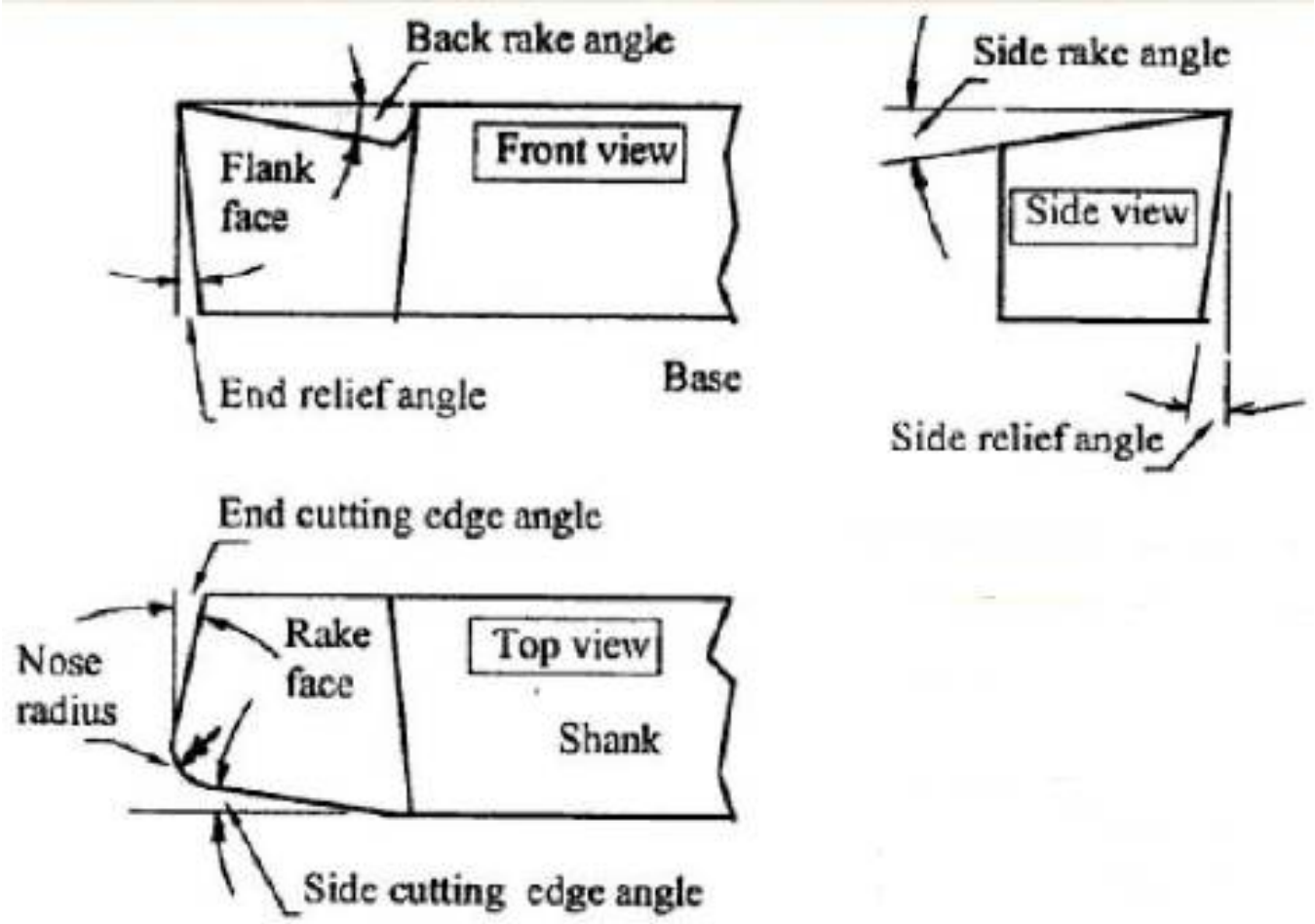
Single Point Cutting Tool Geometry



Pic Source-Google images

Tool Signature

According to the American standard a tool can be designate by seven parameters arranged in a specific manner. It is also known as tool signature. These parameters are all angles and nose radius.

- If a tool has shown by 2, 9, 5, 5, 9, 11, 3 it means

Back rake angle: 2°

Side rake angle: 9°

End relief angle: 5°

Side relief angle: 5°

End cutting edge angle: 9°

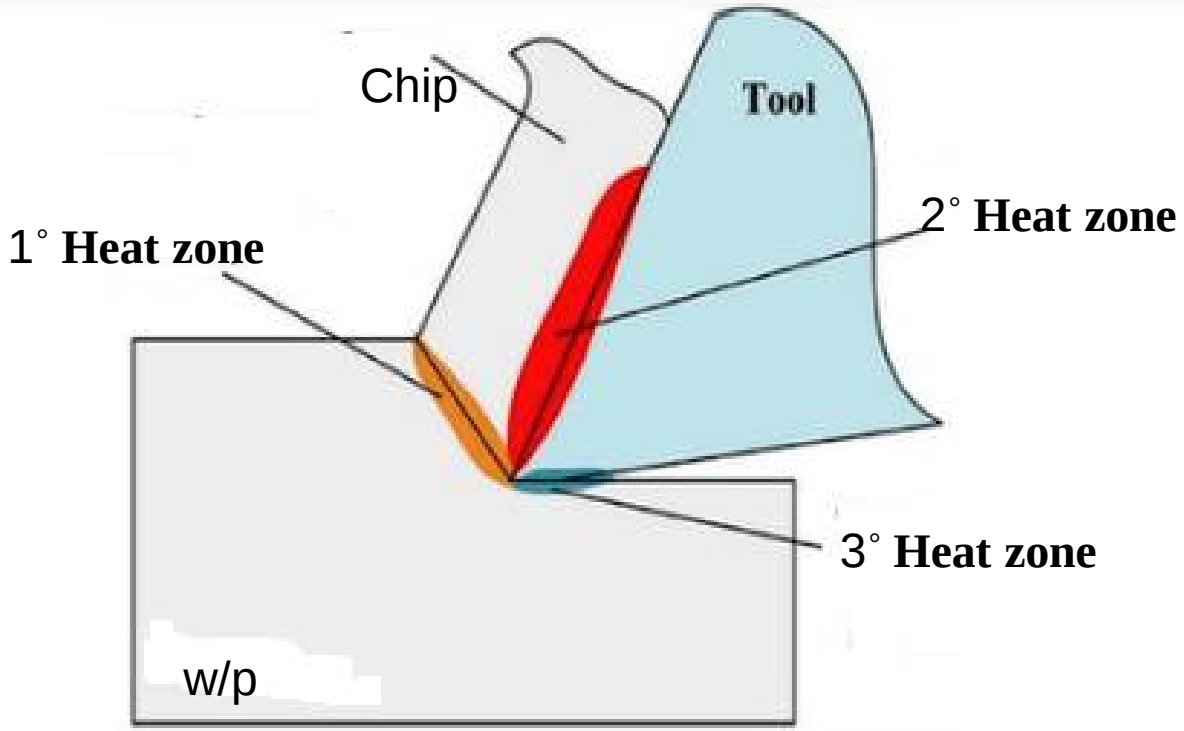
Side cutting edge angle: 11°

Nose radius: 3mm

Cutting Fluids

- Cutting fluids are used in machining work for helping the efficient performance of the tool operation
- In metal machining a lot of heat energy is generated, proves harmful to tool or work or both
- These fluids help in minimizing these adverse effects and thus help to increase tool life and surface finish

Sources of Heat in Metal Cutting



Heat generated = Heat carried by chip, w/p and tool.

Heat carried by chip = 75-80 %

Heat carried by work piece = 15-20 %

Heat carried by tool = 5 to 8 %

Sources of Heat in Metal Cutting

1) Primary heat zone: (Elasto-plastic deformation)

(Around 60 to 65 % energy is converted into heat energy)

2) Secondary heat zone: (Plastic deformation, sticking-sliding friction)

3) Tertiary heat zone: (Friction, elastic deformation)

Heat generated due to friction between tool and work piece entrance.

(Neglecting heat carried away to the atmosphere)

Functions of Cutting Fluids

Primary Function- to control the total heat

Basic actions of Cutting Fluids-

- to cool the tool and w/p
- to reduce the friction
- to reduce the energy consumption
- to increase tool life due to cooling effects
- to improve the surface finish
- to wash away chips from the cutting zone

Pic Source- https://news.cision.com/q8oils/i/q8-cutting-fluids-are-being-used-to-machine-316l-stainless-steel,c1413363)

Mechanism of Cutting Fluids

- **Cooling action**

  - ✓ Most of the tool wear mechanism are thermally activated
  - ✓ Cooling chip tool interface helps in retaining original properties of tool
  - ✓ Increased tool life

- **Lubricating action**

  - ✓ Reduces heat generated, thus reducing energy required

Types of Cutting Fluids

- **Water based emulsions**
  - High heat carrying capacity
  - Cheap and easily available
  - Low viscosity (easily penetrates cutting zone)
  - Corrodes work material very quickly, at high tempt.
  - Other materials added (water soluble oils) to improve properties

Types of Cutting Fluids

- **Mineral Oils**
  - Fats of fossil origin
  - Lubrication and rust prevention
  - Chemically stable
  - Limited to light duty application only
- **Mineral Oils with additives**
  - Largest variety available commercially
  - Improve load carrying capacity (fatty oils)
  - EP (Extreme Pressure) additives (Cl, S) for more difficult machining situations
  - Form anti-welding layer of solid lubricant precisely where required

Cutting Fluid Selection

- Work piece material
- Cutting tool material
- Machining operation

- ✓ For general machining water based cutting fluids
- ✓ For heavy duty work EP based cutting fluids
- ✓ EP based oils reduce problem of adhesion of chip with tool


THANK YOU