Cutting Tool Technology

Two principal aspects:

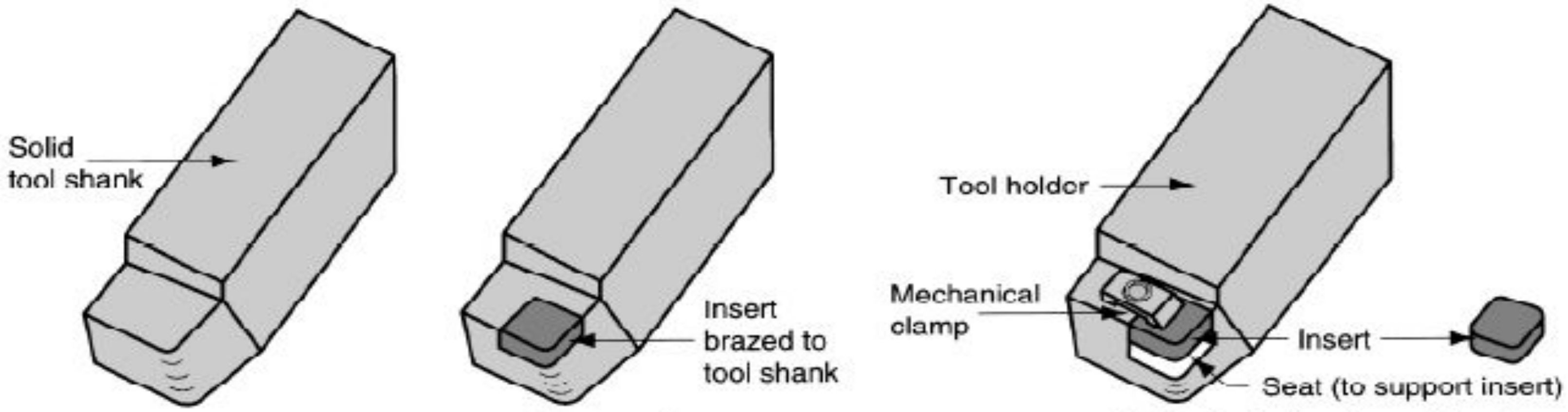
- 1. Tool geometry
- 2. Tool material

CLASSIFICATION

According to the number of major cutting edges (points) involved as follows:

- 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



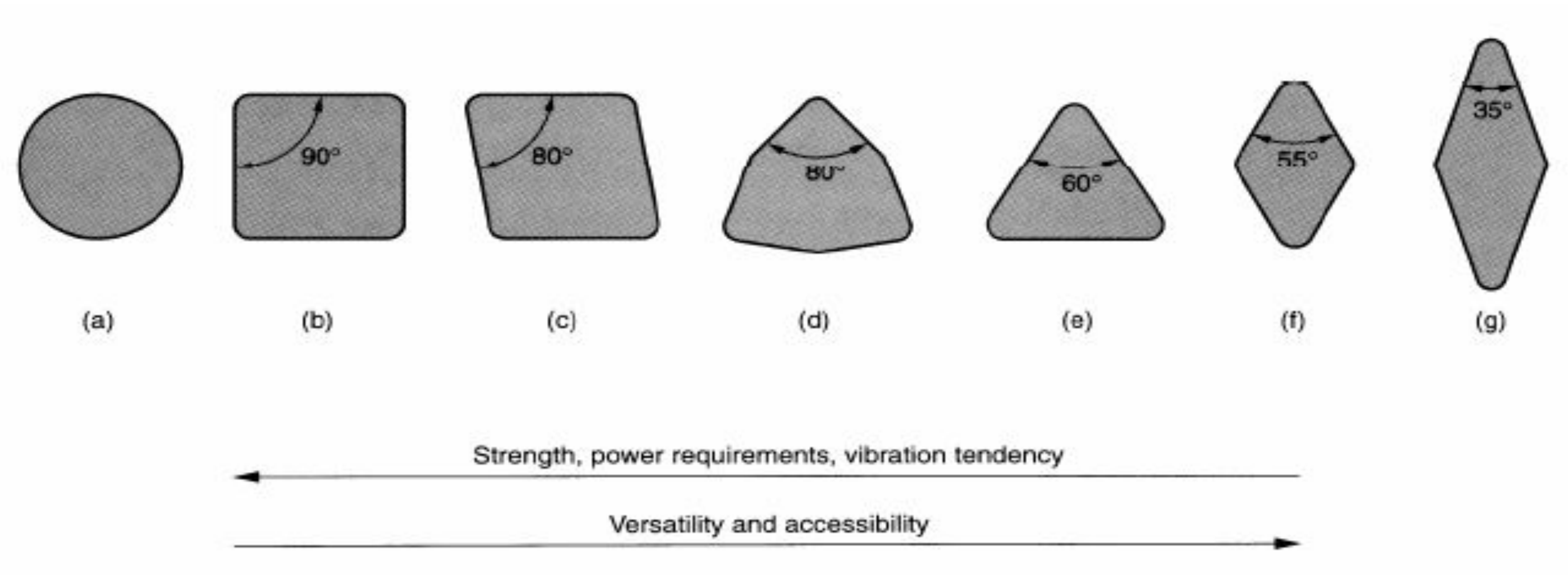
(a) Solid tool
(b) Brazed insert
(c) Mechanically clamped insert

Three ways of holding and presenting the cutting edge for a single-point tool:

(a) solid tool, typical of HSS;

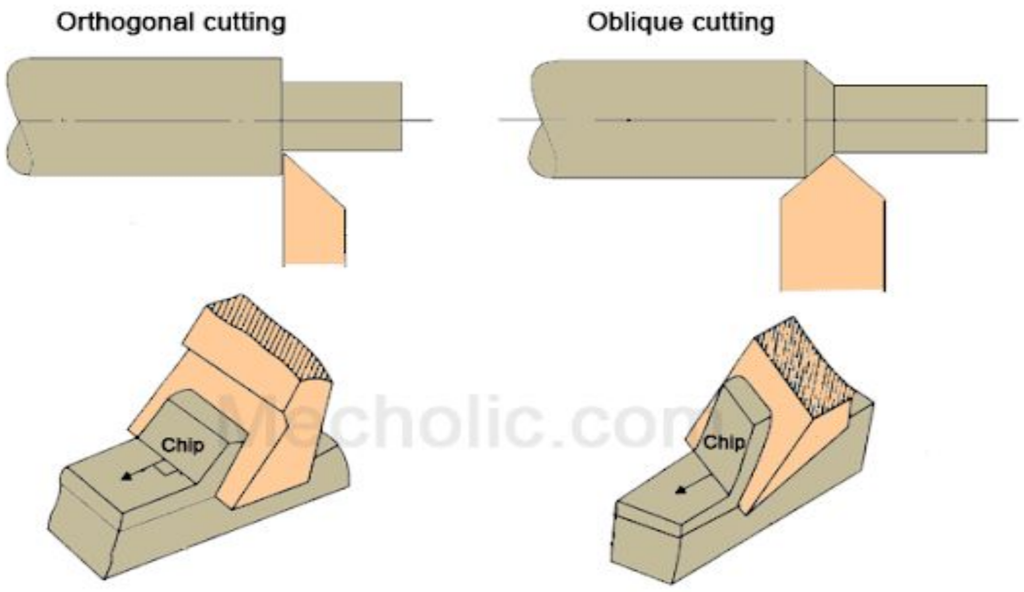
(b) brazed insert, one way of holding a cemented carbide insert; and

(c) mechanically clamped insert, used for cemented carbides, ceramics,



Common insert shapes: (a) round, (b) square, (c) rhombus with two 80□point angles, (d) hexagon with three 80□point angles, (e) triangle (equilateral), (f) rhombus with two 55□ point angles, (g) rhombus with two 35□point angles. Also shown are typical features of the geometry.

S. No	Orthogonal Cutting	Oblique Cutting
1	The cutting angle of tool make right angle to the direction of motion	The cutting angle of tool does not make right angle to the direction of motion
2	The flow of chip is perpendicular to cutting edge.	The flow of chip is not perpendicular to cutting edge.
3	The tool has lesser cutting life.	The tool has higher cutting life.
4	The shear force per unit area is high which increases the heat per unit area.	The shear force per unit area is low which decrease heat per unit area .
5	In this cutting, chip flow over the tool.	In this cutting, chip flow along the sideways.
6	In orthogonal cutting, surface fiish is poor.	In oblique cutting surface finish is good.
7	Cutting edge is longer than edge of cut.	Cutting may or may not be longer than edge of cut.
8	Two mutually perpendicular cutting force act on the workpiece	Three mutually perpendicular forces are involved .



Types of chips in Metal Cutting

The various types of chips in metal cutting are

- Continuous chips
- Discontinuous chips &
- Continuous chips with built-up edge (or BUE chips)

Types of chips in Metal Cutting

1. Continuous chips

According to its name, continuous chips have a continuous segment. This chip is form during cutting of ductile material like aluminum, mild steal, cooper etc. with a high cutting speed. The friction between tool and material is minimum during this process. This is form due to continuous plastic deformation of the material by application of tool. These chips have equal thickness throughout the length. It generally gives good surface finish.

Types of chips in Metal Cutting

The most favorable conditions of forming continuous chips are

1. Work piece should have ductile in nature.
2. The rake angle should be large.
3. Friction between work piece and tool should minimum.
4. Cutting speed should high.
5. Depth of cut should be small.
6. Proper use of coolant and lubricant.
7. Tool should have low coefficient of friction.

Advantages

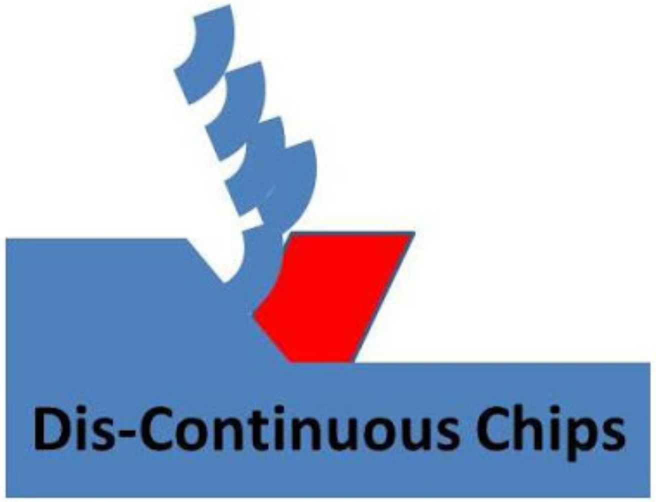
The formation of continuous chips during machining process has the following advantages

- Better surface finish to the ductile material.
- Less heat generation due to minimum friction between the tool face and chip.
- Low power consumption.
- Long tool life due to less wear and tear.

Types of chips in Metal Cutting

2. Discontinuous chips or segmental chips:

According to its name, this chips form in segment. It is form when machining of brittle material like cast iron, brass etc. with slow cutting speed. Chips cut into small segment during cutting. This is formed during slow cutting speed with small rake angle. This chips form in ductile material when the friction between tool and work piece is high. Discontinuous chips in ductile material give poor surface finish and slow machine. It is suitable form of chips of machining brittle material.



Types of chips in Metal Cutting

Conditions which are responsible for the formation of discontinuous chips are:

- Low feed rate.
- Small rake angle of the tool.
- High cutting speed.
- High friction forces at the chip tool interface.
- Too much depth of cut.

Advantages

- The formation of discontinuous types of chips in brittle materials provides good surface finish, increases the tool life and reduces the consumption of power.

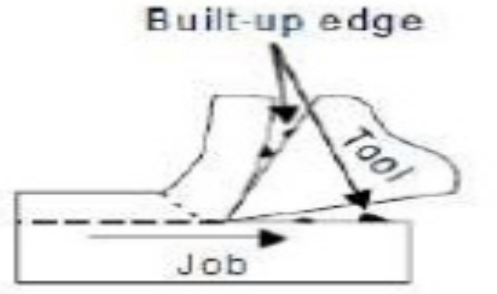
Disadvantages

- When discontinuous chips are formed in the ductile materials, the workpiece result in poor surface finish and excessive wear and tear of the tool takes place.

Types of chips in Metal Cutting

3. Continuous Chips with built up edge:

This type of chip is same as the continuous chips except a built edge is form at the face of tool. It is form during machining of ductile metal with excessive friction between tool and work piece. This chip is not smooth as continuous chips. The built up edge form due to high temperature between tool and work piece. This high temperature is due to high friction force between tool and work piece.



(c) Chips with built-up edge

Types of chips in Metal Cutting

The factors which are responsible for promoting the formation of the BUE chips are:

- Excessive feed rate.
- The small rake angle of the tool.
- Low cutting speed.
- Lack of coolant and this increase the friction between the chip tool interfaces.

Advantages

- The making of the BUE has one advantage i.e. it protects the tool from getting damaged from high friction and temperature generated during the machining process and hence the tool life increases.

Disadvantages

- The formation of these types of chips results in rough surface finish, change in the rake angle and cutting forces.

Types of chips in Metal Cutting

S.no	Factors	Continuous Chips	Discontinuous Chips	Continuous chips with Built Up Edge (BUE)
1.	**Material types**	Ductile	Brittle, ductile but hard	Ductile
2.	**Rake angle**	Large	Small	Small
3.	**Cutting speed**	High	Medium or high	Low or medium
4.	**Friction between chip tool interface**	Minimum	Maximum	Maximum
5.	**Depth of cut**	Small	High	Medium

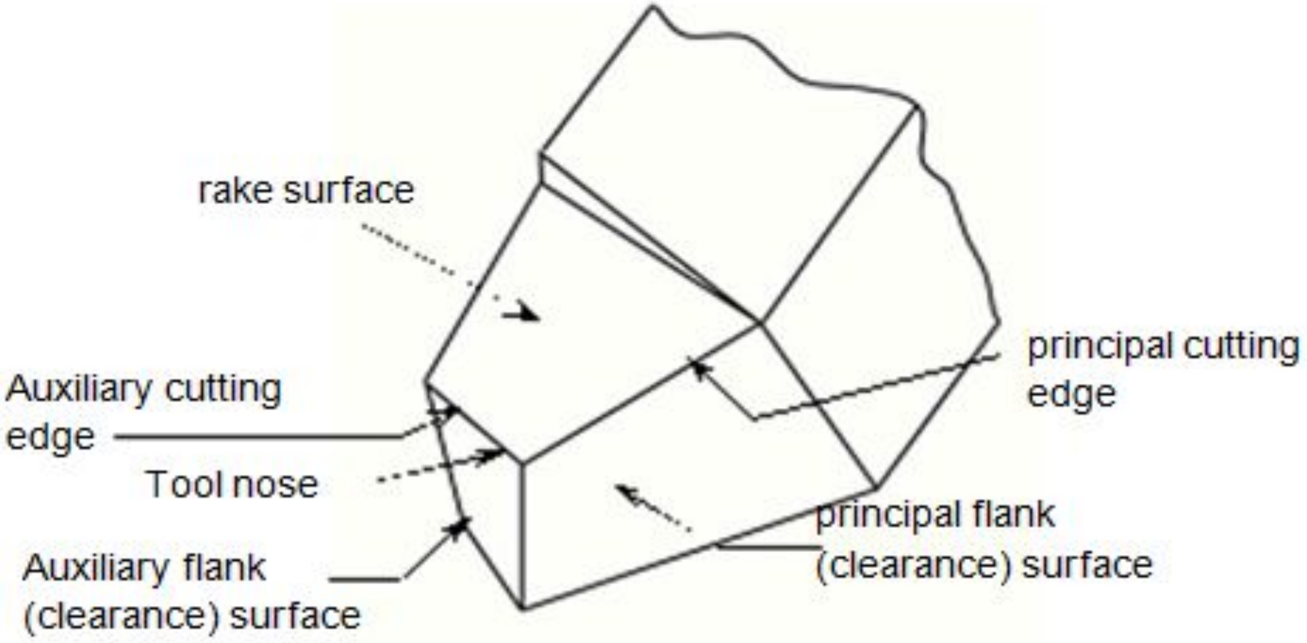
What is tool signature ? And what are the different systems of specifying tool geometry?

- In simple words The numerical code that describes all the key angles of a given cutting tool is called tool signature

- Convenient way to specify tool angles by use of standardized abbreviated system is known as tool signature or tool nomenclature. The tool signature comprises of seven elements and is specified in different systems .

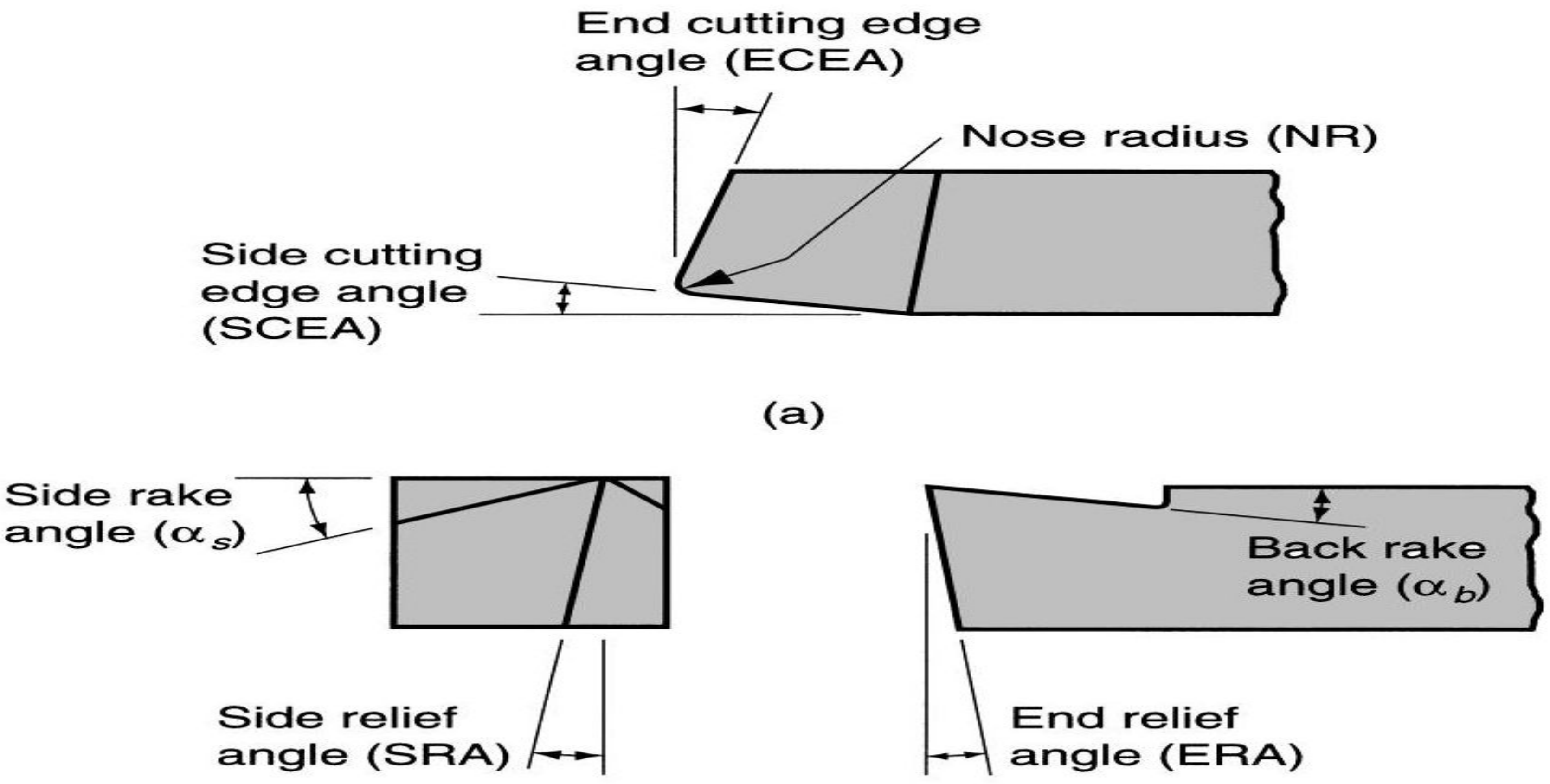
1. Tool-in-Hand System

- There is no quantitative information, i.e., value of the angles.



IMPORTANT TERMS OF SINGLE POINT CUTTING TOOL

- seven element defining the tool signature



(b) Tool signature: α_b, α_s, ERA, SRA, ECEA, SCEA, NR

Tool Wear

- **Meaning of Tool Wear:**
- Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to-metal contact between the chip and work piece, under high stress and temperature. The situation becomes severe due to the existence of extreme stress and temperature gradients near the surface of the tool.
- Tool wear is generally a gradual process due to regular operation. Tool wear can be compare with the wear of the tip of an ordinary pencil. According to Australian standard, the tool wear can be defined as “The change of shape of the tool from its original shape, during cutting, resulting from the gradual loss of tool material”.

Tool Wear

Tool wear depends upon following parameters:

i. Tool and work piece material.

ii. Tool shape.

iii. Cutting Speed.

iv. Feed.

v. Depth of cut.

vi. Cutting fluid used.

vii. Machine Tool characteristics etc.

Tool wear affects following items:

i. Increased cutting forces.

ii. Increased cutting temperature.

iii. Decreased accuracy of produced parts.

iv. Decreased tool life

v. Poor surface finish

vii. Economics of cutting operations

Types of Wear

(i) Flank wear.

(ii) Crater wear.

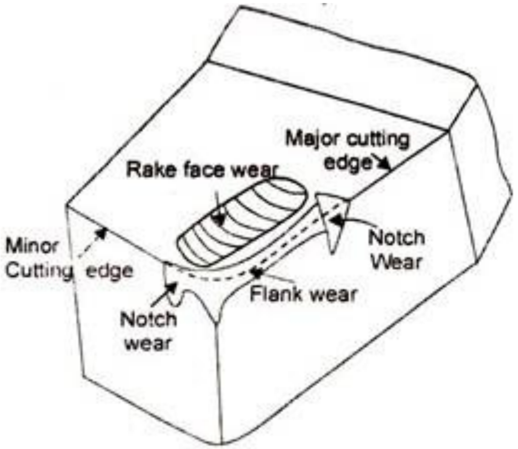


Fig. 9.16. (*a*) Tool Wear Phenomena.

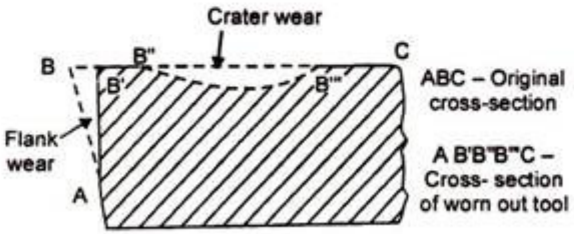
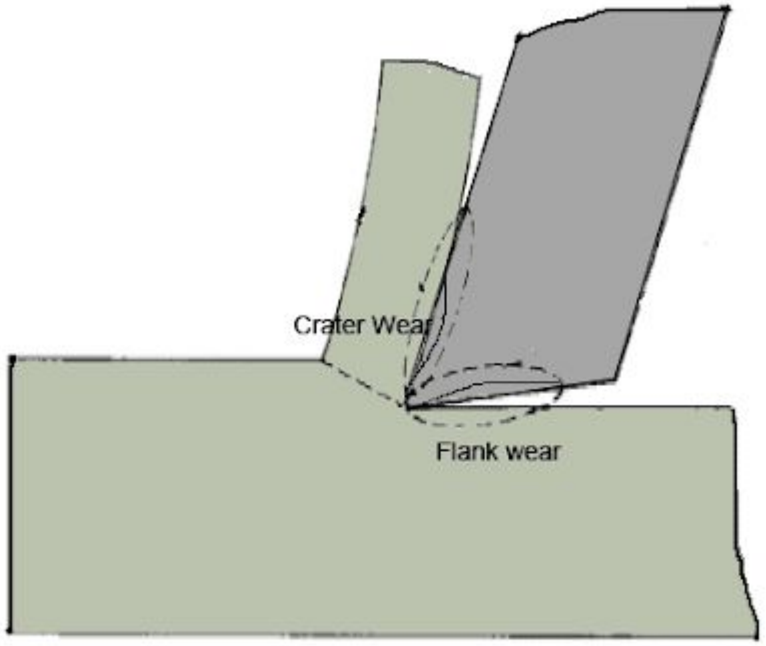


Fig. 9.16. (*b*) Flank and Crater wear.

Types of Wear

(i) Flank Wear:

Wear on the flank face (relief or clearance face) of the tool is called flank wear



Types of Wear

Reasons of Flank Wear:

- Increased cutting speed causes flank to wear grow rapidly.
- Increase in feed and depth of cut can also result in larger flank wear.
- Abrasion by hard panicles in the work piece.
- Shearing of micro welds between tool and work-material.
- Abrasion by fragments of built-up edge, which strike against the clearance face (Flank face) of the tool.

Remedies for Flank Wear:

- Reduce cutting speed.
- Reduce feed and depth of cut.
- Use hard grade of carbide if possible.
- Prevent formation of built-up edge, using chip breakers.

Types of Wear

The characteristics of flank wear are following:

i. It is the most important wear that appears on the flank surface parallel to the cutting edge. It is most commonly results from abrasive/adhesive wear of the cutting edge against the machined surface.

ii. It is generally results from high temperatures, which affect tool and work material properties.

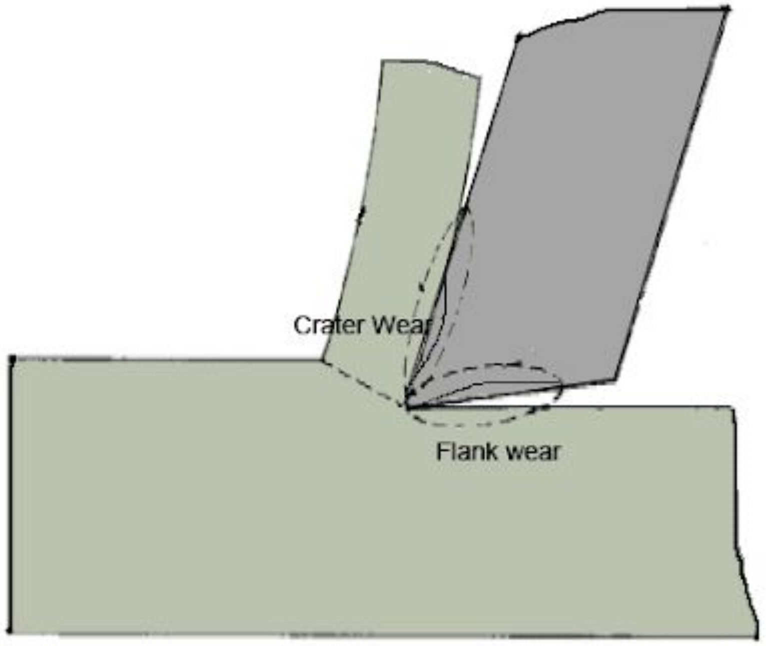
Effects of Flank Wear:

- Increase in the total cutting force.
- Increase in component surface roughness.
- Also affect the component dimensional accuracy.
- When form tools are used, flank wear will also change the shape of the components produced

Types of Wear

(ii) Crater Wear:

Wear on the rake face of the tool is called crater wear. As the name suggests, the shape of wear is that of a crater or a bowl.



Types of Wear

The characteristics of crater wear are following:

i. In crater wear chips erodes the rake face of tool.

ii. The chips flows across the rake face develop severe friction between the chip and rake face. This produces a scar on the rake face which is usually parallel to the major cutting edge.

iii. It is somewhat normal for tool wear and does not seriously degrade the use of a tool until it becomes serious enough to cause a cutting edge failure.

iv. The crater wear can increase the working rake angle and reduce the cutting force, but it will also weaken the strength of the cutting edge.

v. It is more common in ductile materials like steel which produce long continuous chips. It is also more common in H.S.S. (High Speed Steel) tools than the ceramic or carbide tools which have much higher hot hardness.

Types of Wear

Reasons of Crater Wear:

- Severe abrasion between the chip-tool interfaces, specially on rake face.
- High temperature in the tool-chip interface.
- Increase in feed results in increased force acting on tool interface, this leads to rise in temperature of tool-chip interface.
- Increase in cutting speed results in increased chip velocity at rake face, this leads to rise in temperature at chip-tool interface and so increase in crater wear.

Remedies for Crater Wear:

- Use of proper lubricants, can decrease the abrasion process, and so decrease in crater wear.
- Proper coolant for rapid heat dissipation from tool-chip interface.
- Reduced cutting speeds and feed rates.
- Use tougher and hot hardness materials for tools.
- Use positive rake tool.

Causes of Tool Wear

There are large numbers of causes for tool wear.

(i) Abrasive wear (Hard particle wear).

(ii) Adhesive wear.

(iii) Diffusion wear.

(iv) Chemical wear.

(v) Fracture wear.

Causes of Tool Wear

(i) Abrasive Wear (Hard Particle Wear):

Abrasive wear is basically caused by the impurities within the work piece material, such as carbon nitride and oxide compounds, as well as the built-up edge fragments. It is a mechanical type of wear. It is the main cause of the tool wear at low cutting speeds.

(ii) Adhesive Wear:

Due to high pressure and temperature at tool-chip interface, there is a tendency of hot chips to weld on to the tool rake face. This concept leads to subsequently formation and destruction of welded junctions. When the weld intermittently breaks away picking particles of cutting tool. This leads to a crater wear.

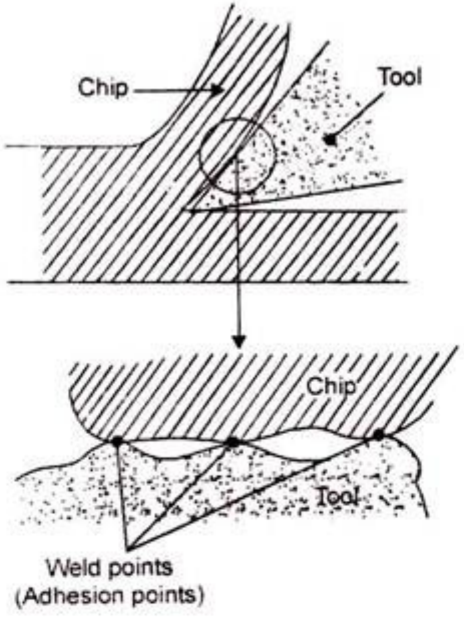


Fig. 9.19. Adhesion Wear.

Causes of Tool Wear

(iii) Diffusion Wear:

Diffusion wear is usually caused by atomic transfer between contacting materials under high pressure and temperature conditions. This phenomena starts at chip-tool interface. At such elevated temperatures, some particles of tool materials diffuse into the chip material. It can also happen that some particles of work material also diffuse into the tool materials.

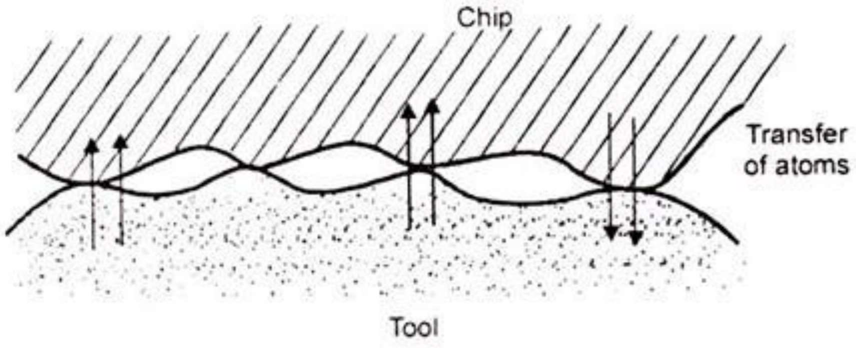


Fig. 9.20. Diffusion Wear.

Causes of Tool Wear

(iv) Chemical Wear:

The chemical wear is caused due to chemical attack of a surface.

(v) Facture Wear:

The facture wear usually caused by breaking of edge at end or length. The bulk breakage is the most harmful and undesirable type of wear, and it should be avoided as far as possible.

Cutting tool parameters

- **Cutting Speed (V):**
- It is the speed at which the metal is removed by the cutting tool from the workpiece. In case of lathe machine cutting speed is the peripheral speed of the work past the cutting tool. It is expressed in meter/min. or mm/min.
- Cutting speed (V) = π DN/60 × 1000 mm/min
- Where, D = diameter of the workpiece (mm)
- N = rpm of the work

Cutting tool parameters

Feed (f):

- It is the relative motion of tool in one revolution of workpiece. It is expressed in mm/rev.

Depth of Cut (t):

- It is the total amount of metal removed per pass of the cutting tool. It is expressed in mm. It can vary and depending upon the type of tool and work material. Mathematically, it is half of difference of diameters.
- Depth of cut (t) = D-d/2 mm

Cutting-Tool Materials

- Tool bits generally made of seven materials
  - High-speed steel
  - Cast alloys (such as stellite)
  - Cemented carbides
  - Ceramics
  - Cermets
  - Cubic Boron Nitride
  - Polycrystalline Diamond

Cutting Tool Properties

- Hardness
  - Cutting tool material must be 1 1/2 times harder than the material it is being used to machine.

- Capable of maintaining a red hardness during machining operation
  - Red hardness: ability of cutting tool to maintain sharp cutting edge
  - Also referred to as hot hardness or hot strength

Cutting Tool Properties

- Wear Resistance
  - Able to maintain sharpened edge throughout the cutting operation
  - Same as abrasive resistance

- Shock Resistance
  - Able to take the cutting loads and forces

- Shape and Configuration
  - Must be available for use in different sizes and shapes.

High-Speed Steel

- Highly alloyed tool steel capable of maintaining hardness at elevated temperatures better than high carbon and low alloy steels
- May contain combinations of tungsten, chromium, vanadium, molybdenum, cobalt
- Can take heavy cuts, withstand shock and maintain sharp cutting edge under red heat
- Especially suited to applications involving complicated tool geometries, such as drills, taps, milling cutters, and broaches
- Generally two types (general purpose)
    - Molybdenum-base (Group M)
    - Tungsten-base (Group T)
- Cobalt added if more red hardness desired

- Typical composition:

  Grade T1: 18% W, 4% Cr, 1% V, and 0.9% C

Cast Alloy

- Usually contain 25% to 35% chromium, 4% to 25% tungsten and 1% to 3% carbon
  - Remainder cobalt
- Qualities
  - High hardness
  - High resistance to wear
  - Excellent red-hardness
- Operate 2 ½ times speed of high-speed steel
- Weaker and more brittle than high-speed steel

Cemented Carbides

- Class of hard tool material based on tungsten carbide (WC) using powder metallurgy techniques with cobalt (Co) as the binder

- Two basic types:
    1. Non-steel cutting grades - only WC-Co
    2. Steel cutting grades - TiC and TaC added to WC-Co

Cemented Carbides -General Properties

- High compressive strength but low-to-moderate tensile strength
- High hardness (90 to 95 HRA)
- Good hot hardness
- Good wear resistance
- High thermal conductivity
- Toughness lower than high speed steel

Non-steel Cutting Carbide Grades

- Used for nonferrous metals and gray cast iron

- Properties determined by grain size and cobalt content
  - As grain size increases, hardness and hot hardness decrease, but toughness increases
  - As cobalt content increases, toughness improves at the expense of hardness and wear resistance

Steel Cutting Carbide Grades

- Used for low carbon, stainless, and other alloy steels
- For these grades, TiC and/or TaC are substituted for some of the WC
- Titanium carbide
  - Addition provides resistance to tool cratering
  - Content increased
    - Toughness of tool decreased
    - Abrasive wear resistance at cutting edge lowered
- Tantalum carbide
  - Addition provides resistance to tool cratering
    - Without affecting abrasive wear resistance
  - Addition increases tool's resistance to deformation

Cermets

- Combinations of TiC, TiN, and titanium carbonitride (TiCN), with nickel and/or molybdenum as binders.
  - Some chemistries are more complex
  - Applications: high speed finishing and semi finishing of steels, stainless steels, and cast irons
- Higher speeds and lower feeds than steel-cutting carbide grades
- Better finish achieved, often eliminating need for grinding

Coated Carbides

- Cemented carbide insert coated with one or more thin layers of wear resistant materials, such as TiC, TiN, and/or Al_2O_3
    - Coating applied by chemical vapor deposition or
- physical vapor deposition
    - Coating thickness (0.0001 to 0.0005 in)
- Applications:
    - cast irons and steels in turning and milling operations
    - Best applied at high speeds where dynamic force and thermal shock are minimal

Ceramics

- Primarily fine-grained Al_2O_3, pressed and sintered at high pressures and temperatures into insert form with no binder
  - Applications: high speed turning of cast iron and steel
  - Not recommended for heavy interrupted cuts (e.g. rough milling) due to low toughness
  - Al_2O_3 also widely used as an abrasive in grinding

Synthetic Diamonds

- *Sintered polycrystalline diamond* (SPD) - fabricated by sintering very fine-grained diamond crystals under high temperatures and pressures into desired shape with little or no binder

  - Usually applied as coating (0.5 mm thick) on WC-Co insert

  - Applications: high speed machining of nonferrous metals and abrasive nonmetals such as fiberglass, graphite, and wood
    - Not for steel cutting

Cubic Boron Nitride

- *cubic boron nitride* (cBN) is hardest material
  - Fabrication into cutting tool inserts same as SPD: coatings on WC-Co inserts
  - Applications: machining steel and nickel-based alloys
  - SPD and cBN tools are expensive

CUTTING FORCES IN METAL CUTTING

- We need to determine the cutting forces in turning for
- Estimation of cutting power consumption, which also enables selection of the power source(s) during design of the machine tools
- Structural design of the machine – fixture – tool system
- Evaluation of role of the various machining parameters (tool material and geometry, environment – cutting fluid) on cutting forces
- Study of behaviour and machinability characterization of the work materials
- Condition monitoring of the cutting tools and machine tools.

Merchant's Circle Diagram

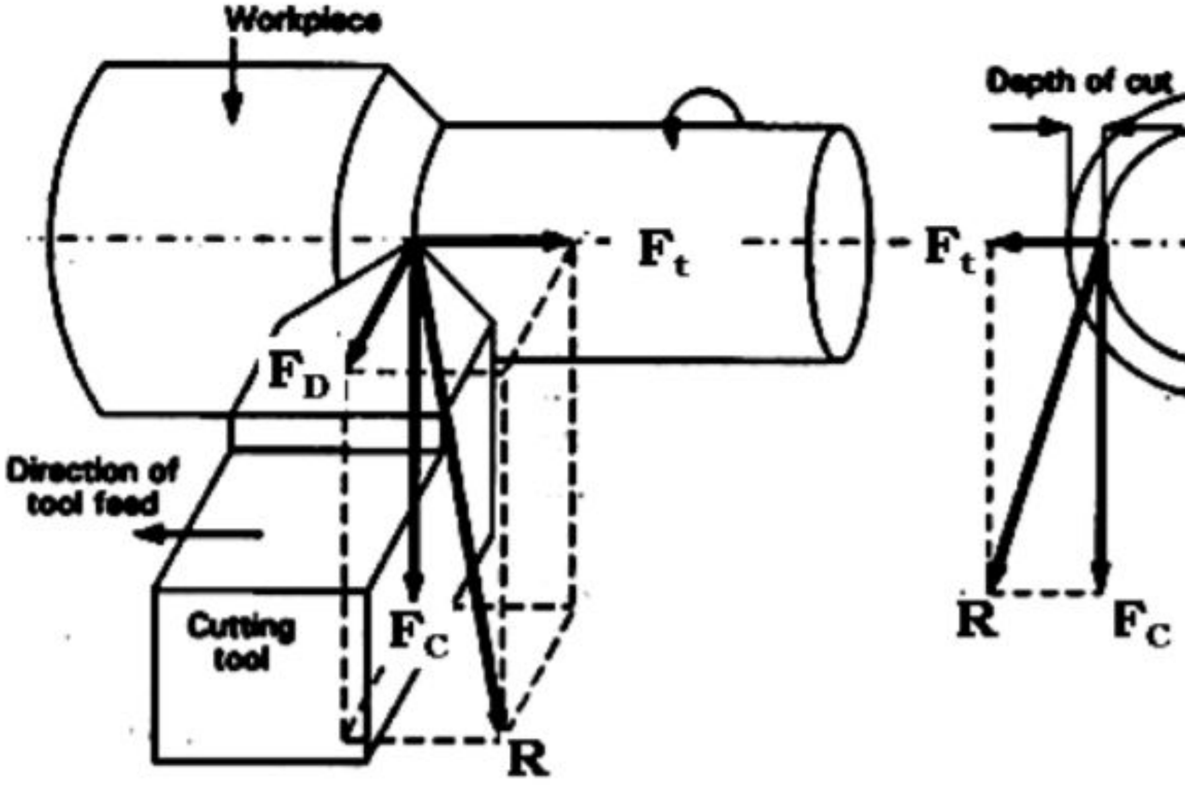
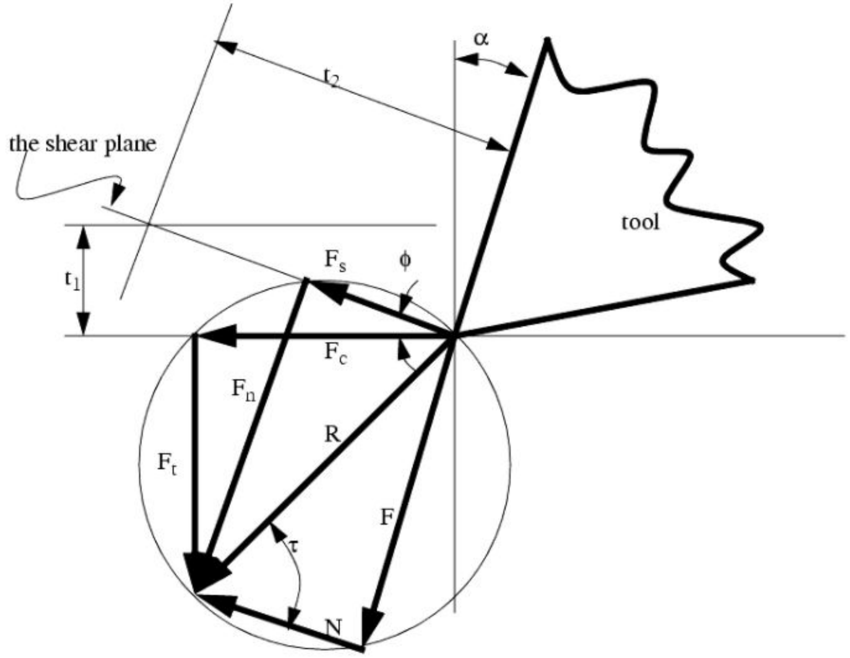


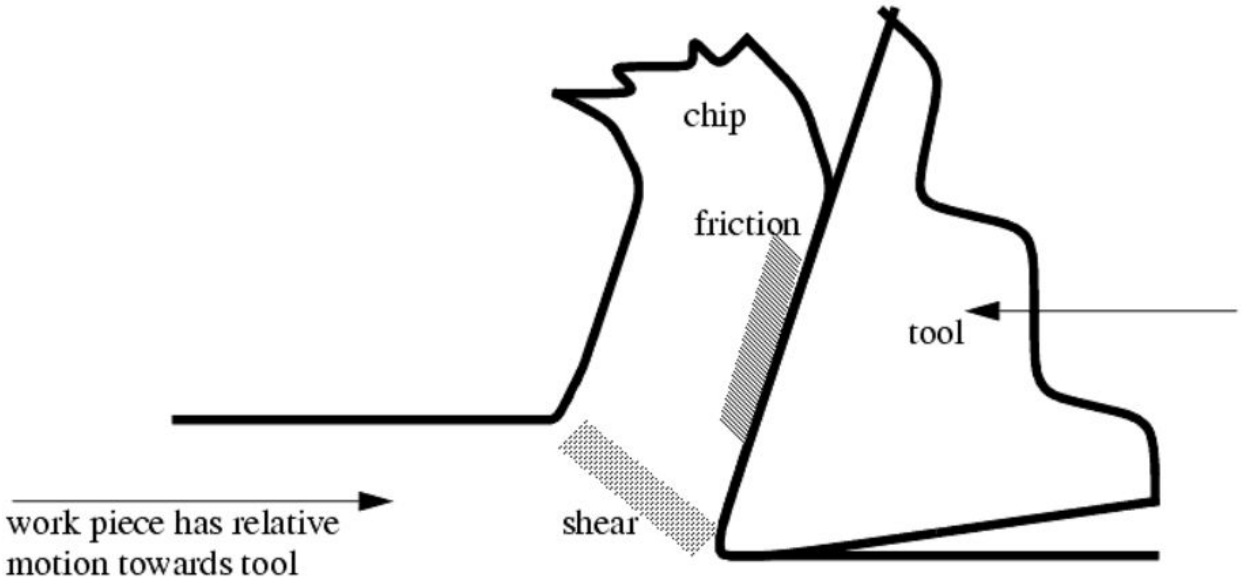
Fig.1: Cutting forces in a turning operation.



F_s = shear force
F_n = force normal to shear plane
α = tool rake angle (positive as shown)
ϕ = shear angle
τ = friction angle

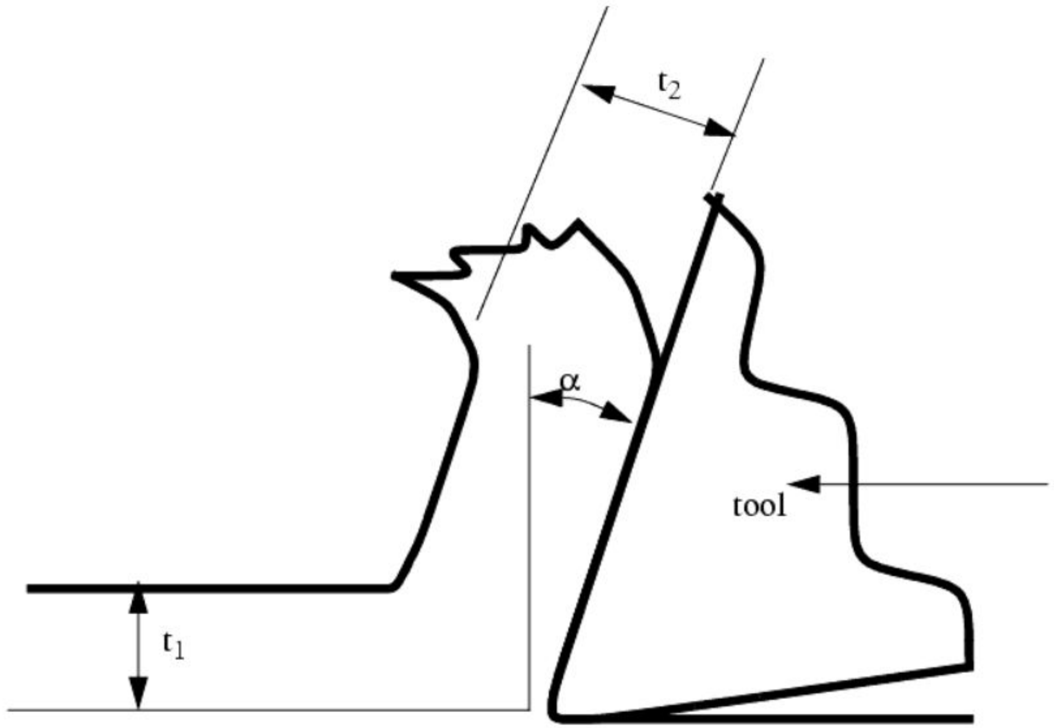
Merchant's Circle Diagram

- Assuming that the cutting action is continuous we can develop a continuous model of cutting conditions.
- Orthogonal Cutting - assumes that the cutting edge of the tool is set in a position that is perpendicular to the direction of relative work or tool motion. This allows us to deal with forces that act only in one plane.



Merchant's Circle Diagram

- We can obtain orthogonal cutting by turning a thin walled tube, and setting the lath bit cutting edge perpendicular to the tube axis.
- Next, we can begin to consider cutting forces, chip thicknesses, etc.
- First, consider the physical geometry of cutting,



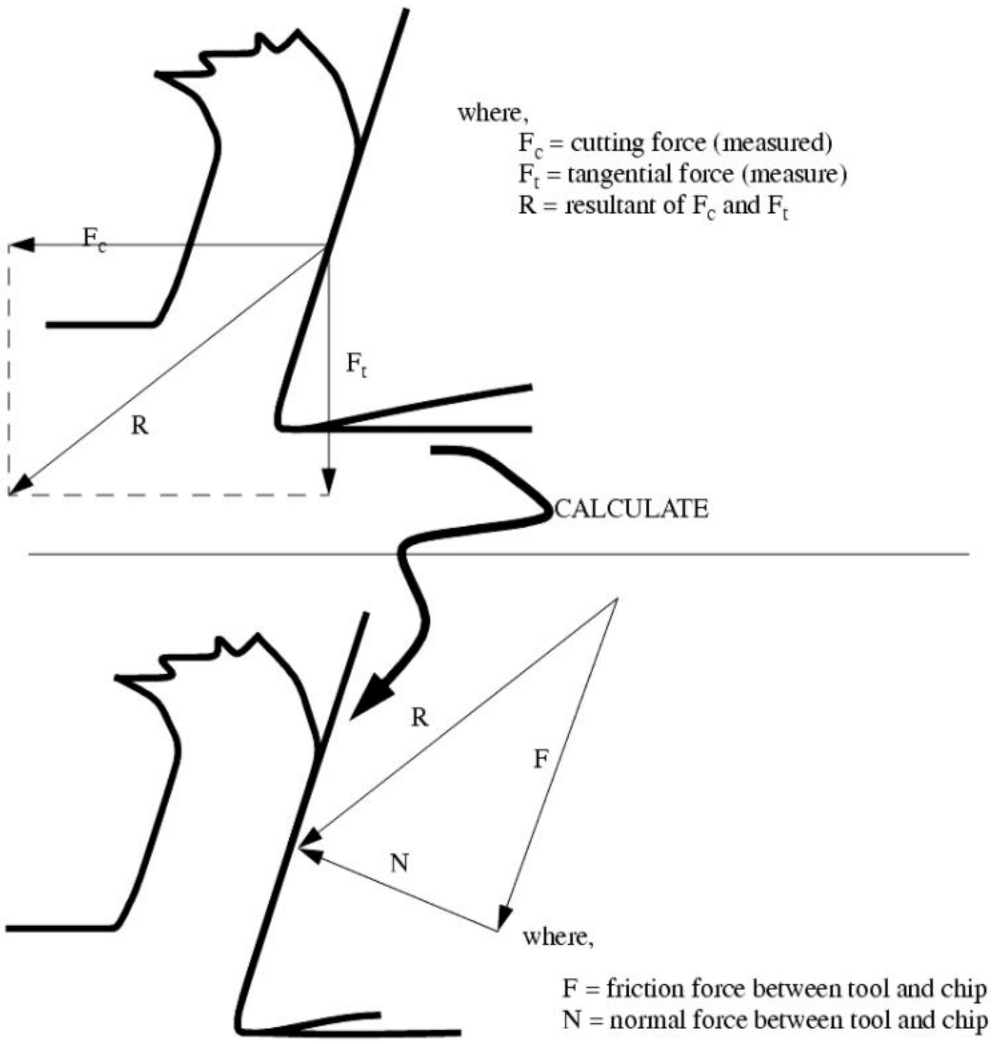
where,

t_1 = undeformed chip thickness
t_2 = deformed chip thickness (usually $t_2 > t_1$)
α = tool rake angle

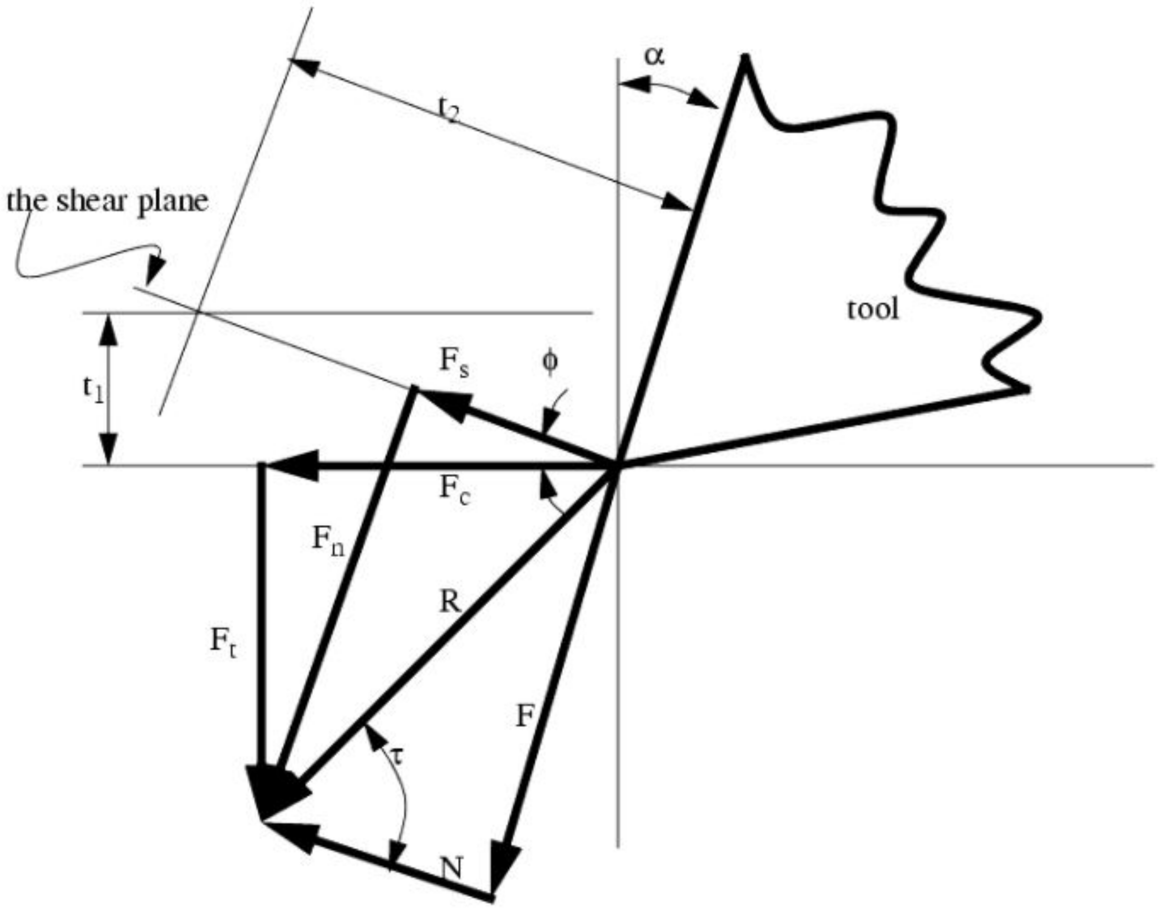
If we are using a lathe, t_1 is the feed per revolution

Merchant's Circle Diagram

Next, we assume that we are also measuring two perpendicular cutting forces that are horizontal, and perpendicular to the figure above. This then allows us to examine specific forces involved with the cutting. The cutting forces in the figure below (Fc and Ft) are measured using a tool force dynamometer mounted on the lathe.



Merchant's Circle Diagram



F_s = shear force
F_n = force normal to shear plane
α = tool rake angle (positive as shown)
ϕ = shear angle
τ = friction angle

Merchant's Circle Diagram

- Having seen the vector based determination of the cutting forces, we can now look at equivalent calculations

$$\frac{F}{N} = \tan\tau = \mu$$

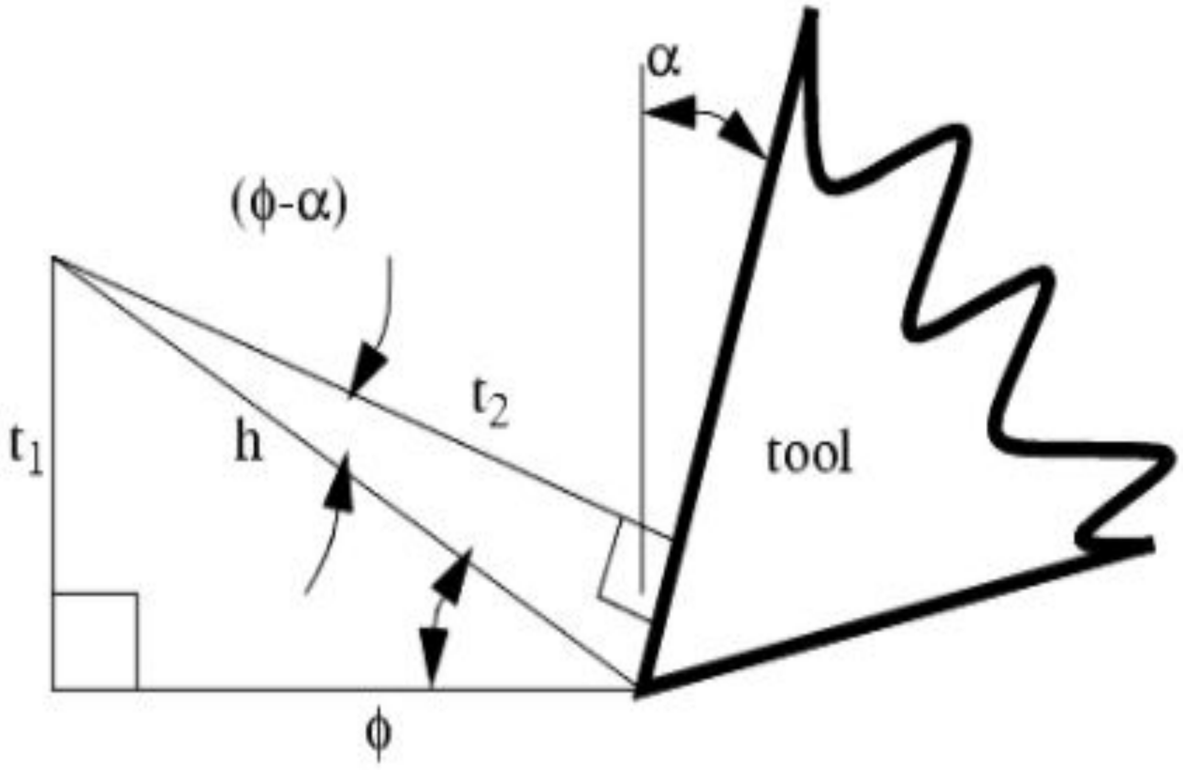
where,

μ = the coefficient of friction

$$\boxed{r_c = \frac{t_1}{t_2}}$$

where,

r_c = the cutting ratio



Merchant's Circle Diagram

$$t_1 = h\sin\phi \qquad t_2 = h\cos(\phi - \alpha)$$

$$r_c = \frac{t_1}{t_2} = \frac{h\sin\phi}{h\cos(\phi-\alpha)} = \frac{\sin\phi}{\cos\phi\cos\alpha + \sin\phi\sin\alpha}$$

$$\therefore r_c\cos\phi\cos\alpha + r_c\sin\phi\sin\alpha = \sin\phi$$

$$\therefore \frac{r_c\cos\phi\cos\alpha}{\sin\phi} + \frac{r_c\sin\phi\sin\alpha}{\sin\phi} = 1$$

$$\therefore \frac{r_c\cos\alpha}{\tan\phi} = 1 - r_c\sin\alpha$$

$$\boxed{\therefore \tan\phi = \frac{r_c\cos\alpha}{1 - r_c\sin\alpha}}$$

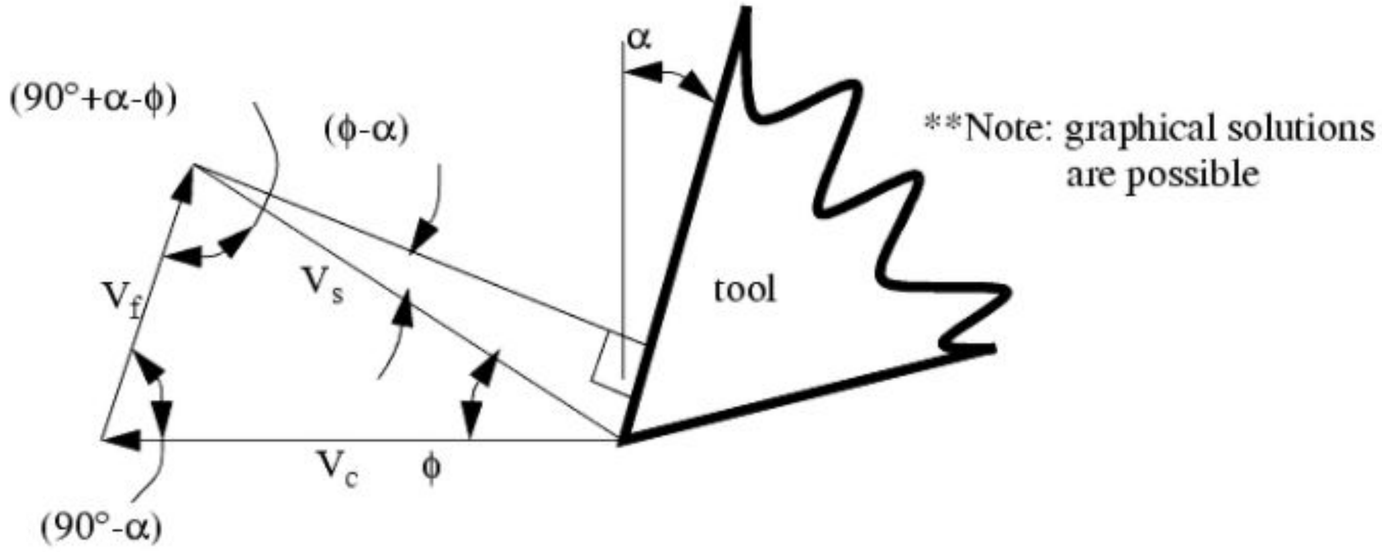
And, by trigonometry,

$$\boxed{F = F_t\cos\alpha + F_c\sin\alpha \qquad F_s = F_c\cos\phi - F_t\sin\phi}$$

$$N = F_c\cos\alpha - F_t\sin\alpha \qquad F_n = F_c\sin\phi + F_t\cos\phi$$

Merchant's Circle Diagram

- The velocities are also important, and can be calculated for later use in power calculations. The Velocity diagram below can also be drawn to find cutting velocities.



where,

V_c = cutting velocity (ft./min.) - as set or measured on the machine
V_s = shearing velocity
V_f = frictional velocity

Merchant's Circle Diagram

Using the sine rule,

$$\frac{V_s}{\sin(90^\circ - \alpha)} = \frac{V_c}{\sin(90^\circ + \alpha - \phi)}$$

$$\boxed{\therefore V_s = \frac{V_c \sin(90^\circ - \alpha)}{\sin(90^\circ + \alpha - \phi)} = \frac{V_c \cos\alpha}{\cos(\phi - \alpha)}}$$

Also,

$$\boxed{V_f = \frac{V_c \sin\phi}{\cos(\phi - \alpha)}}$$

A final note with vectors, the forces F_c and F_t, are used to find R, from that two other sets of equivalent forces are found.,

$$R = \sqrt{F_c^2 + F_t^2} = \sqrt{F_s^2 + F_n^2} = \sqrt{F^2 + N^2}$$

Desired properties of Cutting tool

Hot Hardness:

- Generally hardness is measured at room temperature. But the term Hot hardness indicates that the hardness at elevated temperature. We know that the hardness decreases as temperature increases. In metal cutting, heat is generated during the process. The tool material must be able to maintain its hardness, wear resistance and strength at such a high elevated temperature, which ranges nearly 600°C to 1800°C.

Desired properties of Cutting tool

Toughness:

- The tool material must be tough enough so that it can work without fracture in impact forces occurs in interrupted cutting operations (such as milling, turning of splined shaft). It must be able to withstand vibrations occurred during machining.

Wear Resistance:

- The term wear means loss of material. As tool continues cutting, its cutting edge which is always in touch with the workpiece and the rake face (over which the chip flows) lose their material gradually with time. Therefore the tool material must have wear resistance, so that an acceptable tool life is obtained before the tool is indexed or replaced.

Chemical Stability or Inertness:

- Tool material must have chemical stability or inertness with respect to the work material, so that any undesirable reactions between tool material, and work material are avoided.

Desired properties of Cutting tool

Shock Resistance:

- Tool material must have high resistance against thermal and mechanical shocks, specially in intermittent cutting in which tool-work engages and dis-engages at regular intervals.

Low Friction:

- Tool material must have low coefficient of friction. So that the heat generated will be lower, and tool life increases.

Favourable Cost:

- In competitive industrial environment, tool material cost must be favourable for better profits. For example, diamond tools are not used for common applications due to its high cost.

What is machinability?

- Machinability is defined as the ease with which a material can be machined to intended geometry and purpose at a satisfactory cost. The machinability often regarded as the work piece material property, however, the ease of machining also depends on other factors such as rigidity of cutting tool. Good machinability related to removal of material with moderate forces, good surface finish, small chips, and with minimum tool wear. It is difficult to maintain all these objectives at once for a machining operation. For example, the fine-grained material results in good surface finish but have high resistance to machining. So it is always a challenge to engineers to find ways to improve machinability without spoiling the performance.

https://www.youtube.com/watch?v=CXeKsdN-HII

What are the Factors that affect machinability?

Material variables:

- Heat treatment of material
- Chemical composition of workpiece such as presence of alloying metal.
- Hardness, tensile strength and ductility of workpiece
- Microstructure and grain size of workpiece

Machining variables:

- Tool geometry, tool dullness etc. indirectly affects the machinability.
- Cutting parameters such as feed, speed, cutting force etc. are directly affect machinability.
- Use of cutting fluid.
- Rigidity of tool, fixture, and work holding devices.

Taylor's tool life equation

Wear and hence tool life of any tool for any work material is governed mainly
by the level of the machining parameters, i.e., cutting velocity,(Vc), feed,
(s_o) and depth of cut (t). cutting velocity affects maximum and depth of cut minimum.
The usual pattern of growth of cutting tool wear (mainly VB),
principle o assessing tool life and its dependence on cutting velocity are
schematically shown in Fig.1.

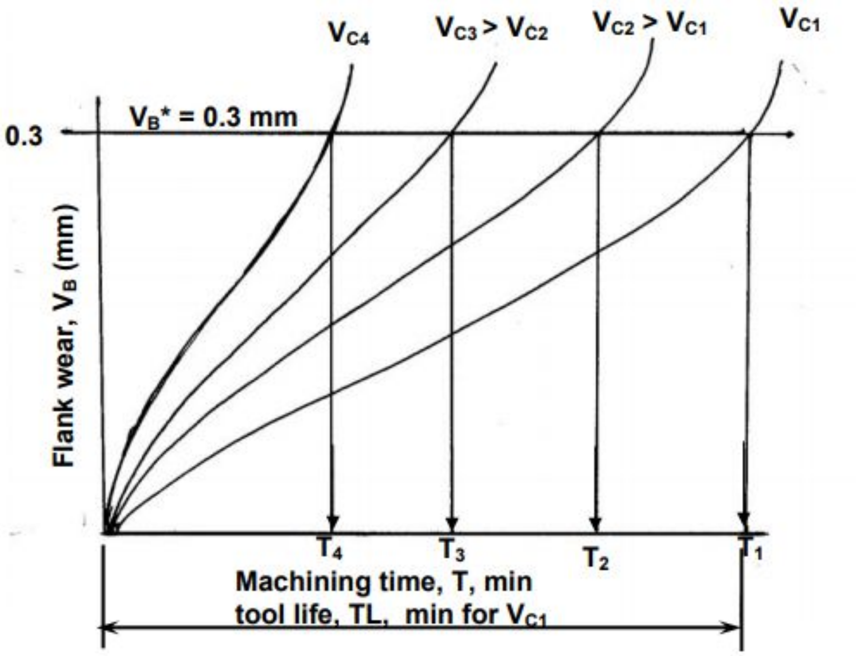


Figure 1: Growth of flank wear and assessment of tool life

Taylor's tool life equation

The tool life obviously decreases with the increase in cutting velocity keeping other condition’s unaltered as indicated in Fig.1. If the tool lives, T_1,T_2,T_3,T_4T1,T2,T3,T4 etc. are plotted against the corresponding cutting velocities, V_1,V_2,V_3,V_4V1,V2,V3,V4 etc as shown in Fig.2, a smooth curve like a rectangular hyperbola is found to appear.

When F.W.Taylor plotted the same figure taking both V and T in log-scale, a more distinct linear relationship appeared as schematically shown in Fig.3. With the slope, n and intercept, c, Taylor derived the simple equation as

$VT_n=C$

Taylor's tool life equation

Where, n is called, Taylor's tool life exponent. The values of both 'n' and 'c' depend mainly upon the tool-work materials and the cutting environment (cutting fluid application). The value of C depends also on the limiting value of VsVs undertaken (i.e., 0.3 mm, 0.4 mm, 0.6 mm etc.)

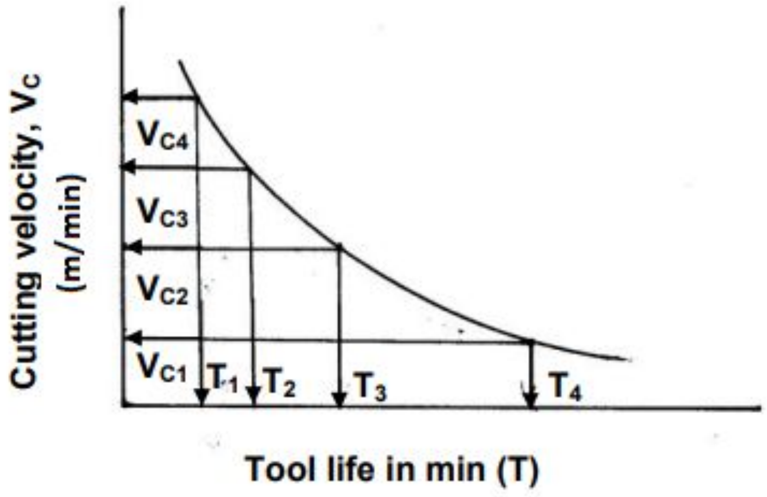


Figure 2: Cutting velocity - tool life relationship

Numerical: Taylor's tool life equation

If in turning of a steel rod by a given cutting tool (material and geometry) at a given machining condition (S_o and t) under a given environment (cutting fluid application), the tool life decreases from 80 min to 20 min. due to increase in cutting velocity, V_c from 60 m/min to 120 m/min, then at what cutting velocity the life of that tool under the same condition and environment will be 40 min?

Solution :

Assuming Taylor's tool life equation, VT_n=C

V_1T_1=V_2T_2=V_3T_3=.........=CV1T1=2T2=3T3=.........=C

Here,

V_1 = 60 m/min, T_1 = 80 min.

V_2 = 120 m/min, T_2 = 20 min.

V_3 = ? (to be determined), T_3 = 40 min.

Taking,

V_1T_{n1}=V_2T_{n2}

i.e. (T_1T_2)$_n$=V_2V_1)

or (80 min20 min)n=(120 m/min60 m/min)

from which, n = 0.5

again V_3T_{n3}=V_1T_{n1}

or V3=(8040)0.5×60=84.84 m/min