UNIT I

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THEORY OF METAL CUTTING

INTRODUCTION:

Metal cutting is the process of producing work piece by removing unwanted material from a block of metal in the form of chips. The major drawback of the process is loss of material in the form of chips.
The process is basically adopted because of the following reasons.
a) To get higher surface finish.
b) To achieve close tolerance.
c) To get complex geometric shapes.
d) Some times it may be economical to produce a component by machining process.

MATERIAL REMOVAL PROCESSES

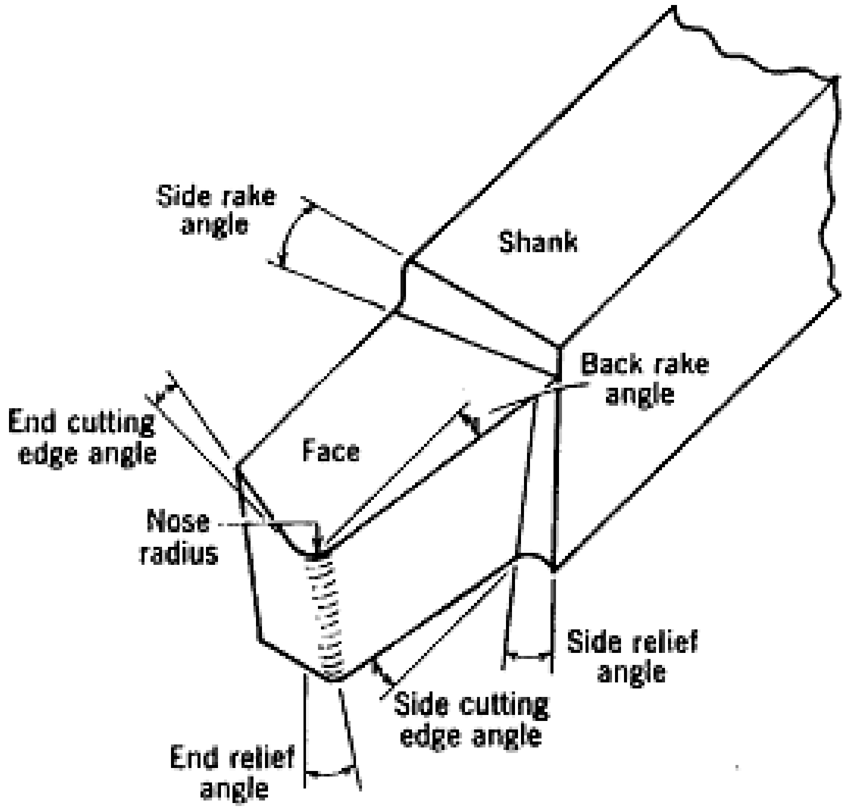
Machining of material is basically adopted to get higher surface finish, close tolerance and complex geometric shapes which are other wise difficult to obtain.
•Metal removal is probably the most expensive one because a substantial amount of material is removed from the raw material in the form of chips to achieve the required shape.
•The choice of material removal is an option for manufacturing is concerned when no other manufacturing process suits the purpose.
•Invariably all components undergo a material removal operation at some points.
•A machine tool is one which while holding the cutting tool is able to remove the metal from a work piece to generate the required part of the given size, configuration and finish.

Metal Cutting

- Process where a stronger metal is used to cut a softer metal.
- One of the most popular and commonly used manufacturing processes.
- Lathe has been used since mid-seventeenth century.
- Metal cutting also includes methods of machining such as
- Parts after heat treatment are usually distorted and hence need machining
- Accurate dimension, sharp corners
- Desired texture - such as shiny finish, mirrored surface etc.
- With modern machine it can be very economical
- Disadvantages
    - Higher cost of labor and tools
    - Scrap metal results
    - Longer cycle time

THEORY OF METAL CUTTING

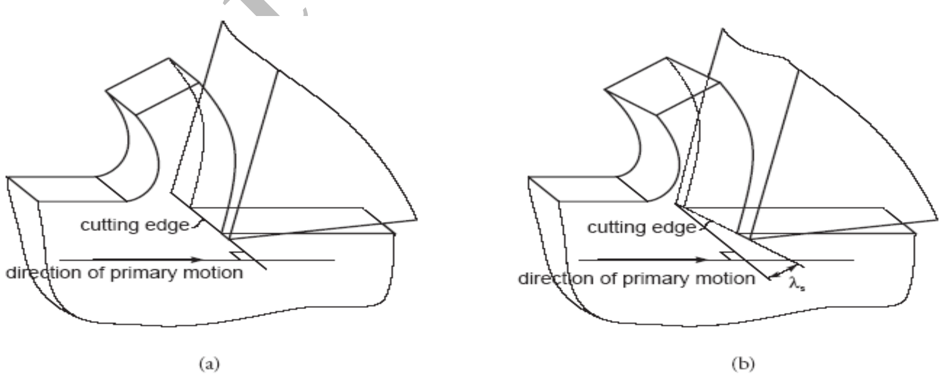
The two basic methods of metal cutting using a single-point tool are
• The orthogonal or two-dimensional
• The oblique or three-dimensional



<u>Orthogonal and oblique cutting</u>

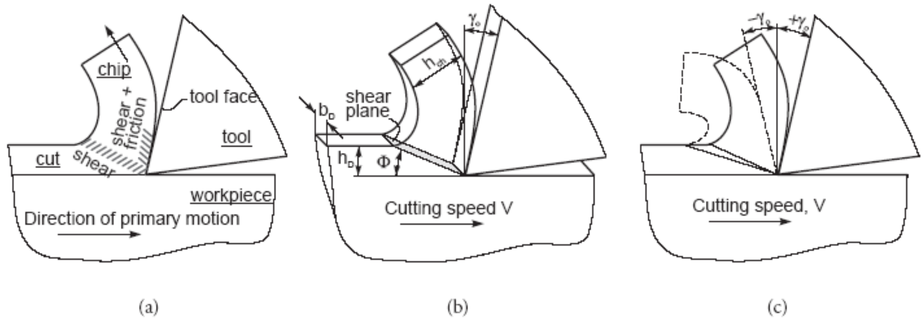
- ***Orthogonal cutting*** the cutting edge is straight and is set in a position that is perpendicular to the direction of primary motion. This allows us to deal with stresses and strains that act in a plane.
- ***Oblique Cutting*** the cutting edge is set at an angle (the *tool cutting edge inclination*

λs). This is the case of three-dimensional stress and strain conditions



(a) Orthogonal cutting with a cutting tool set normally to the direction of primary motion; (b) Oblique cutting with a cutting tool set at the tool cutting edge inclination angle λ_s to the direction of primary

Mechanism of chip formation



(a) Chip formation in metal cutting is accompanied by substantial shear and frictional deformations in the shear plane and along the tool face; (b) Schematic illustration of the two-dimensional cutting process (also called *orthogonal cutting*), h_D and b_D are the *thickness of cut* and *width of cut* respectively, h_{ch} is the *chip thickness*, γ_o is the *tool orthogonal rake* angle, and Φ is the *shear plane angle*; (c) Cutting with positive and negative rake angles. Note the change in the shear plane angle and chip thickness.

Chip formation

•The metal is severely compressed in the area in front of the cutting tool.
•This causes high temperature shear and plastic flow if the metal is ductile. When the stress in the work piece just ahead of the cutting tool reaches a value exceeding the ultimate strength of the metal, particles will shear to form a chip element which moves up along the face of the work.
•The outward or shearing movement of each successive element is arrested by work hardening and the movement transferred to the next element. The process is repetitive and a cutting forces.
•In conventional turning process the force system in the general case of conventional turning process.

- Most important factors in all machining process:
  - Geometry of cutting tool
  - Machining conditions:
    - Speed of tool
    - Speed of workpiece
    - Hardness of workpiece
    - Hardness of tool
  - Work holding and fixtures
  - Coolant, type of process, accuracy issues, etc.
  - Machine condition - such as stiffness

There are three types of chips that are commonly produced in cutting,
- ➢ discontinuous chips
- ➢ continuous chips
- ➢ continuous chips with built up edge

A ***discontinuous chip*** comes off as small chunks or particles. When we get this chip it may indicate,

- brittle work material
- small or negative rake angles
- coarse feeds and low speeds

•This type of chip is obtained in machining most brittle materials, such as cast iron and bronze. These materials rupture during plastic deformation, and form chips as separate small pieces.
•As these chips are produced, the cutting edge smoothes over the irregularities and a fairly good finish is obtained.
•Tool life is also reasonably good, and the power consumptions low.
•Discontinuous chips can also be formed on some ductile metals only under certain conditions particularly at very low speeds and if the coefficient of friction is low.

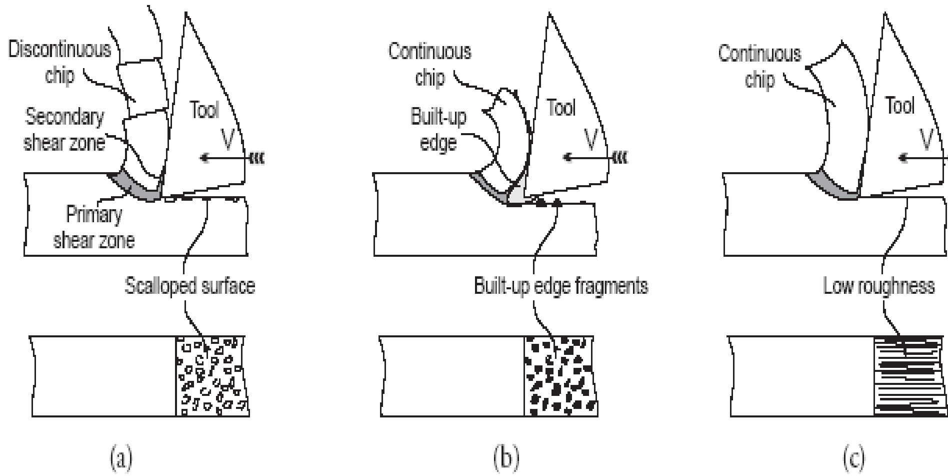
A ***continuous chip*** looks like a long ribbon with a smooth shining surface. This chip type may indicate,

- ductile work materials
- large positive rake angles
- fine feeds and high speeds

• Under the best conditions the metal flows by means of plastic deformation, and gives a continuous ribbon of metal which, under the microscope, shows no signs of tears or discontinuities.
• The upper side of a continuous chip has small notches while the lower side, which slides over the tool face, is smooth and shiny.
• The continuous form is considered most desirable for low friction at the tool-chip interface, lower power consumption, long tool life and good surface finish.

The term built-up

•It appears that, when the cut is started in ductile metals, a pile of compressed and highly stressed metal forms at the extreme edge of the tool.
•Owing to the high heat and pressure generated there, this piled up metal is welded to the cutting tip and forms a “false” cutting edge to the tool.
•This is usually referred to as the “built up edge”.
•At very high speeds, usually associated with sintered carbide tools, the built-up edge is very small or nonexistent, and a smooth machined surface results.



The type of chip changes with cutting speed. When cutting mild steel, the chip is discontinuous at low cutting velocity (a), forms with a built-up edge at about 0.5 m/s (b), and is continuous with well developed secondary shear zone at high velocity (c).

<u>Chip control</u>

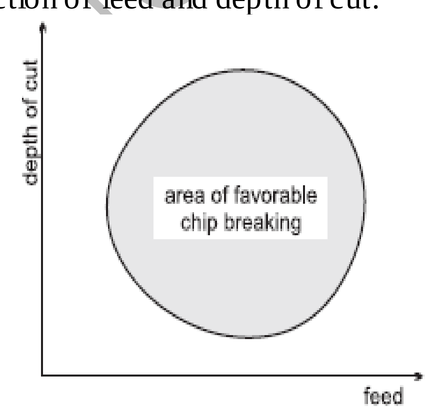
Discontinuous chips are generally desired because they

- are less dangerous for the operator
- do not cause damage to workpiece surface and machine tool
- can be easily removed from the work zone
- can be easily handled and disposed after machining.

There are three principle methods to produce the favourable discontinuous chip:

- proper selection of cutting conditions
- use of chip breakers
- change in the work material properties

<u>Proper selection of cutting conditions</u> Cutting velocity changes chip type as discussed. Since the cutting speed influences to the great extend the productivity of machining and surface finish, working at low speeds may not be desirable. If the cutting speed is to be kept high, changing the feed and depth of cut is a reasonable solution for chip control. At constant cutting speed, the so-called chip map defines the area of desirable chip type as a function of feed and depth of cut:



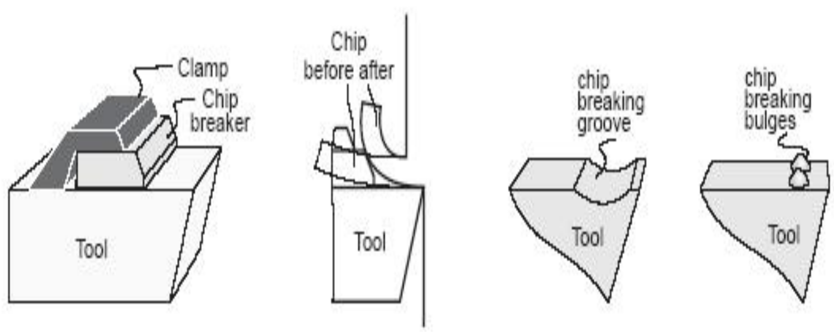
Chip map identifies the area of favourable chip formation for particular work material and cutting tool geometry

Chip breaker

Chip break and chip curl may be promoted by use of a so-called *chip breaker*. There are two typesof chip breakers

- external type, an inclined obstruction clamped to the tool face
- integral type, a groove ground into the tool face or bulges formed onto the tool face.

•A continuous-type chip from a long cut is usually quite troublesome.
•Such chips foul the tools; clutter up .the machine and workplace, besides being extremely difficult to remove from the swarf tray.
•They should be broken into comparatively small pieces for ease of handling and to prevent it from becoming a work hazard.
•Hence chip breakers are used to reduce the swarf into small pieces as they are formed. The fact that the metal is removed from the work piece.



Chip breakers and schematic illustration of the action of a chip breaker

Cut-off carbide insert with an inbuilt advanced chip breaking groove

THE ORTHOGONAL OR TWO-DIMENSIONAL METAL CUTTING

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•Orthogonal cutting takes place when the cutting face of the tool is 90º to the line of action or path of the tool.
•If, however, the cutting face is inclined at an angle less than 90º to the path of the tool, the cutting action is known as oblique.
Orthogonal and oblique cutting action, which shows two bars receiving identical cuts. The depth of cut is the same in both cases, and so is the feed, but the force which cuts or shears the metal acts on a larger area in the case of the oblique tool.
•The oblique tool will, thus, have a longer life as the heat developed per unit area due to friction along the tool-work piece interface is considerably small.

•Alternatively, the oblique tool will remove more metal in the same life as an orthogonal tool.
•Orthogonal cutting in the machine shop is confined mainly to such operations as knife turning, broaching and slotting, the bulk of machining being done by oblique cutting.
•But orthogonal cutting is the simplest type and is considered in the major part of this Chapter. The principles developed for orthogonal cutting apply generally to oblique cutting.

Cutting tool materials

Characteristic: The characteristics of the ideal material are:
1. Hot hardness. The material must remain harder than the work material at elevated operating temperatures.
2.Wear resistance. The material must withstand excessive wear even though the relative hardness of the tool-work materials changes.
3. Toughness. The term ' toughness' actually implies a combination of strength and ductility. The material must have sufficient toughness to withstand shocks and vibrations and to prevent breakage.
4.Cost and easiness in fabrication. The cost and easiness of fabrication should have within reasonable limit.

TYPE OF TOOL MATERIALS:

The selection of proper tool material depends on the type of service to which the tool will be subjected. No material is superior in all respects, but rather each has certain characteristics which limit its field of application.
The principal cutting materials are:
1. Carbon steels.
5. Cemented carbides.
2. Medium alloy steels. 6. Ceramics.
3. High-speed steels. 7. Diamonds.
4. Stellites.

1.CARBON STEELS:

•Carbon steels contain carbon in amounts ranging from 0.08 to 1.5 percent. A disadvantage of carbon tool steels is their comparatively low-heat and wear-resistance.
•They lose their required hardness at temperatures from 200º C to 250º C.

2.MEDIUM ALLOY STEELS:

•The high carbon medium alloy steels have a carbon content akin to plain carbon steels, but in addition there is, say, up to5 per cent alloy content consisting of tungsten, molybdenum, chromium and vanadium.
•Small additions of one or more of these elements improve the performance of the carbon steels in respect of hot hardness, wear resistance, shock and impact resistance and resistance to distortion during heat treatment.
•The alloy carbon steels, therefore, broadly occupy a midway performance position between plain carbon and high speed steels. They lose their required hardness at

temperatures from 250º C to 350º C.

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•**HIGH-SPEED STEEL :**

•High-speed steel(hss) is the general purpose metal for low and medium cutting speeds owing to its superior hot hardness and resistance to wear.

•High-speed steels operate at cutting speeds 2 to 3 times higher than for carbon steels and retain their. It is used as popular operations of drilling, tapping, hobbing, milling, turning etc.

•There are three general types of high-speed steels; high tungsten, high molybdenum, and high cobalt.

•Tungsten in h.s.s. provides hot hardness and form stability, molybdenum or vanadium maintains keen ness of the cutting edge, while addition of cobalt improves hot hardness and makes the cutting tool more wear resistant.

Three general types of high-speed steels are as follows:

a. 18-4-1 high-speed steels (T-series).This steel containing 18 per cent tungsten, 4 per cent chromium and I per cent vanadium, is considered to be one of the best of all purpose tool steels. In some steels of similar composition the percentage of vanadium is slightly increased to obtain better results in heavy-duty work.

b. Molybdenum high-speed-steel (M-series).This steel containing 6 per cent molybdenum, 6 per cent tungsten, 4 per cent chromium and 2 per cent vanadium have excellent toughness and cutting ability.

There are other molybdenum high speed steels now marketed, having various tungsten-molybdenum ratios, with or without cobalt, or with variations in percentages of the minor alloys chromium and vanadium.

c. Cobalt high-speed steels: This is sometimes called super high-speed steel. Cobalt is added from 2 to 15 per cent to increase hot hardness and wear resistance. One analysis of this steel contains 20 per cent tungsten, 4 per cent chromium, 2 per cent vanadium and 12 percent cobalt.

4. STELLITES:

•Stellite is the trade name of a nonferrous cast alloy composed of cobalt, chromium and tungsten. The range of elements in these alloys is 40 to 48 per cent cobalt, 30 to 35 per cent chromium, and 12 to 19 per cent tungsten.

•In addition to one or more carbide forming elements, carbon is added in amounts of 1.8 to 2.5 per cent. They can not be forged to shape, but may be deposited directly on the tool shank in an oxy-acetylene flame; alternately, small tips of cast stellite can be brazed into place.

•Stellites preserve hardness up to 1000º C and can be operated on steel at cutting speeds 2 times higher than for high-speed steel.

•These materials are not widely used for metal cutting since they are very brittle, however, they are used extensively in some non-metal cutting application, such as in rubbers, plastics, where the loads are gradually applies and the support is firm and where wear and abrasion are problems.

5. CEMENTED CARBIDES:

•Cemented carbides are so named because they are composed principally of carbon

mixed with other elements.
•The basic ingredient of most cemented carbides is tungsten carbide which is extremely hard. Pure tungsten powder is mixed under high heat, at about 1500º C, with pure carbon (lamp black) in the ratio of 94 per cent and 6 per cent by weight
•The new compound, tungsten carbide, is then mixed with cobalt until the mass is entirely homogeneous. This homogenous mass is pressed, at pressures from 1,000 to 4,200 kg/cm2, into suitable blocks and then heated in hydrogen.
•Boron, titanium and tantalum are also used to form carbides. The amount of cobalt used will regulate the toughness of the tool.

6.CERAMICS:
•The latest development in the metal-cutting tools uses aluminium oxide generally referred to as ceramics.
•Ceramics tools are made by composing aluminium oxide powder in a mould at about 280 kg/cm2 or more. The part is then sintered at 2200º C.This is known as cold pressing.
•Hot pressed ceramics are more expensive owing to higher mould costs. Ceramic tool materials are made in- the form of tips that are to be clamped on metal shops.
•Other materials used to produce ceramic tools include silicon carbide, boron carbide, and titanium carbide and titanium boride.

7.DIAMOND:
•The diamonds used for cutting tools are industrial diamonds, which are naturally occurring diamonds containing flaws and therefore of no value as gemstones.
•Alternatively they can be also artificial. The diamond is the hardest known material and can be run at cutting speeds about 50 times greater than that forH.S.S. tool, and at temperatures up to 1650º C.
•In addition to its hardness the diamond is incompressible, is of a large grain structure, readily conducts heat, and has a low coefficient of friction.

8.ABRASIVE:
•Abrasive grains in various forms loose, bonded into wheels and stone, and embedded in papers and cloths-find wide application in industry.
•They are mainly used for grinding harder materials and where a superior finish is desired on hardened or unhardened materials.
•For most grinding operations there are two kinds of abrasives in general use, namely aluminium oxide (carborundum) and silicon carbide
•The aluminium oxide abrasives are used for grinding all high tensile materials, whereas silicon carbide abrasives are more suitable for low tensile materials and non-ferrous metals.

9.CUBIC BORON NITRIDE (CBN):
• This material, consisting atoms of boron and nitrogen, is considered as the hardest tool material available next to diamond.
• It is having high hardness, high thermal conductivity and tensile strength. In certain application a thin layer ~(0.5 mm) of CBN isC applied on cemented carbide tools to obtain better machining performance.

• It can also be made in terms of index able inserts in standard form and size

(OR)

Carbon Steels

It is the oldest of tool material. The carbon content is 0.6~1.5% with small quantities of silicon,chromium, manganese, and vanadium to refine grain size. Maximum hardness is about HRC 62.This material has low wear resistance and low hot hardness. The use of these materials now is very limited.

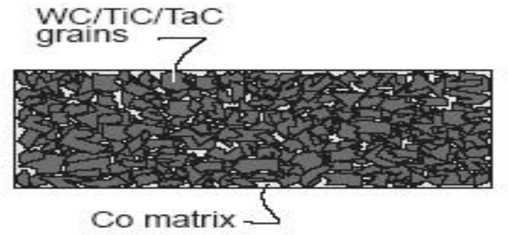
High-speed steel (HSS)

First produced in 1900s. They are highly alloyed with vanadium, cobalt, molybdenum, tungsten and chromium added to increase hot hardness and wear resistance. Can be hardened to various depths by appropriate heat treating up to cold hardness in the range of HRC 63-65. The cobalt component give the material a hot hardness value much greater than carbon steels. The high toughness and good wear resistance make HSS suitable for all type of cutting tools with complex shapes for relatively low to medium cutting speeds. The most widely used tool material today for taps, drills, reamers, gear tools,end cutters, slitting, broaches, etc.

Thread tap and die made of high-speed steel

Cemented Carbides

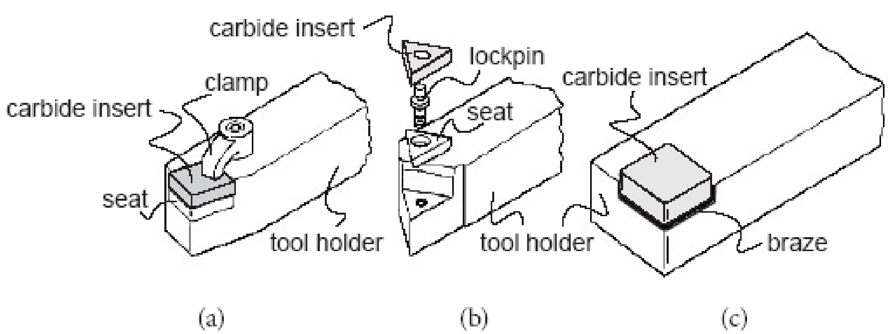
Introduced in the 1930s. These are the most important tool materials today because of their high hothardness and wear resistance. The main disadvantage of cemented carbides is their low toughness. Thesematerials are produced by powder metallurgy methods, sintering grains of *tungsten carbide* (WC) in a*cobalt* (Co) matrix (it provides toughness). There may be other carbides in the mixture, such as *titaniumcarbide* (TiC) and/or *tantalum carbide* (TaC) in addition to WC.



Microstructure of cemented carbides

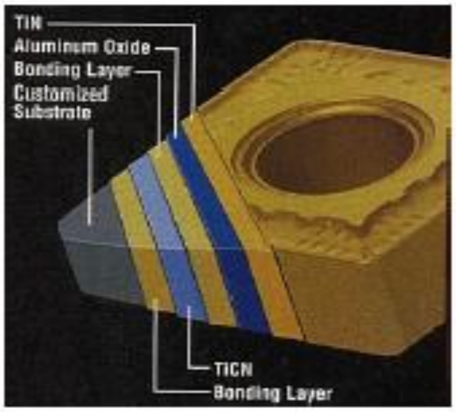
Assortment of cemented carbide inserts for use by different cutting tools. Some of the inserts are coated with a very thin layer of wear-resistant material.

In spite of more traditional tool materials, cemented carbides are available as inserts produced by powder metalurgy process. Inserts are available in various shapes, and are usually *mechanically attached* by means of clamps to the tool holder, or *brazed* to the tool holder (see the figure in the next page). The clamping is preferred because after an cutting edge gets worn, the insert is *indexed* (rotated in the holder) for another cutting edge. When all cutting edges are worn, the insert is thrown away. The indexable carbide inserts are never reground. If the carbide insert is brazed to the tool holder, indexing is not available, andafter reaching the wear criterion, the carbide insert is reground on a tool grinder.



Methods of attaching carbide inserts to tool holder: (a) clamping; (b) wing lockpins; and (c) brazing

One advance in cutting tool materials involves the application of a very thin coating (~ 10 µm) to a K-grade substrate, which is the toughest of all carbide grades. Coating may consists of one or more thin layers of wear-resistant material, such as *titanium carbide* (TiC), *titanium nitride* (TiN), *aluminum oxide* (Al2O3), and/or other, more advanced materials. Coating allows to increase significantly the cutting speed for the same tool life.



Structure of a multi-layer coated carbide insert

Ceramics
Ceramic materials are composed primarily of fine-grained, high-purity aluminum oxide (Al_2O_3), pressed and sintered with no binder. Two types are available:

- *white*, or *cold-pressed ceramics*, which consists of only Al_2O_3 cold pressed into inserts and sintered at high temperature.
- *black*, or *hot-pressed ceramics*, commonly known as *cermet* (from ceramics and metal).

This material consists of 70% Al_2O_3 and 30% TiC.
Both materials have very high wear resistance but low toughness, therefore they are suitable only for continuous operations such as finishing turning of cast iron and steel at very high speeds. There is no occurrence of built-up edge, and coolants are not required.
Cubic boron nitride (CBN) and synthetic diamonds
Diamond is the hardest substance ever known of all materials. It is used as a coating material in its polycrystalline form, or as a single-crystal diamond tool for special applications, such as mirror finishing of non-ferrous materials. Next to diamond, CBN is the hardest tool material. CBN is used mainly as coating material because it is very brittle. In spite of diamond, CBN is suitable for cutting ferrous materials.

Polycrystalline cubic boron nitride or synthetic diamond layer on a tungsten carbide insert

<u>TOOL WEAR AND TOOL LIFE</u>
<u>Introduction</u>
The life of a cutting tool can be terminated by a number of means, although they fall broadly into two main categories:

1. abrupt tool failure.

2. gradual wearing of certain regions of the face and flank of the cutting tool, and Considering the more desirable case 1 the life of a cutting tool is therefore determined by the amount of wear that has occurred on the tool profile and which reduces the efficiency of cutting to an unacceptable level, or eventually causes tool failure (case 2).

When the tool wear reaches an initially accepted amount, there are two options,

- to *resharpen* the tool on a tool grinder, or
- to *replace* the tool with a new one. This second possibility applies in two cases,

(i) when the resource for tool resharpening is exhausted. or (ii) the tool does not allow for resharpening,

The failure of cutting tools may be the result of:

1. WEAR ON THE FLANK OF THE TOOL:

Flank Wear is a flat portion worn behind the cutting edge which eliminates some clearance or relief. Plank wear takes place when machining brittle materials like C.I. or when feed is less than 0.15 mm/rev.

2. WEAR AT THE TOOL-CHIP INTERFACE:

•It occurs in the form of a depression or crater .This is caused by the pressure of the chip as it slides up the face of the cutting tool. Both flank and crater wear take place where feed is greater than0.15 mm/rev at low or moderate speeds.

•Actually a limited amount of cratering or depression improves the cutting action. This eventually will cause the cutting edge to be weakened so that it will break. This type of failure occurs when high speed steel, stellite, or sintered-carbide tools turn ductile metals.

3.THE SPALLINGOR CRUMBLINGOF THE CUTTING EDGE:

•When cutting extremely hard material, the cutting tool that has improperly ground relief angles will either rub on the material or be weak because of excessive clearance angles.

•If the cutting edges are not well supported, they will be subject to cracking and spalling. The proper setting of the tool is, therefore, an important consideration.

4. THE LOSS OF HARDNESS:

Because of excessive heat but under cutting conditions when the temperature and stresses are high plastic deformation may cause loss of "form stability".

6. FRACTURE BY A PROCESS OF MECHANICAL BREAKAGE:

•When the cutting force is very large or by developing fatigue cracks under chatter conditions.

•Frequently in the formation of chips, high-frequency vibration occurs when the tool or work is not supported rigidly, because of the sliding of the chip elements into sections.

•Because of the flank wear, or because of the periodic sloughing off of the built-up edge. These work, or even the whole machine, which in turn may cause a disagreeable noise called chatter.

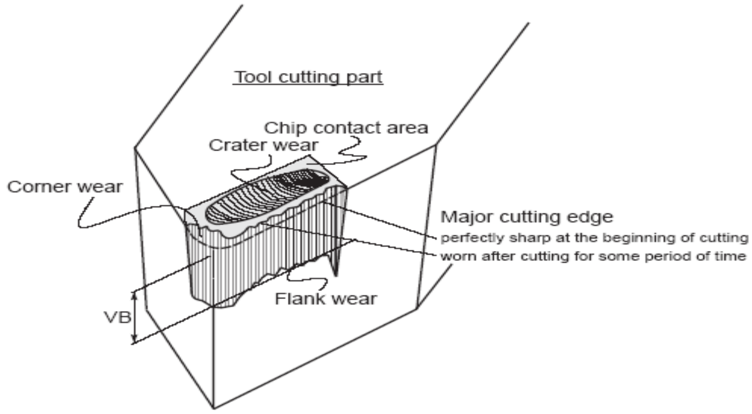
Wear zones

Gradual wear occurs at three principal location on a cutting tool. Accordingly, three main types of tool
wear can be distinguished,

1. crater wear
2. flank wear

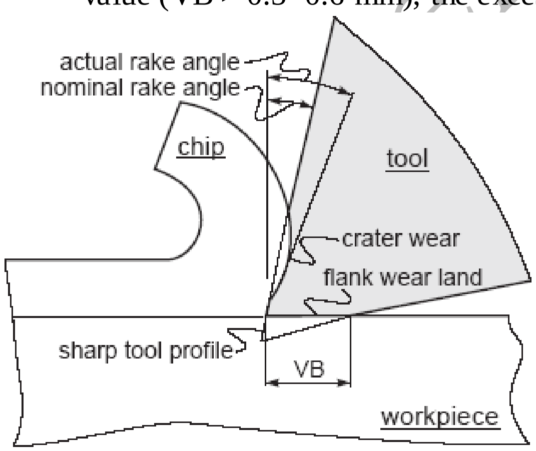
3. corner wear

These three wear types are illustrated in the figure:

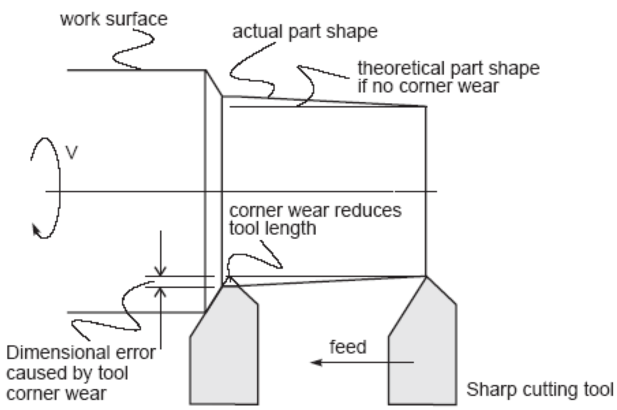


Types of wear observed in cutting tools

- ***Crater wear***: consists of a concave section on the tool face formed by the action of the chip sliding on the surface. Crater wear affects the mechanics of the process increasing the actual rake angle of the cutting tool and consequently, making cutting easier. At the same time, the crater wear weakens the tool wedge and increases the possibility for tool breakage. In general, crater wear is of a relatively small concern.
- ***Flank wear***: occurs on the tool flank as a result of friction between the machined surface of the workpiece and the tool flank. Flank wear appears in the form of so-called *wear land* and is measured by the width of this wear land, VB, Flank wear affects to the great extend the mechanics of cutting. Cutting forces increase significantly with flank wear. If the amount of flank wear exceeds some critical value (VB > 0.5~0.6 mm), the excessive cutting force may cause tool failure.



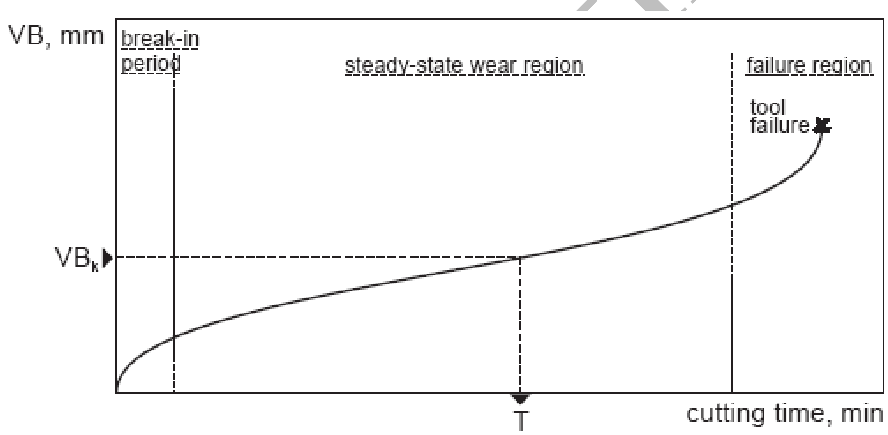
Cross-section perpendicular to the major cutting edge of a worn cutting tool showing the effect of crater wear on the tool rake angle and the flank wear land



Top view showing the effect of tool corner wear on the dimensional precision in turning

<u>Corner wear</u>: occurs on the tool corner. Can be considered as a part of the wear land and respectively flank wear since there is no distinguished boundary between the corner wear and flank wear land. We consider corner wear as a separate wear type because of its importance for the precision of machining. Corner wear actually shortens the cutting tool thus increasing gradually the dimension of machined surface and introducing a significant dimensional error in machining, which can reach values of about0.03~0.05 mm.

<u>Tool life</u>



Flank wear as a function of cutting time. Tool life T is defined as the cutting time required for flank wear to reach the value of VB_k

Tool wear is a time dependent process. As cutting proceeds, the amount of tool wear increases gradually.But tool wear must not be allowed to go beyond a certain limit in order to avoid tool failure. The most important wear type from the process point of view is the flank wear, therefore the parameter which has to be controlled is the width of flank wear land, VB. This parameter must not exceed an initially set safe limit, which is about 0.4 mm for carbide cutting tools. The safe limit is referred to as *allowable wear land (wear criterion)*, VBk. The cutting time required for the cutting tool to develop a flank wear land of width VBk is called *tool life*, T, a fundamental parameter in machining.The general relationship of VB versus cutting time is shown in the figure (so-called *wear curve*).Although the wear curve shown is for flank wear, a similar relationship occur for other wear types. The figure shows also how to define the tool life T for a given wear criterion VBk.

FACTORS AFFECTING TOOL LIFE:

• The life of a tool is affected by many factors such as cutting speed, feed, and depth of cut, chip thickness tool geometry, material of the cutting fluid and rigidity of the machine.

• Physical and chemical properties of work materials influence tool life by affecting form stability and rate of wear of tools.

• The nose radius also tends to affect tool life. Researchers have identified a .number of factors which are established by experimental verification.

• Some of them are briefly described in the subsequent paragraphs. Physical and chemical properties of work materials influence tool-life by affecting form stability and rate of wear of tool.

SURFACE FINISH (MACHINABILITY)

The ‘ ease’ with which a given material may be worked with a cutting tool is machinability.

Machinability depends on:

1. Chemical composition of work piece material.
2. Micro-structure.
3. Mechanical properties.
4. Physical properties.
5. Cutting conditions.

In evaluating machinability the following criterion may be considered:

1. Tool-life between grinds.
2. Value of cutting forces.
3. Quality of surface finish.
4. Form and size of chips.
5. Temperature of cutting.
6. Rate of cutting under a standard force.
7. Rate of metal removal.

The main factor to be chosen for judging machinability depends on the type of operation and production requirements.

Cutting Fluids

Cutting fluids, sometimes referred to as lubricants or coolants are liquids and gases applied to the tool and work piece to assist the cutting operation.

Functions of cutting fluids:

- To cool the tool.
- To cool the work piece.
- To lubricate and reduce friction
- To improve surface finish.
- To protect the finished surface from corrosion

•To wash the chips away from the tool.

PURPOSE OF CUTTING FLUIDS:

1.To cool the tool.

•Cooling the tool is necessary to prevent metallurgical damage and to assist in decreasing friction at the tool-chip interface and at the tool-work piece interface.

•Decreasing friction means less power required to machine, and more important, increased tool life and good surface finish.

•The cooling action of the fluid is by direct carrying away of the heat developed by the plastic deformation of the shear plane and that due to friction

•For cooling ability, water is very effective, but is objectionable for corrosiveness and lack of friction reducing wear.

2.To cool the work piece.

The role of the cutting fluid in cooling the work piece is to prevent its excessive thermal distortion.

3.To lubricate and reduce friction.

•The energy or power consumption in removing metal is reduced

•Abrasion or wear on the cutting tool is reduced thereby increasing the life of the tool

•By virtue of lubrication, less heat is generated and the tool, therefore, operates at lower temperatures with the tendency to extend tool life

4. To improve surface finish.

5.To protect the finished surface from corrosion.

To protect the finished surface from corrosion, especially in cutting fluids made up of a high percentage of water, corrosion inhibitors are effective in the form of sodium nitrate or triethanolamine.

6.To cause chips break up tiny small parts rather than remain as long ribbons which are hot and sharp and difficult to remove from the work piece.

7. To wash the chips away from the tool. This is particularly desirable to prevent fouling of the cutting tool with the work piece.

Properties of cutting fluids

•High heat absorption capability.

•Good lubricating quality.

•High flash point so as to eliminate the hazard of fire.

•Stability so as not to get oxidized in presence of air.

•Neutral so as not to react chemically.

•Odourless so as not to produce bad smell even when heated.

•Harmless to the skin of the operators.

•Non corrosive to the work or the machine.

•Transparency so that the cutting action of tool may be observed by the operators.

•Low viscosity to permit free flow of the liquid.

•Low priced to minimize production cost.

Type of Cutting fluid

- Water: Water provided good cooling effect but is not a good lubricant. Water is hardly used as cutting fluid because of its corrosiveness. Soluble oil or water miscible cutting fluids: These are also called water based cutting fluids. These comprises of mineral oil or fat mixtures and
  emulsifiers added to water. The emulsifier breaks the oil into minute particles and disperses them throughout water. These cutting fluids have excellent lubricating properties. It has milky appearance.
- Straight cutting oils: These oils have good lubricating but poor heat absorption properties and therefore are suitable only for low cutting speed.
- These are of three types:

Mineral oil: Kerosene, low viscosity petroleum fraction.
Fatty oil: Lard oil Combination of mineral and fatty oil

Oils with adhesives: The benefits of mineral oils can be improved with the help of adhesives, which are generally compounds of sulphur or chlorine Addition of sulphur or chlorine compounds reduces chances of chip welding on the tool rake face. Besides these there are other adhesives which are also added to improve corrosion protection, prevent any organic growth

Choice of cutting fluids
1. Type of operation.
2. The rate of metal removal.
3. Material of the work piece.
4. Material of the tool.
5.Surface finish requirement.
6. Cost of cutting fluid

Factors influencing cutting process

Parameter	Influence and interrelationship

Cutting speed depth of cut,feed,cutting fluids.	Forces power,temperature rise,tool life,type of chips,surface finish.
Tool angles	As above;influence on chip flow direction;resistance to tool chipping.
Continuous chip	Good surface finish;steady cutting forces;undesirable in automated machinery.
Built-up-edge chip	Poor surface finish,thin stable edge can product tool surface.
Discontinuous chip	Desirable for ease of chip disposal;fluctuating cutting forces;can affect surface finish and cause vibration and chatters.
Temperature rise.	Influences surface finish,dimensional accuracy,temperature rise,forces and power.
Tool wear	Influences surface finish,dimensional accuracy,temperature rise,forces and power.
Machinability	Related to tool life,surface finish,forces and power

ANNA UNIVERSITY IMPORTANT QUESTION

Part A (Two marks Questions)

1. Give any four properties of cutting tool material?*
2. What is meant by cutting tool signature?*
3. Define tool life.*
4. Define the term machinability.*
5. What is the difference between orthogonal and oblique cutting?
6. What is the utility of orthogonal cutting?
7. What are the materials used for cutting tool?
8. What is the instrument used to measure the temperature of chips?
9. What are the various types of chips?
10. What is chips breakers?
11. Why cutting fluids are required while machining?
12. How to measure tool life?
13. What are the types of cutting fluids available?
14. What are significations characteristics of H.S.S?
15. What is meant by built up edge in chips?

Part B (16 Mark Questions)

1. Explain orthogonal and oblique cutting with suitable sketches?
2. Explain the mechanics of cutting and chip formation in metal cutting?
3. Explain the cutting force in orthogonal cutting and oblique cutting and the instruments used to measure the cutting force?
4. Explain the cutting tool nomenclature and the geometrical control of tool angle?
5. Explain the types of cutting tool material?
6. Explain the important of cutting fluids and their properties?
7. Explain the economic of machining?