Fundamentals of Machining

Elementary treatment of metal cutting theory –

Metals are shaped into usable forms through various processes & further classified into ① Non-cutting shaping process.
② Cutting shaping process.

① In non-cutting shaping process, no chip formation takes place & the metal is shaped under the action of heat, pressure or both. Ex:- forging, drawing, spinning, rolling, extruding etc.

② If the components are brought to the desired shape & size by removing the unwanted material (Chip) from the parent metal in the form of chips through machining then it is termed as Cutting shaping process.

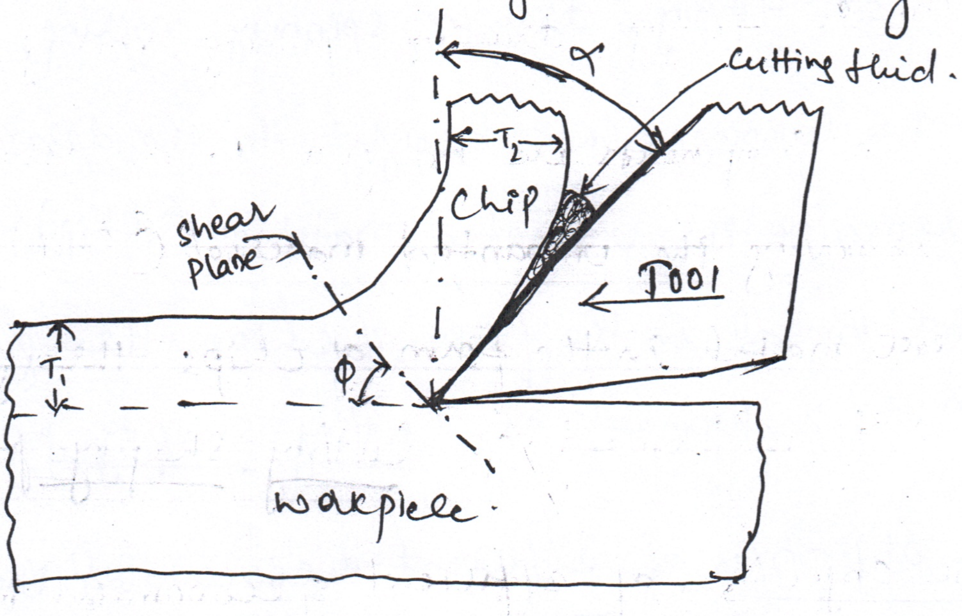
Basic objectives of efficient & economical Machining practice:-

1. Quick Metal Removal,
2. High class surface finish,
3. Economy in tool cost,
4. Less power consumption,
5. Economy in the cost of replacement of tools,
6. Minimum idle time of machine tools.

Basic elements of machining

The basic elements of all machining operations are
1) workpiece, 2). Tool & 3) chip.

The cutting action of a tool happens in two-dimensional (or) orthogonally. For providing the cutting action, a relative motion between the tool and the workpiece is necessary. This relative motion can be provided by either keeping the workpiece stationary and moving the tool or by keeping the tool stationary and moving the work or moving both relatively.

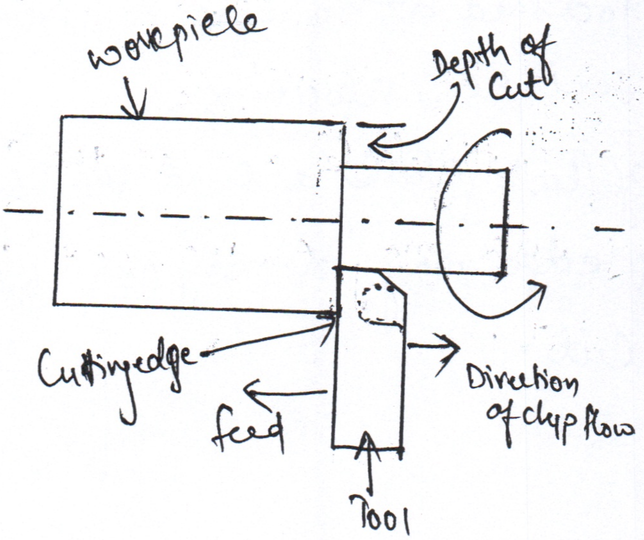


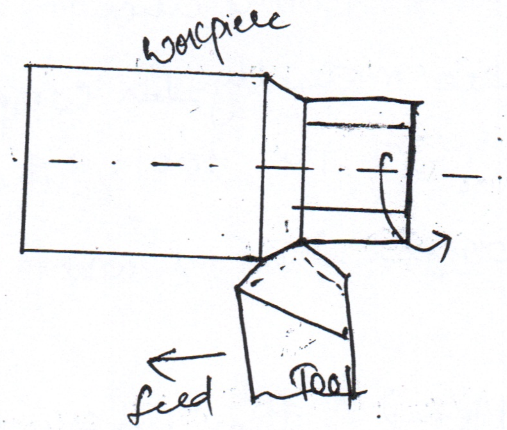
The workpiece provides the parent metal, from which the unwanted metal is removed by the cutting action of the tool to obtain the predetermined shape & size of the component. The chemical composition & the physical properties of the metal of the workpiece have a significant effect on the machining operation.

* The process of metal cutting is divided into following two main classes - They are.

1) Orthogonal Cutting.

2) oblique Cutting.





In orthogonal cutting, the cutting edge of the tool remains at right angles to the direction of cutting velocity or work feed. This Type of cutting is also known as 2-Dimensional cutting.

- The angle of inclination 'i' of (the cutting edge of the tool) with the (normal to the velocity) is 'zero'
- The chip flow angle 'β', i.e., the angle b/w the direction of chip flow and the normal to the cutting edge of the tool, measured in the plane of the tool face is 'zero'
- The cutting edge is longer than the width of the cut.

In oblique cutting, the cutting edge of the tool always remains inclined at an acute angle to the direction of tool feed (or) work feed. Direction of the chip flow velocity is at an angle 'β' with the normal to the cutting edge of the tool. The angle is known as chip flow angle.

The cutting edge of the tool is inclined at an angle 'i' with the normal to the direction of work feed i.e., velocity V_c.

Three mutually ⊥ar components of cutting forces act at the cutting edge of the tool. The cutting edge may or may not be longer than the width of the cut.

⇒ Metal Cutting Theories

These theories has developed encompassing three main parameters: those are Shear angle (φ), rake angle (α), & angle of friction (ζ).

The most popular of these theories are:

1. Earnst - Merchant theory
2. Lee & shaffer's theory

1. Earnst - Merchant theory was first proposed by Earnst & Merchant in 1941, is based on the principle of minimum energy consumption. It implies that during cutting the metal shear should occur in that direction in which the energy requirement for shearing is minimum.

The other assumptions made by them include:

a) The behaviour of the metal being machined is like that of an ideal plastic.

b) At shear plane the shear stress is maximum is constant & independent of shear angle (ϕ)

They deduced the following relationship:

$$\phi = \frac{\pi}{4} - \frac{\gamma}{2} + \frac{\alpha}{2}.$$

2. <u>Lee & shaffer's Theory</u>:

Lee & shaffer analysed the process of orthogonal metal cutting by applying the theory of plasticity for an ideal rigid plastic material. The principal assumptions made by them are:-

a) The workpiece material ahead of the cutting tool behaves like an ideal plastic material

b) The deformation of the metal occurs on a single shear plane.

c) There is a stress field within the produced chip which transmits the cutting force from the shear plane to the tool face and therefore the chip does not get hardend. At shear plane chip gets seperate. From this the relation derived is

$$\phi = \frac{\pi}{4} + \alpha - \gamma.$$

$$= 45^\circ + \alpha - \gamma \quad (\text{or}) \quad \phi + \gamma - \alpha = 45^\circ$$

If in case of built up edge chip, equation is modified to

$$\phi = \frac{\pi}{4} + \alpha + \theta - \gamma$$

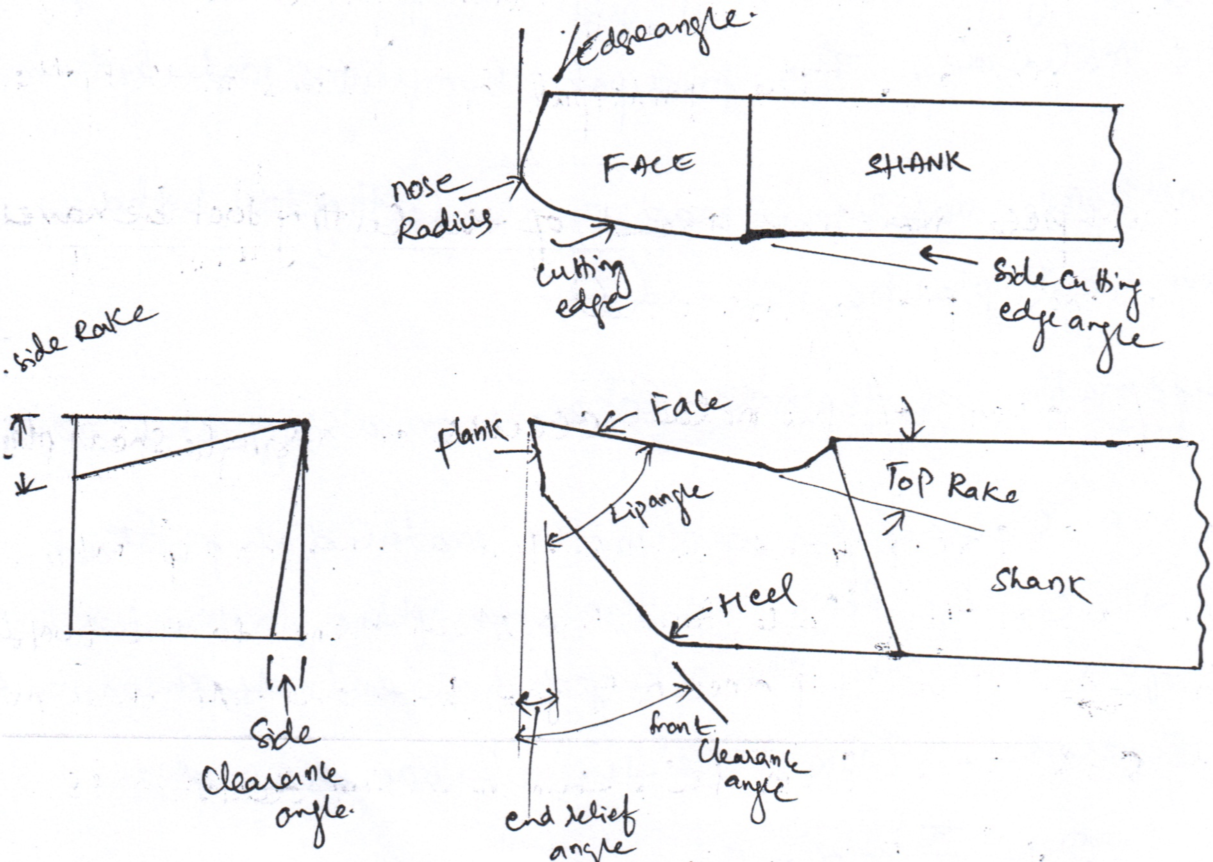
$$(\text{or}) \quad \phi + \gamma - (\alpha + \theta) = 45^\circ$$

* Classification of Cutting Tools

All the cutting tools used in metal cutting can be broadly classified as

1. **Single point tools** :- These have only one cutting edge; such as lathe tools, shaper tools, planer tools, boring tools etc.
2. **Multipoint tools** :- These have more than one cutting edge such as miller cutters, drills, broaches, grinding wheels etc.

Important terms & Principle angles of a Single point Cutting Tool.



1. **Shank** :- It forms the main body of a solid tool & it is the Part of the tool which is gripped in the tool holder

2. **Face** :- It is the top surface of the tool b/w the shank & the point of the tool. In the cutting action the chips flow along this surface only.

3. **Point** :- It is the wedge shaped portion where the face & flank of the tool meet. It is the cutting part of the tool. It is also called as nose.

4. **Flank** :- Portion of the tool which faces the work is termed as flank. It is the surface adjacent to and below the cutting edge when the tool lies in a horizontal position.

5. **Base** : It is actually the bearing surface of the tool on which it is held in a tool holder or clamped directly in a tool post.

6. **Heel** :- It is the curved portion at the bottom of the tool where the base & flank of the tool meet.

7. **Nose Radius.**

If the cutting tip of a single point tool carries a sharp cutting point the cutting tip is weak. It is, therefore, highly stressed during the operation, may fail or lose its cutting ability soon and produces marks on the machined surface. In order to prevent these harmful effects the nose is provided with a radius called Nose Radius.

It enables greater strength of the cutting tip, a prolonged tool life and a superior surface finish on the work piece.

1. **Rake Angle**:- It is the angle formed b/w the face of the tool and a plane parallel to its base. If this inclination is towards the shank, it is known as back rake or top rake. When it is measured towards the side of the tool, it is called the side rake.

These rake angles guide the chips away from the cutting edge, thereby reducing the chip pressure on the face & increasing the keeness of the tool, so that less power is required for cutting. An increased rake angle will reduce the strength of the cutting edge.

2. **Negative Rake**:- When no rake is provided on the tool, it is said to have a zero rake, when the face of the tool is so ground that it slopes upwards from the point it is said to contain a negative rake. A tool with negative rake will have a larger lip angle.

3. **Lip angle**:- The angle b/w the face and the flank of the tool is known as lip angle.

4. **Clearance angle**:- It is the angle formed by the front or side surfaces of the tool which are adjacent & below the cutting edge when the tool is held in horizontal position. It is the angle between one of the surfaces and a plane normal to the base of the tool.

5. **Relief angle**:- It is the angle formed between the flank of the tool and a lar line drawn from the cutting point to the base of the tool.

5. Cutting angle :- The total cutting angle of the tool is the angle formed b/w the tool face & a line through the point, which is a tangent to the machined surface of the work at that point.

Tool Signature :-

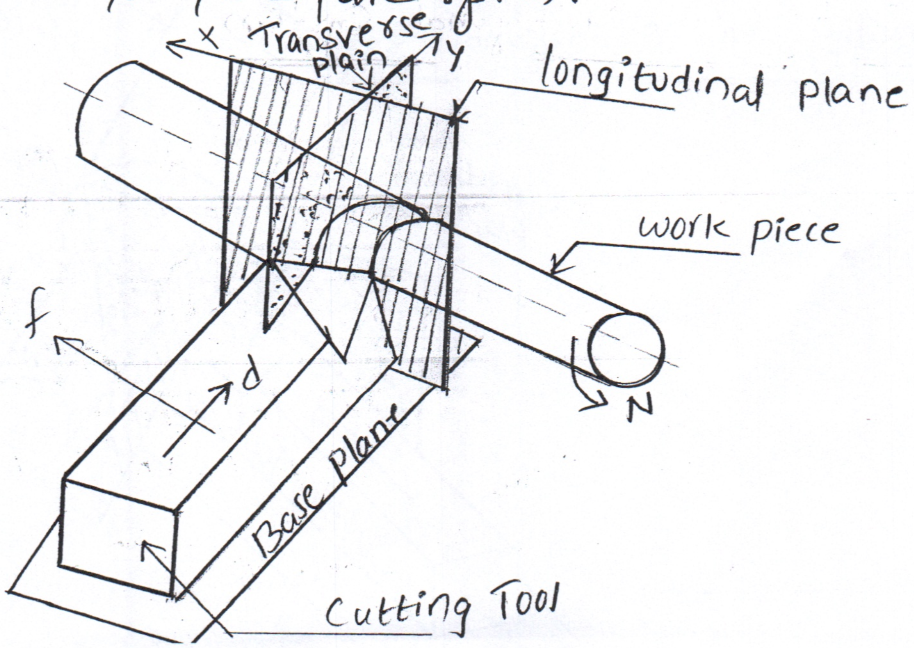
The term tool signature or tool designation is used to denote a standardised system of specifying the principal tool angles of a single point cutting tool. Some of them are :-

1. American (or ASA) system
2. British system
3. Continental system
4. International system.

Tool geometry in co-ordinate system

This system has been adopted by American Standards Association (A.S.A) is also known as A.S.A. system of tool signature.

Also, because of its nomenclature of reference planes as X, Y, Z, it is described as X-Y-Z plane system.



α_y = Toprake / Back rake angle

α_x = Side rake angle

β_y = end relief / clearance angle

β_x = Side relief / clearance angle

φ_e = End cutting edge angle.

φ_s = Side cutting edge angle

θ = Nose angle.

Ex!. Describe a tool with 8, 10, 6, 6, 6, 10, 2 Signature in A.S.A system

Sol:

Back rake $\alpha_y = 8°$

Side rake $\alpha_x = 10°$

End relief angle $\beta_y = 6°$

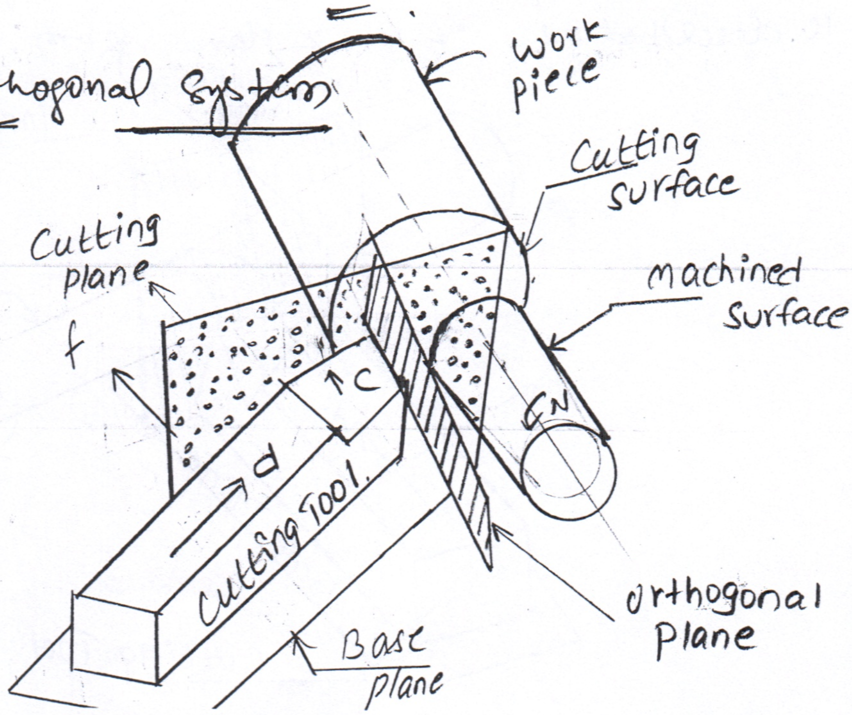
Side relief angle $\beta_x = 6°$

End cutting edge angle $\varphi_e = 6°$

Side cutting edge angle $\varphi_s = 10°$

Nose radius = 2mm

Tool geometry in orthogonal system



It is called as orthogonal rake system, only the main parameters of a single point cutting tool are designated in the following ord

Inclination angle (λ), orthogonal rake angle (α), side relief angle (γ) end relief angle (γ_1), Auxiliary cutting angle (φ_1), Approach angle (φ_0) and Nose Radius (R).

Ex: A cutting tool designated as 0 - 10 - 5 - 5 - 8 - 90 - 1 will have the following values of its different parameters.

$\lambda = 0^\circ$ — inclination angle

$\alpha = 10^\circ$ — orthogonal rake angle

$\gamma = 5^\circ$ — side relief angle

$\gamma_1 = 5^\circ$ — end relief angle

$\varphi_1 = 8^\circ$ — Auxiliary cutting angle

$\varphi_0 = 90^\circ$ — Approach angle

$R = 1\,mm$ — nose radius.

Interrelationship Between ASA & ORS systems

$$\tan\alpha = \tan\alpha_y \cdot \cos\varphi_0 + \tan\alpha_x \cdot \sin\varphi_0$$

$$\tan\lambda = \tan\alpha_y \cdot \sin\varphi_0 - \tan\alpha_x \cdot \cos\varphi_0$$

$$\tan\alpha_x = \sin\varphi_0 \cdot \tan\alpha - \cos\varphi_0 \cdot \tan\lambda$$

$$\tan\alpha_y = \cos\varphi_0 \cdot \tan\alpha + \sin\varphi_0 \cdot \tan\lambda$$

Ex: A single point cutting tool has a back rake of 10° and side rake of 14°. Calculate its orthogonal rake & inclination angle when the approach angle is 70°.

Sol

Back rake $\alpha_y = 10^\circ$

Side rake $\alpha_x = 14^\circ$

Approach angle $\varphi_0 = 70^\circ$

Using the relation

$$\tan\alpha = \tan\alpha_y \cdot \cos\varphi_0 + \tan\alpha_x \cdot \sin\varphi_0$$

$$= \tan 10^\circ \cdot \cos 70^\circ + \tan 14^\circ \cdot \sin 70^\circ$$

$$= 0.1763 \times 0.3420 + 0.2493 \times 0.9397$$

$$= 0.2932$$

$$\therefore \alpha = \tan^{-1} 0.2932$$

Orthogonal rake $\boxed{\alpha = 16^\circ 21'}$

Also,

$$\tan\lambda = \tan\alpha_y \cdot \sin\varphi_0 - \tan\alpha_x \cdot \cos\varphi_0$$

$$= \tan 10^\circ \times \sin 70^\circ - \tan 14^\circ \times \cos 70^\circ$$

$$= 0.1763 \times 0.9397 - 0.2493 \times 0.3420$$

$$= 0.1657 - 0.0853$$

$$= 0.0804$$

$$\lambda = \tan^{-1} 0.0804 = 4^\circ 36'$$

Inclination angle $\boxed{\lambda = 4^\circ 36'}$

Practice problems:

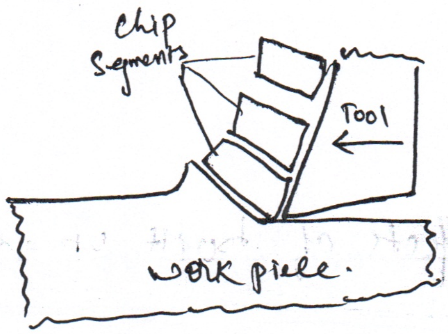
- In an orthogonal cutting a single point turning tool has side rake of 12° & an approach angle of 70°. Calculate the back rake when the inclination angle is 0°.
- In an orthogonal cutting operation on a lathe the cutting tool used has the tool designation of 0-10-6-6-8-80-1 mm (ORS). Calculate the values of i) Back rake & ii) Side rake.

Types of Chips:-

The chips produced during machining of various metals can be broadly classified into the following three types. The production of any particular type will largely depend upon the type of material being machined & the cutting conditions.

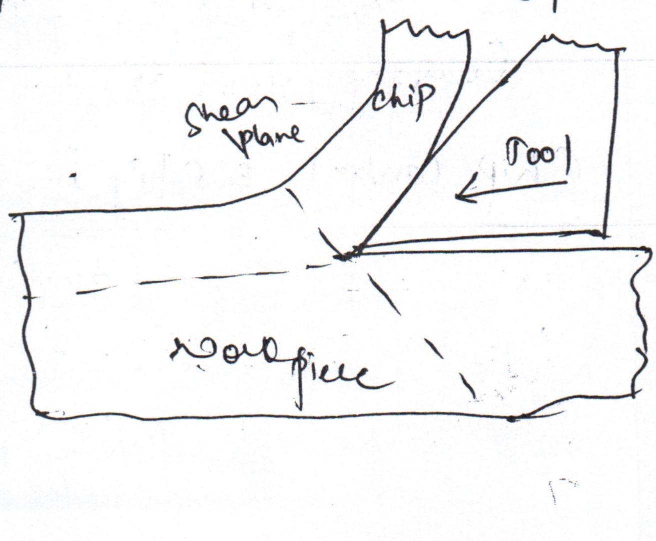
1. Discontinous (or) segemental chips:-

This type of chips are produced during maching of brittle materials like cast iron & bronze. These chips are produced in the form of small segments. Such chips are also sometimes produced in the machining of ductile materials when low cutting speeds are used and adequate lubrication is not provided.



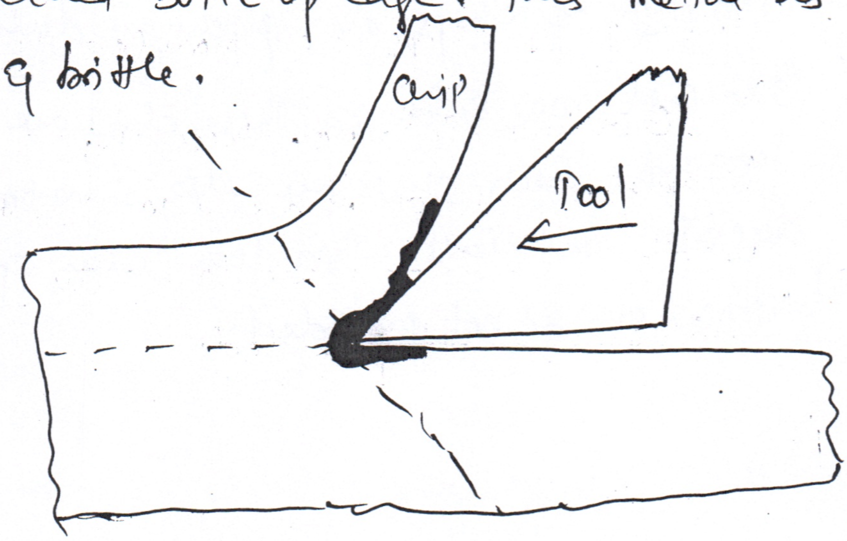
2. Continous chip:-

This type of chip is produced while machining a ductile material, like mild steel, under favourable cutting conditions, such as high cutting speed & minimum friction b/w the chip and the tool face. The friction can be reduced by polishing the tool face & use of coolant.



3. Continous chip with built-up edge:

Such a chip is usually formed while maching ductile materi when high friction exists at the chip tool interface. The upward flowing chip exerts pressure on the tool face. The chip gets hot & oxidises as it comes off the tool and turn blue in color. The extra metal welded to the nose or Point of the tool is called built up edge. This metal is highly strain hardened & brittle.



Affects of built up edge formation.

a) Rough Surface finish on the workpiece.
b) Fluctuating Cutting force, Causing vibrations in cutting tool.
c) chances of carrying away some material from the tool by the built-up surface, producing crater on the tool face & Causing tool wear.

Chip control & Chip breakers:

The chip produced during machining, specially while employing higher speeds in maching of high tensile strength materials need to be effectively controlled.

In case of higher speeds carbide tipped tools are being used for machi

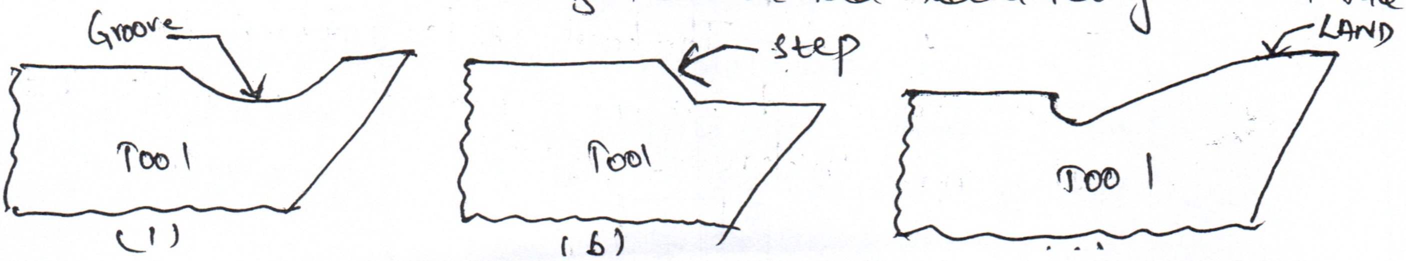
Because in that case higher speeds will be used & therefore due to high temperatures the resulting chip will be continous, of blue color & take the shape of coil.

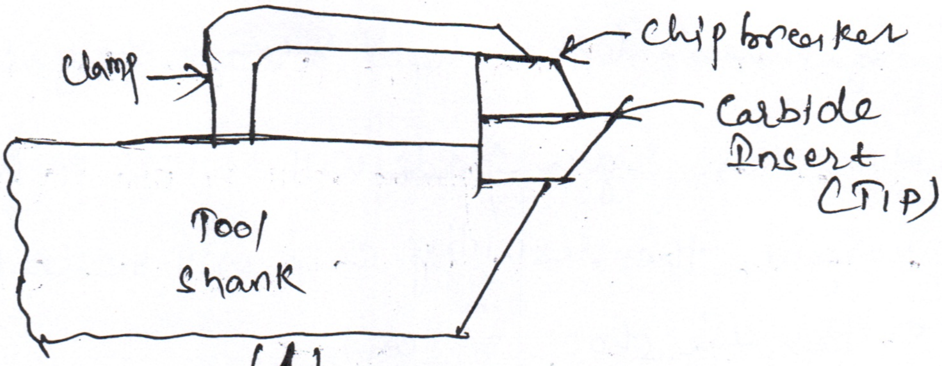
If chip is not broken & removed surroundings & workpiece area will effect & it results in:

1. It creates crater & rising temperature.
2. Its presence may lead to a poor surface finish on the workpiece
3. It may be hazardous to the machine operator.
4. Very large coils offer a lot of difficulty in their removal.

To avoid this condition chip breakers are used, these produces chips in to small pieces. They are:

1. **Groove type**:- It consists of grinding a groove on the face of the tool, behind the cutting edge, leaving a small land near the tip.
2. **Step type**:- It consists of grinding a step on the face of the tool, adjacent to the cutting edge.
3. **Secondary rake type**:- It consists of providing a secondary rake on the tool through grinding, together with a small step.
4. **Clamp type**:- This type of chip breaker is very common with the carbide tipped tools. The chip breaker is a thin & small plate which is brazed to or held mechanically on tool face.

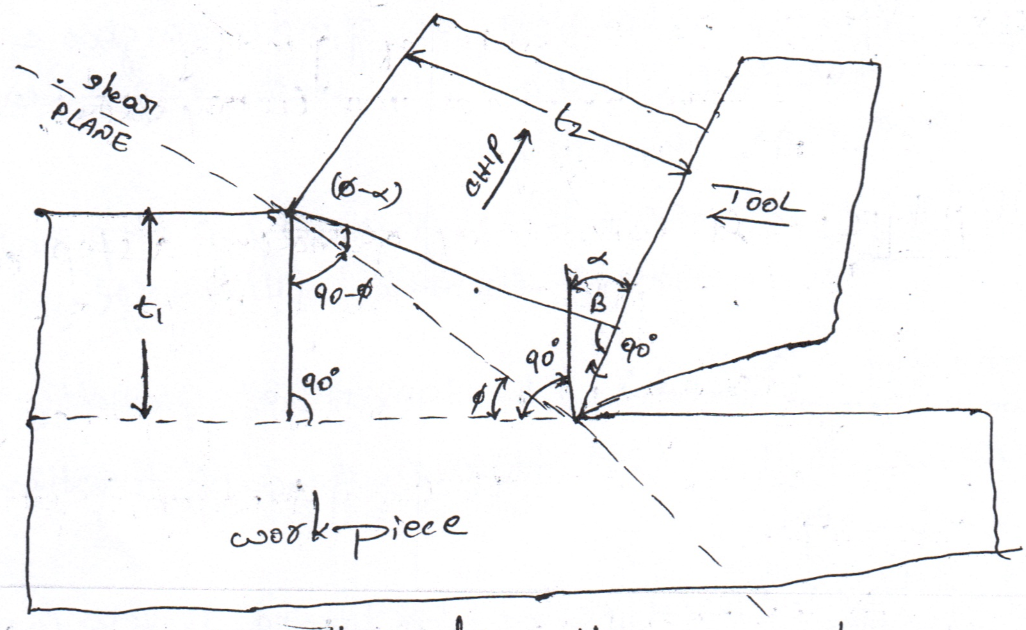




(4)

Chip Thickness Ratio

During the cutting action of a metal it will be observed that the thickness of the deformed or upward flowing chip is more than the actual depth of cut. It is because of the chip flow upwards at a slower rate than the velocity of the cut. It is directly effected by the shear plane angle. The smaller this angle The slower will be The chip-flow-velocity and, Therefore, larger will be The thickness of the chip.



An orthogonal cutting operation.

where,

t_1 = chip thickness prior to deformation

t_2 = chip Thickness after deformation

The above discussion leads to The result that $t_2 > t_1$

The chip thickness ratio 'r' is given by:

$$r = \frac{t_1}{t_2}$$

Since t_2 is always greater than t_1, The value of chip Thickness ratio 'r' is less than unity. The higher The value of 'r' The better is supposed to be The cutting action. The reverse of 'r' is known as chip reduction coefficient. If 'k' is The chip reduction coefficient, Then:

$$\boxed{k = \frac{1}{r}}$$

Now, in orthogonal cutting The width of The chip equals to The width of The cut. Considering The specific gravity of The metal as constant The volume of The chip produced will be equal to The volume of The metal cut widths of both being equal, The product of The thickness and its length will, therefore, be equal to The product of The thickness and The length of The metal cut. If L_1 & L_2 are The lengths of The metal cut & The chip respectively it follows That:

$$t_1 L_1 = t_2 L_2$$

$$\frac{t_1}{t_2} = \frac{L_2}{L_1}$$

But, $\frac{t_1}{t_2} = r$

$$r = \frac{t_1}{t_2} = \frac{L_2}{L_1}$$

$$k = \frac{1}{r} = \frac{t_2}{t_1} = \frac{L_1}{L_2}$$

we have two right angled triangles OAP and OBP Considering the right angled triangle OAP, we have:

$$\frac{AP}{OP} = \sin AOP = \sin\phi$$

$$OP = \frac{AP}{\sin\phi} \qquad [\text{But } AP = t_1]$$

$$OP = \frac{t_1}{\sin\phi} \quad \text{——— (1)}$$

Now, Considering The right angled triangle OBP, we have

$$\frac{BP}{OP} = \sin BOP = \sin(90 - \phi + \alpha)$$

$$= \cos(\phi - \alpha)$$

$$OP = \frac{BP}{\cos(\phi - \alpha)} \quad [\text{But, } BP = t_2]$$

$$OP = \frac{t_2}{\cos(\phi - \alpha)} \quad \text{——— (2)}$$

Now, by equating The eq (1) & (2) for OP, we get

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

$$\frac{t_1}{t_2} = \frac{\sin\phi}{\cos(\phi - \alpha)} = r$$

$$r = \frac{\sin\phi}{\cos(\phi - \alpha)} \quad \text{——— (3)}$$

Eq (3) Can be expanded as:

$$r = \frac{\sin\phi}{\cos\phi \cos\alpha + \sin\phi \cdot \sin\alpha}$$

$$\Rightarrow r(\cos\phi \cdot \cos\alpha) + r(\sin\phi \cdot \sin\alpha) = \sin\phi$$

$$\therefore \frac{r(\cos\phi \cdot \cos\alpha)}{\sin\phi} + \frac{r(\sin\phi \cdot \sin\alpha)}{\sin\phi} = 1$$

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

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

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

Also by subst, The value of 'r' in terms of t_1 & t_2, we get

$$\boxed{\tan\phi = \frac{t_1/t_2 \cos\alpha}{1 - t_1/t_2 \sin\alpha}}$$

Tool life

Tool life can be defined as the time interval for which The Tool works satisfactory between two successive grinding (sharpings) Thus, it can be basically conceived as functional life of the Tool.

The Tool is subjected to wear continuously while it is operating, obviously, after some time, when the tool wear is increased considerably, The tool loses its ability to cut efficiency. and must be reground.

The Tool life can be effictively used as the basis to evaluate the performance of the Tool material, assess machinability of the work piece material and know the cutting conditions.

They are three common ways of Expressing Tool life

1. As Time period in minutes between two successive grindings.
2. In Terms of number of components machined between Two successive grindings. This mode is commonly used when the tool operates continuously, as in case of automatic machines.
3. In Terms of the volume of material removed between two successive grindings. This mode of expression is commonly used when the tool is primarily used for heavy stock removal.

volume of metal removed per minute

$$= \pi . D . t . f . N \quad mm^3/min$$

where, D = Dia. of workpiece in 'mm'
t = depth of cut in 'mm'
f = feed rate in mm/rev
N = No. of Revolutions of work per minute

If, 'T' be the time in minutes to tool failure, Then Total volume of metal removed to tool failure

$$= \pi . D . t . f . N . T \quad mm^3 \quad \text{—— (1)}$$

we also know that the cutting speed

$$V = \frac{\pi D N}{60} \quad m/min$$

$$\pi D N = V \times 1000$$

from ①, $= V \times 1000 \times t \times f \times T \ mm^3$

Tool life (T_L) in terms of the total volume of the metal Removed to tool failure is given by.

$$T_L = V \cdot 1000 \cdot t \cdot f \cdot T \ (mm^3)$$

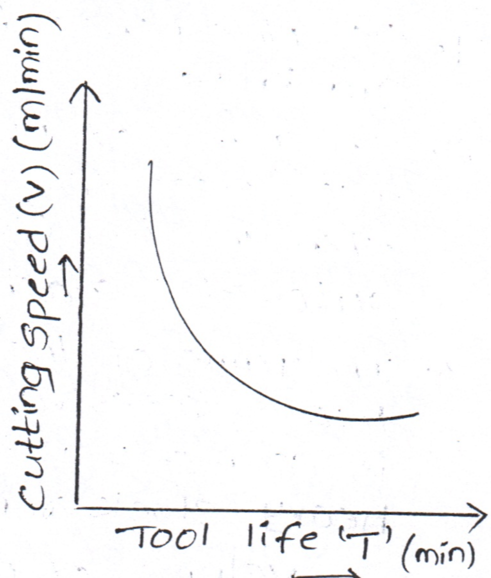
[FACTORS AFFECTING TOOL LIFE]

The life of a Cutting Tool is affected by the following factors.

1. cutting speed
2. Feed and depth of cut
3. Tool Geometry
4. Tool material.
5. work material
6. Nature of cutting
7. Rigidity of machine Tool and work
8. use of cutting fluids.

[EFFECT OF CUTTING SPEED]

The maximum effect on Tool life is of cutting speed. The Tool life varies inversly speed. The Tool life varies higher cutting speed., The Reduction in tool life corrosponding to an increase in cutting speed parabolic.

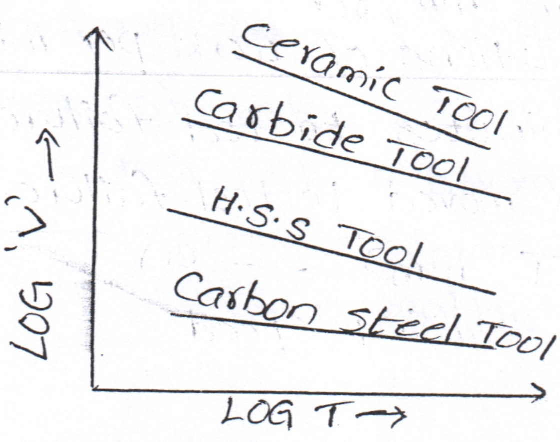


→ The curve showing parabolic Reduction in Tool life the increasing of cutting speed.

→ The Relationship between cutting speed and Tool life can be Expressed as :-

$$VT^n = C$$

where, V = cutting speed (m/min)
T = Tool life (min)
n = Tool life index
C = machining canestant



Cutting speed-Tool life curves for different tool materials.

The average values of exponent "n" for common Tool material can be Taken as

$n = 0.1$ to 0.15 for high speed steel Tools
$n = 0.2$ to 0.5 for Cemented Carbide Tools
$n = 0.6$ to 1.0 for Ceramic Tools.

→ If the Relationship between different cutting speeds and the corresponding Tool lives are plotted on a log-log graph. straight lines are obtained.

→ In which Revel that the Tool life decrease with the increase in cutting speed.

[FEED AND DEPTH OF CUT]

→ Feed rate and depth of cut are the other important cutting variables which also effect the Tool life appreciably.

→ An increase in the feed rate and depth of cut has a similar effect and Reduction of Tool life

→ The different variables, cutting speed, Tool life, feed Rate and depth of cut, are inter-related as given in the following imperical formula:

$$V = \frac{257}{T^{0.19} \times f^{0.36} \times t^{0.80}} \ m/min$$

V = cutting speed m/min
T = Tool life in 'min'
f = feed rate in mm/min
t = Depth of cut in 'mm'

for given Tool life the Relationship among the other variables is also given by

$$V = \frac{C}{f^a \times t^b}$$

C = a canestant
V = cutting speed.
t = Depth of cut

The Exponents 'a' and 'b' of (f) and (t) will depend upon the mechanical properties of the workpiece material

→ The Tool life is considered as constant the cutting speeds (v) will decrease if the feed Rate (f) and depth of cut (t) are increased.

[TYPES OF CUTTING TOOL MATERIALS]

The following materials are commonly used for manufacturing the cutting Tools. selection of a particular materials will depend on the Type of service it is expected perform

1. High Carbon steel
2. High speed steel
3. Camented Carbides
4. stellite
5. cemented oxides (or) ceramics, and
6. Diamond.

1. High Carbon steel :-

→ plain carbon steel having a Carbon percentage as high as 1.5% are in common use as tool material for general class of work ...

→ They are not considered suitable for Tools used in production work on account of the fact that they are not able to withstand very high Temperature. with the result, they Connot be employed at high speeds

→ The hardness is lost by them as soon as the temperature rises to about 200°c - 250°c. They are also not highly wear Resistant. It can be used in hand Tools.

→ however less costly, easily, forgeable and easy to heat treat.

High Carbon medium alloy steels

→ these are the more effective than plain high Carbon steels.

→ Better hot hardness; higher impact resistance, higher wear Resistance, etc.

2. High speed steel :-

→ It is a special alloy-steel which may contain the alloying elements like Tungsten, Chromium, vanadium, Cobalt and molybdenum etc. up to 25%.

→ These alloying elements increase its strength, Toughness wear resistance, cutting ability to Retain its hardness at elevated temperatures in the range of 550°C to 600°C

→ on account of these added properties the high speed steel Tool are capable of operating safely at 2 to 3 times. higher cutting speeds than those of high Carbon steel tools.

→ high speed steel is better known by composition of alloying elements as 18-4-1, ie, the one that 18% W, 4% Cr and 1% V. Another class of HSS contains high properties of cobalt (2 to 15%) is known as Cobalt H.S.S

It wear resistance and carries high hot hardness.

3. Cemented Carbides :-

→ These carbides are formed by the mixture of Tungsten, titanium (or) Tantalum with carbon.
→ The carbides, in powdered form, are mixed with cobalt which acts as a binder. at high pressures of 1500 kg per sq cm to 4000 kg per sq. cm and Temperatures of over 1500°C is shaped into desired forms of Tips.
→ These carbide tips are than brazed or fastened clamped to the shank made of medium carbon steel.
→ These cemented carbids process a very high degree of hardness and wear Resistance.
→ They are able to retain this hardness at elevated Temperatures up to 1000°C
→ The Tools tipped with cemented carbide tips are capable of operating at speeds 5 to 6 times higher than those with the high speed steels.
→ They are of rigid construction and carry high powered motor so that higher cutting speeds can be employed.

4. Stellite

→ It is a non-ferrous alloy consisting mainly of cobalt. Tungsten and chromium. other elements added in varying properties are tantalum molybdenum and Boron.
→ It has good shock and wear Resistances and retains is hardness at red heat upto about 920°C.
→ Tools made of stellite are capable of operating at speeds up to 2 times more than those of common high speed steel Tools.
→ stellite does not respond to the usual heat Treatment process
→ only grinding can be used for machining it effectively. A stellite may contain 40-50% Co, 15-35% Cr, 12-25% W and 1-4% carbon.

5. Cemented Oxides or Ceramics :-

→ The introduction of ceramic material as a useful cutting Tool material is, rather, a latest development in the field of Tool metallurgy.
→ It mainly consists of aluminium oxide, which is comparatively much cheaper than any of the chief constituents of cemented carbides.
→ Tool made of ceramic material are capable of withstanding high Temperature; without losing their hardness up to 1200°C
→ They are much more wear resistance as compard to the cemented carbide Tools.

→ The ceramic tools are capable of removing four times more material than the tungsten carbide tool with a consumption of 20% less power than the latter. They can safely operate at 2-3 times the cutting speeds of tungsten carbide tools.

6. Diamond :

→ Diamond is the hardest material known and used as cutting tool meterial. It is brittle and offers a low resistance to shock, but is highly wear resistance.

→ on account of the above factors diamonds are employed for only light cuts on materials like bakelite, carbon, plastics aluminium and brass. etc.

→ low coefficient of friction they produce a high grade of surface finish.

→ Diamond particals are used in diamond wheels and laps.

[MACHINABILITY]

machinability of a material gives the idea of the ~~material depends on various variable factors, it is not~~ ease with which it can be machined. The parameters generally influencing the machinabity of a material are.

1. physical properties of the material
2. mechanical properties of the material
3. chemical composition of the material.
4. micro-structure of the material, and.
5. cutting conditions.

Since this property (machinability) of the material depends on various variable factors, it is not possible to evaluate the same in terms of precise numerical values. but as a relative quantity. The criteria of determining the same may be as follows:

1. Tool life :-

The longer the tool life it enables at a given cutting speed the better is the machinability

2. Surface finish :-

It is also directly proportional, i.e, the better the surface finish the higher is the machinability.

3. Power consumption :

Lower power consumption per unit of matal removed indicate better machinability.

4. Cutting forces :-

The lesser the amount of cutting force required for the removal of a certain volume of metal. or the higher the volume of metal removed under standard cutting forces the higher will be the machinability.

5. shear angle :-

Larger shear angle denoted better machinability.

6. Rate of metal removal under standard cutting conditions.