SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

AN AUTONOMOUS INSTITUTION

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INTERNAL ASSESSMENT EXAMINATION – II

III Semester

B.E. - Mechanical Engineering

19ME301- Manufacturing Technology

Question Bank with Answers

PART A - (5 X 2 = 10 marks)

Q.No	Question	M	CO
1.	What are the three different types of chips formed during machining?	2	CO-3
2.	Compare orthogonal and oblique cutting.	2	CO-3
3.	List any two methods by which taper turning is done in a center lathe.	2	CO-3
4.	Write short notes on formability of sheet metal.	2	CO-2
5.	Why is it necessary to provide proper clearance between the punch and die in a shearing operation?	2	CO-2
6.	What is rake angle?	2	CO-3
7.	Name the factors that contribute to poor surface finish in cutting.	2	CO-3
8.	List any four lathe accessories.	2	CO-3
9.	What is the spring back effect in sheet metal component?	2	CO-2
10.	What is punching operation?	2	CO-2

PART B

6.	(a)	Explain the various cutting tool materials and their applications.	13	CO-3
	(b)	Mention the specifications of center lathe with a neat sketch.	13	CO-3
7.	(a)	Explain the explosive forming process with neat sketch.	13	CO-2
	(b)	Describe the shearing and bending operations with suitable examples.	13	CO-2

PART C

8.	(a)	With a neat sketch elaborate the nomenclature of single point cutting tool.	14	CO-3
	(b)	Construct the Merchant circle diagram and explain the three-angle relationship.	14	CO-3

PART B

6.	(a)	Explain the different types of cutting fluids, their properties and applications.	13	CO-3
	(b)	Illustrate any two Taper Turning Methods with neat sketches.	13	CO-3

7.	(a)	Explain the rubber pad forming process with neat sketch.	13	CO-2
	(b)	Describe the shearing and bending operations with suitable examples.	13	CO-2

PART C

8.	(a)	Write a short note on tool wear and explain the different wear mechanisms.	14	CO-3
	(b)	Enumerate the Merchant's theory with a neat diagram.	14	CO-3

1. What is flanging?

It is a process of bending edges of sheet metals usually to 90^o

2. Define the term formability.

Formability of a material is the ability of the sheet metal to undergo the desired shape change without failure.

3. What is the spring back effect in sheet metal component?

In bending operation, the bent part retains some of its elasticity which is recovered after the punch is removed is called spring back.

This can be recovered by over bending by an amount that brings the part to return to the correct shape.

4. What are the advantages of hydro forming process?

Thinning of metal, spot stresses and spring back are drastically reduced or completely eliminated.

- It is used for mass production because work performed per operation is high.
- Complicated contours can also be made.

5. Why is it necessary to provide proper clearance between the punch and die in a shearing operation?

- Clearance is the intentional space between the punch cutting edge and the die cutting edge.
- Depends on the type of cutting operation, the space between punch and die is provided known as clearance.

7. What are the limitations of explosive forming?

(i) Highly trained operators are needed. (ii) Noisy operation.

8. What is shear angle? Why is it given in punches and dies?

The angle about which the vertical lines tilt is called shear angle. It is given to reduce the cutting force, shock and to smoothen the cutting operation. To prevent distortion on the stock material, shear angle will be on the die member for blanking operation and the shear angle will be on the punch member for piercing operation.

9. List out the test methods for testing formability of material.

a) Formability tests for bulk deformation.

b) Formability test for elastic – plastic deformation. c) Simulative tests for forming operation.

d) Full scale forming tests.

10. Define Metal Cutting.

Metal cutting or machining is the process of removing unwanted material from a block of metal in the form of chips. To perform the metal cutting operation, relative motion is required between the tool and the work. This relative motion is achieved in most machining operation by means of a primary motion, called "cutting speed" and a secondary motion called "feed "The shape of the tool and its penetration into the work surface, combined with these motions, produce the desired shape of the resulting work surface.

11. What is orthogonal cutting and oblique cutting?

Orthogonal cutting: The cutting edge of tool is perpendicular to the work piece axis. It is also known as two-dimensional cutting.

Oblique cutting: The cutting edge is inclined at an acute angle with normal to the cutting velocity vector is called oblique cutting process. It is also known as Three-dimensional cutting.

12. State any two differences between orthogonal cutting and oblique cutting.

S.No	Orthogonal cutting	Oblique cutting
1.	The cutting edge of tool is perpendicular to the work piece axis.	The cutting edge is inclined at an acute angle with normal to the cutting velocity vector
2	The chip flow in the direction normal to the cutting edge.	The chips make an angle with the normal to the cutting edge.
3.	In orthogonal cutting only two components of force considered cutting force and thrust force which can be represent by 2D coordinate system.	In oblique cutting three component of force are considered, cutting force, thrust force and radial force which cannot represent by 2D coordinate. It used 3D coordinate to represent the forces acting during cutting, so it is known as 3D cutting.
4.	This tool has lesser cutting life compare to oblique cutting.	The tool has higher cutting life.
5.	The chips flow over the tool.	The chips flow along the sideways.

13. What is meant by Shear plane and Shear angle in metal cutting?

When cutting tool is introduced into the work piece, plastic deformation takes place in a narrow region in the surrounding of the cutting edge, the material ahead of it is sheared continuously along a plane called the Shear plane. The shear plane is inclined at an acute angle to the axis, the angle is known as Shear angle.

14. What is chip and mention its different types?

The sheared material begins to flow along the cutting tool face in the form of small pieces is called chip. The chips are mainly classified into three types.

a. Continuous chip.

b. Discontinuous chip.

c. Continuous chip with built up edge(BUE)

15. What are the factors that favour the formation of continuous chips?
The following factor favours the formation of continuous chip.
(i) Ductile material (ii) Smaller depth of cut (iii) High cutting speed (iv) Large rake angle (v) Sharp cutting edge.(vi)Proper cutting fluid,(vii) Low friction between tool face and chips

16. What are the favourable factors for discontinuous chip formation?
a. Machining of brittle material, b. Small rake angle, c. Higher depth of cut, d. Low cutting speeds, e. Cutting ductile material with low speed and small rake angle of tool.

17. What is meant by built up edge ?
While machining ductile materials, due to high temperature and pressure in the cutting zone and also high friction in the tool-chip interface may cause the work material to adhere or weld to the cutting edge of the tool forming the built up edge. This causes the finished surface to be rough.

18. What are the important properties or characteristics required for a tool material?
1.High hot hardness 2.High Temperature strength 3.Low co-efficient of friction 4.High thermal conductivity 5.Low ductility.

19. State few cutting tool materials.
1. Plain Carbon steels, 2. High Speed Steel (HSS) 3. Cemented Carbides 4.CBN 5. Ceramics 6. Stellite 7. Diamonds

20. What are the advantages of diamond tools?
i). High cutting speeds about 50 times greater than HSS tool
ii).Cutting very hard materials such as glass, plastics, ceramics etc.
iii).They have low coefficient of friction and cut up to 1650 °C

21. Classify the various angles in cutting tool?
1) Back rake angle 2) Side rake angle 3) End relief angle 4) Side relief angle 5) Side cutting angle 6) End cutting angle.

22. What are the important characteristics of a cutting tool material?
i. Hot hardness ii. Wear resistance iii. Toughness iv. Low friction v. Cost of tool vi. High thermal conductivity vii. Resistance to thermal shock viii. Easy to grind and resharpen.

23. How do you define tool life?
The time period between two consecutive re sharpening of a cutting tool, with which the tool cuts the material effectively is called as tool life.
Taylor's tool life equation is $VT^n = C$
where, V= Cutting speed in m/min, T = tool life in min, n= exponent & C= Constant.

24. Write the factors affecting the tool life.
Factors affecting cutting tool life are
i. Cutting speed ii. Feed and Depth of cut. iii. Tool Geometry iv. Tool material v. Type of Cutting Fluid vi. Work material

25. What is chip breaker?
The chip coils in a helix and curl around the work and the tool and may injure the operator in case of continuous chip. A chip breaker is a metal piece attached to the tool, breaks the chip and reduces the difficulties.

26. Define tool wear and classify it?

Tool wear can be defined as the loss of weight or mass of tool that lost due to the contact of sliding surfaces. Tool wear can be classified into i) Abrasion wear, ii) Adhesion wear iii Diffusion wear iv) Flank wear v) Crater wear.

27. Name two reasons for flank wear in cutting tools.
The reasons for flank wear are i) Friction ii) Large contact area iii) Temperature
iv) Length of wear land

28. Write the factors which influence the cutting temperature.
The factors influence the cutting temperatures are
a) Work piece b).Tool material, c). Tool geometry d). Cutting speed e). Depth of cut f). Cutting fluid.

29. Why is lubrication not required while machining cast iron?
While machining cast iron, the lubrication is not required because
i).Cast iron is a brittle metal ii). Discontinuous chip formation. iii).Machining at Low temperature iv). Low hardness.

30. What are the functions of cutting fluid?
1.Cool the tool and the work piece 2.Reduce the friction 3.Protect the work against rusting 4.Improves the surface finish 5.Prevent the formation of built up edge.

31. What are the properties of cutting fluid?
i. It should have good lubricant properties, ii. High heat absorbing capacity, iii. It should have a high specific heat, high heat conductivity and high film co-efficient, iv. High flash point. v. It should be odourless, vi. It should be non-corrosive to work and tool, vii. It should have low viscosity to permit free flow of the liquid.

32. Define machinability of metal? and write the factors affecting machinability.
Machinability is defined as the ease with which a material can be satisfactorily machined life of the tool before tool failure or re-sharpening. The factors affecting the machinability are
a. Chemical composition of work piece material, b. Microstructure of work piece material
c. Mechanical properties like ductility, toughness etc.
d. Physical properties of work materials.
e. Method of production of the work materials.

33. What is machinability index?
It is a comparison of machinability of different material to standard material.

$$\text{Machinability index,(\%)MI} = \frac{\text{Cutting speed of material for 20 minutes tool life}}{\text{Cutting speed of of standard steel for 20 minutes tool life.}} \times 100$$

Materials with high machinability index indicates that the material can be easily machined.

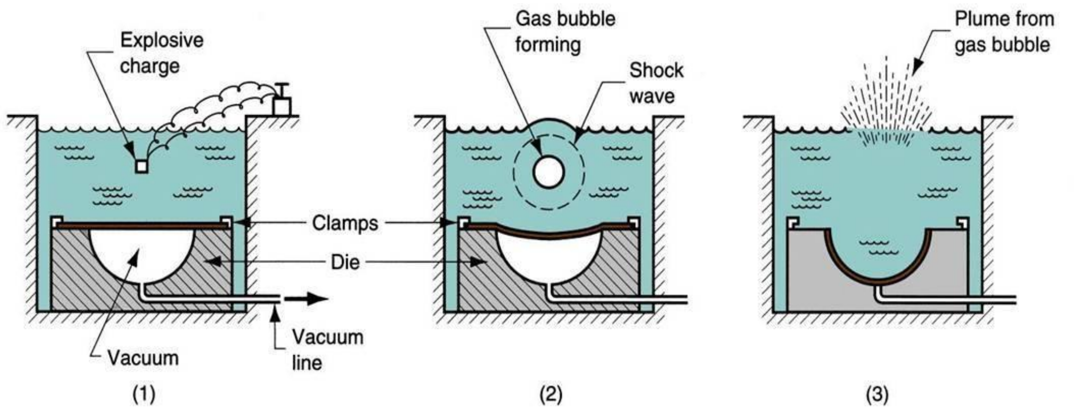
<u>PART-B</u>

1. Explain the explosive with neat sketch.

<u>Explosive forming process:</u>

- Explosive energy used as metal forming

- Sheet-metal blank is clamped over a die
- Assembly is immersed in a tank with water
- Rapid conversion of explosive charge into gas generates a shock wave .the pressure of this wave is sufficient to form sheet metals.



Operations can be divide into two categories

1. Standoff operations
2. Contact operations

1. Standoff operations

    Explosive charge is located at some distance away from the blank and its energy is transmitted through some fluid medium such as water.

    This technique is used to form blanks into various shapes except welding, hardening, compacting and cutting process.

2. Contact operations
    - This operation mainly used for welding, hardening, compacting and cutting process.
    - The forming of sheet metal is done by generating pressure wave in a fluid.
    - Explosive charge is directly located over the blank.
    - The blank being formed is placed against the female die.
    - This female die has required configuration.
    - This entire set up of female die and blank is placed inside the work tank.
    - The work tank contains water to receive the vibration in the form of pressure wave.

- The work Tank should be perfectly insulated to avoid heat transfer from the system to surrounding.
- The explosive charge is ignited by the detonator.
- Due to this, a high-pressure energy is released in the form of waves.
- This pressure waves are applied over the blank to obtain the required shape of female die.

Advantages:

a) Less capital investment

b) Presses are not required

c) Only one die is enough to form the sheet metal.

Disadvantages:

a) Highly trained operators are needed.

b) Noisy operation.

Applications:

This process is mainly used for producing aerospace component.

2. Describe the shearing and bending operations with suitable examples.

Shearing operations:

Sheet metal subjected to shear stress developed between a punch and a die is called *shearing*

Shearing usually starts with formation of cracks on both the top and bottom edges of the work piece.

These cracks meet each other and separation occurs.Shearing process has three important basic stages,

1. Plastic deformation
2. Fracture and
3. Shear.

The shearing operations are,

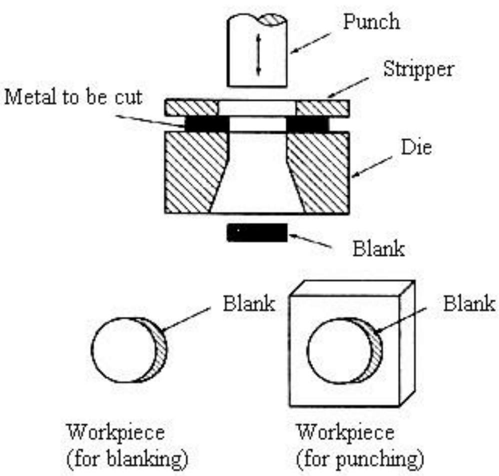
i) Blanking ii) Punching iii) Piercing

iv) Power shearing v) Cutting off vi) Parting vii) Notching

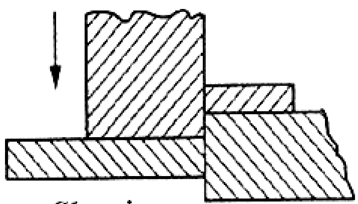
viii) Slitting ix) Lancing x) Nibbling xi) Trimming

xii) Shaving xiii) Perforating

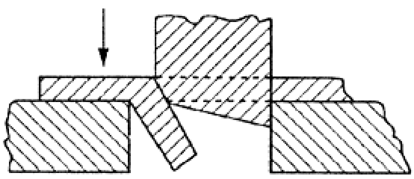
The following figures show different types of shearing operations.



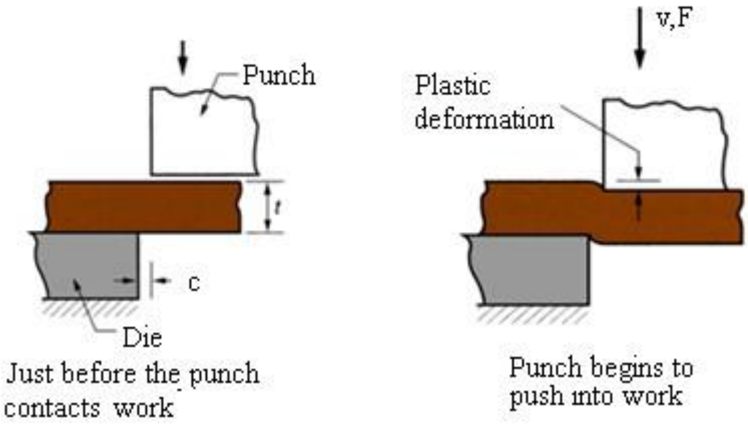
Blanking and punching



Shearing



Lancing



Shearing of sheet metal between two cutting edges:

(1) Just before the punch contacts work;

(2) Punch begins to push into work, causing plastic deformation

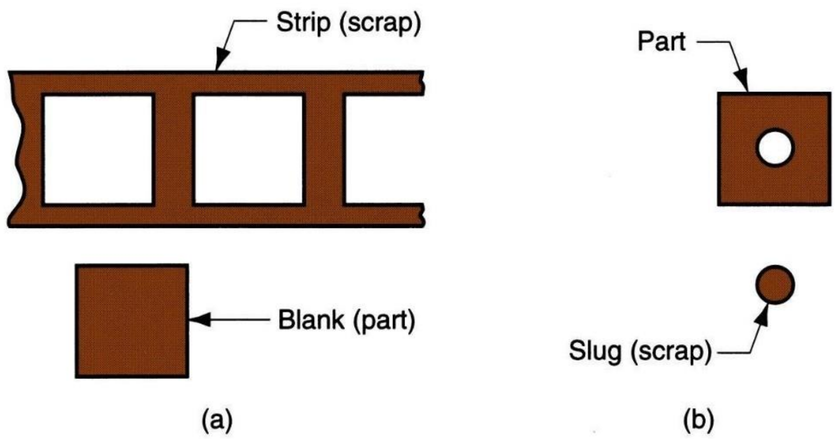
Shearing is a process for cutting sheet metal to size out of a larger stock such as roll stock.

Shears are used as the preliminary step in preparing stock for stamping processes, or smaller blanks for CNC presses

The shearing process produces a shear edge burr, which can be minimized to less than 10% of the material thickness. The burr is a function of clearance between the punch and the die, and the sharpness of the punch and the die.

- **Blanking** – Blanking is the operation of cutting a flat shape from the sheet metal. The portion which is removed is the required part is called as blank and the operation is called as blanking.

Punching - similar to blanking except cut piece is scrap, called a *slug*



(a) Blanking and (b) punching

A slug (the material punched out) is produced in **punching** operations but not in **piercing** work

Piercing is "forming a hole in sheet metal with a pointed punch with no metal fallout (slug)."

In this case, a significant burr or deformed sharp edge is created on the bottom side of the material being pierced.

Piercing is the operation of cutting internal features (holes or slots) in stock, without forming slug scrap

Power shearing-this operation is carried out on power shearing machines where the sheet metal is cut between the movable upper cutting blade and fixed lower cutting blade.

Cutting off – in this operation a piece is removed from a strip by cutting along a single line.

Parting – in parting operation the sheet is sheared into two or more pieces and the scrap is removed between the two pieces to part them.

Notching – notching refers to removing pieces of desired shapes from the edge.

Slitting – shearing operations carried out by means of pair of circular blades called as slitting. It is the operation of marking an unfinished cut through a limited length only A slit edge normally has a burr, which may be plastically folded over the sheet surface by rolling the sheet between two rolls.

Lancing – it is an operation of cutting on one side and bending on the other side to form a sort of tab (or) louver. In this operation no metal is being removed. **Nibbling –** in a nibbler machine a small straight punch moves up and down rapidly into a die. A sheet is fed through the gap and many over lapping holes are made.

Trimming – it is the operation of cutting and removing unwanted excess metal from the periphery of a previously formed/forged/cast component.

Shaving – the rough edges of a blanked part are removed by cutting thin strip of metal along the edge on the periphery.

Perforating – this process is used to make multiple holes which are small in diameter and close together, in a flat work material.

Bending Operations:

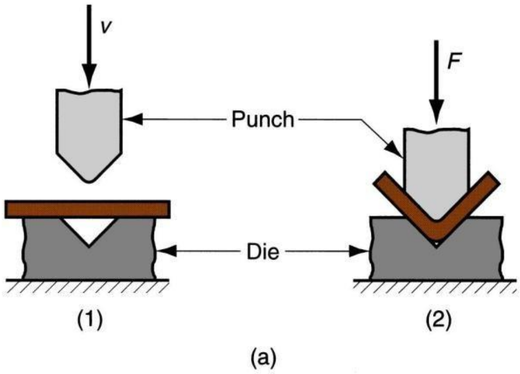
Straining sheet metal around a straight axis to take a permanent bend

Metal on inside of neutral plane is compressed, while metal on outside of neutral plane is stretched

- The material is stressed beyond the yield strength but below the ultimate tensile strength.
- The surface area of the material does not change much.
- Bending usually refers to deformation about one axis

V-bending - performed with a V-shaped die

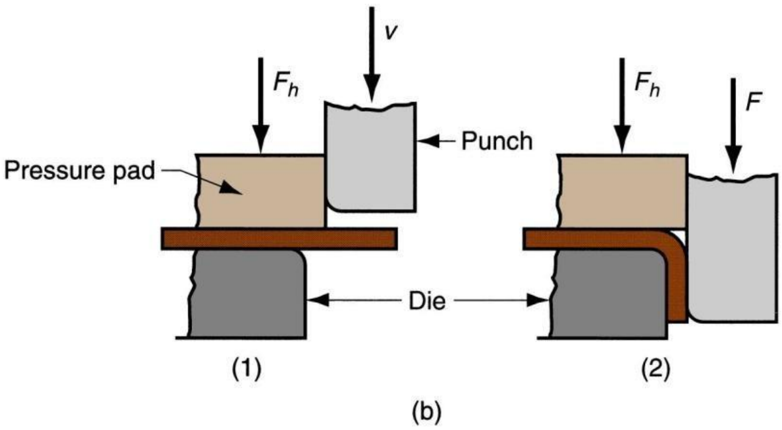
- For low production
- Performed on a ***press brake***
- V-dies are simple and inexpensive



Edge bending - performed with a wiping die

For high production
Pressure pad required

Dies are more complicated and costly



3. Briefly explain with a neat sketch hydro forming process.

Hydro forming is an effective sheet metal forming process. Hydro forming can typically obtain deeper draws than conventional deep drawing operations.

Hydro forming uses a rigid punch to push a sheet metal work piece into a rubber membrane. Behind the rubber membrane is a chamber of pressurized fluid.

When the work is pressed into the chamber, the rubber membrane surrounds it completely and the pressure of the fluid forces the sheet metal to form on the punch.

Fluid pressure can be controlled during the operation and can be as high as 15,000 lbs/in^2, (100MPa). Due to the large amount of evenly distributed pressure on the work piece, very deep draws, (high percent reduction), can be performed with hydro forming.

Friction acts to reduce tensile stresses in the material during the process.

Lubrication affects friction and is an important factor in any type of rubber forming, (this includes hydro forming), process.

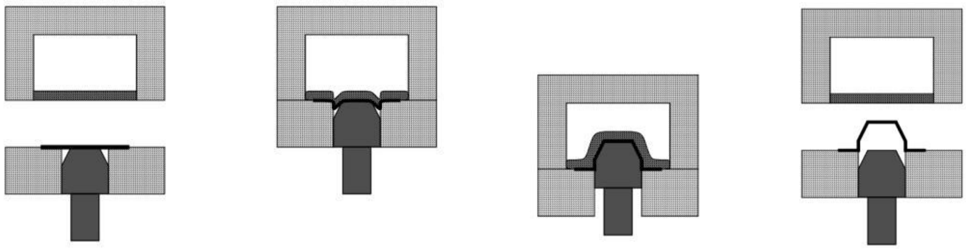
One advantage of manufacturing by a rubber forming process is that the rubber, or flexible material, will be less likely to damage the surface of the sheet metal part.

Basic process,

- A metal sheet is placed over a male punch.
- Fluid is on the other side of the metal sheet.
- The punch advances and the metal sheet are forced into the shape of the punch.
- The hydraulic chamber acts as a mate for the punch.

The basic operation is,

1. The metal is placed between the fluid chamber and the punch bed.
2. The fluid is encased behind a wear pad, and this wear pad is brought into contact with the sheet with pressures up to 5 Kpsi.
3. The punch is advanced with pressures up to 15 Kpsi causing the metal to take the shape of the punch.
4. The pressures are released, the punch withdrawn, the fluid chamber pulled back to remove the metal part.



<u>Compared to conventional forming,</u>

- Higher drawing ratios
- Reduced tool costs
- Less scarring of parts
- Asymmetrical parts made in on pass
- Many high strength alloys can be formed, for example stainless steel

<u>Methods permissible,</u>

- Punch forming - for large drawing depths
- Negative punch forming - allows recessed features
- Cavity die forming
- Male die forming
- Expansion forming

Advantages,

- Any type of sheet material can be used
- Thicknesses of 0.1 to 16mm
- Flexible and easy to operate
- Less expensive tooling
- Reduced setup times
- Reduced die wear

Disadvantages,

- Sharp corners difficult to control
- High equipment cost
- No holes in surface
- Incorrectly set pressures may lead to buckling and tearing for high pressures

Applications,

- Cups/kitchenware
- Auto body panels
- Covers.

4. What is super plastic forming? Explain with neat sketch.

Super plastic forming is a process that is employed to all common metal working techniques. Following are some of the materials that are being developed for plastic forming:

- Super plastic alloys
- Zinc aluminium (Zn-22AL)
- Titanium-Al(Ti-6AL-V)
- Bismuth-tin
- Aluminium (2004,2419,7475)
- Aluminium – lithium alloys (2090,2091,8090)

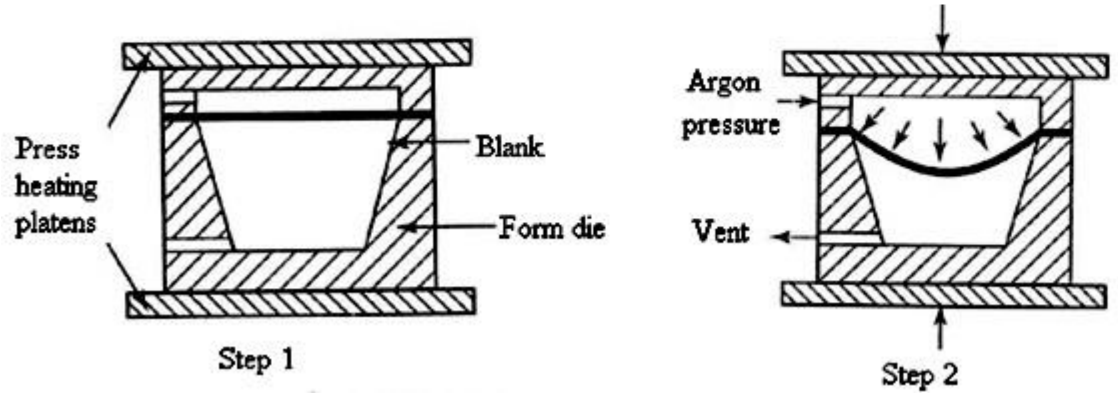
Super plastic forming process improves productivity by eliminating mechanical fasteners and it produces parts with good dimensional accuracy and low residual stress.

The super-plastic forming process is usually carried out at a temperature of 900°C for titanium alloys and at a temperature of 500°C for aluminium alloys.

Operation:

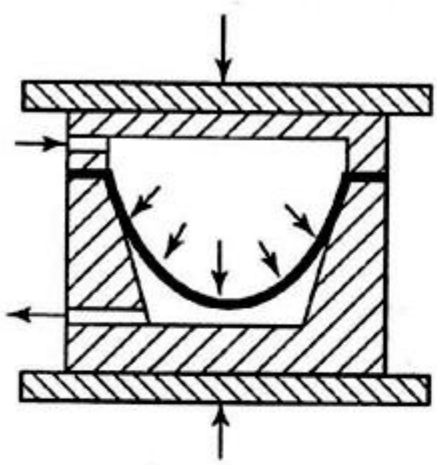
Step 1: The blank is loaded in the form die. The hot press heats the die and the blank to the material super plastic temperature.

Step 2: Once the temperature is attained, the gas pressure slowly inflates the blank.

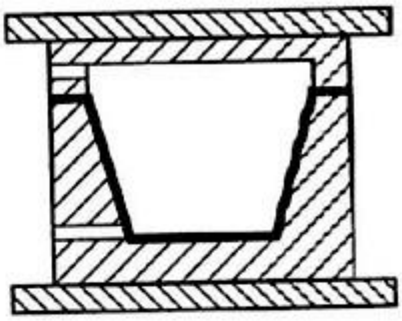


Step 3: The gas keeps inflating the part to fit the die. The material at the super plastic temperature can allow up to 5 times elongation.

Step 4: At the end of the forming cycles, the part perfectly conforms to the die even in its smallest details.



Step 3



Step 4

Conventional forming techniques compared to SPF,

- require multiple annealing and forming steps
- have lower accuracy and repeatability
- have spring back
- Poorer surface finish

For SPF of aluminum,

- 70-90% of melting temperature
- Typical time is 30-120 min.
- Temperature must be carefully maintained
- Cavitations (voids) can occur in the aluminum if pressure is not applied to both sides of the sheet - a different pressure still causes motion.

Parts are less expensive because only half of the tooling is required.

1. Explain various types of cutting tool materials and its applications.

Types of chip formation

Discontinuous Chips

Cast Iron, Hard Brass and other materials that produce a Powdery chip.

"Discontinuous Chip - Discontinuous or segmented chips are produced when brittle metal such as cast iron and hard bronze are cut or when some ductile metals are cut under poor cutting conditions.

As the point of the cutting tool contacts the metal, some compression occurs, and the chip begins flowing along the chip-tool interface. As more stress is applied to brittle metal by the cutting action, the metal compresses until it reaches a point where rupture occurs and the chip separates from the unmachined portion.

This cycle is repeated indefinitely during the cutting operation, with the rupture of each segment occurring on the shear angle or plane. Generally, as a result of these successive ruptures, a poor surface is produced on the workpiece."

Notice how the chips deform and begin to break up at a considerable distance in front of the cutting edge. Chip control is usually not a problem when machining these materials. Harder, more heat and wear resistant Carbide Grades can be used in these applications. Edge strength becomes less of a factor vs. machining Steel or Stainless or other materials that make long chips.

Continuous Chips

Medium to High carbon and alloy Steels – Long Chipping Materials

"Continuous Chip - Continuous chips are a continuous ribbon produced when the flow of metal next to the tool face is not greatly restricted by a built-up edge or friction at the chip tool interface. The continuous ribbon chip is considered ideal for efficient cutting action because it results in better finishes. Unlike the Type 1 chip, fractures or ruptures do not occur here, because of the ductile nature of the metal."

Carbon and Alloy Steels such as 1030, 1035, 1045, 1144, 4130, 4140, 4340 contain at least .3% carbon that allows them to be hardened by heating and quenching. They produce long continuous chips.

When machining these metals with Carbide Inserts the material in front of the cutting edge deforms resulting in high temperatures which softens the metal and consequently lowers its strength and hardness making it easier to machine

The chips weaken and begin to break in front the cutting edge; the tool acts much in the same way that a wedge does when splitting wood. In some cases, air, oil or coolant quenches the hot chips, hardening them and making them brittle and easier to break.

The chips produced when cutting these metals contact the face of the tool behind the cutting edge creating a zone of high heat that can result in cratering. Coatings usually eliminate this problem.

Built up Chips

Low carbon Steels, Stainless Steels, Nickel Alloys, Titanium, Copper, Aluminum and other soft, "gummy' Materials.

Sheared Chips or as some refer to it "Continuous Chip with a Built-up Edge (BUE). The metal ahead of the cutting tool is compressed and forms a chip which begins to flow along the chip-tool interface.

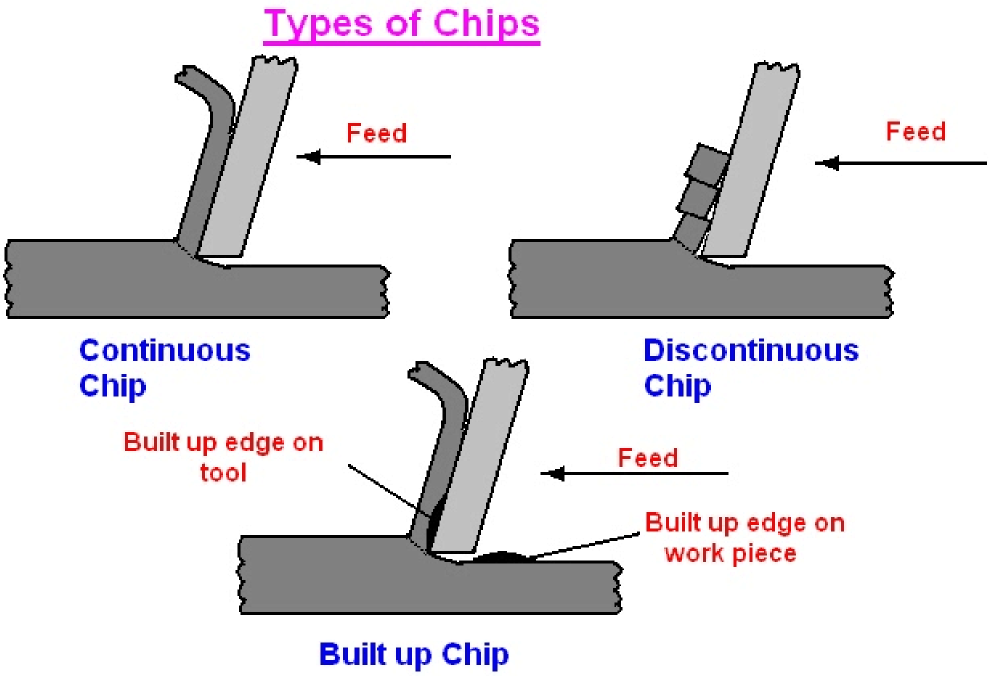
As a result of the high temperature, the high pressure, and the high frictional resistance against the flow of the chip along the chip-tool interface, small particles of metal begin adhering to the edge of the cutting tool while the chip shears away.

As the cutting process continues, more particles adhere to the cutting tool and a larger build-up results, which affects the cutting action. The built-up edge increases in size and becomes more unstable. Eventually a point is reached where fragments are torn off. Portions of these fragments break off and stick to both the chip and the workpiece.

The build-up and breakdown of the built-up edge occur rapidly during a cutting action and cover the machined surface with a multitude of built-up fragments. These fragments adhere to and score the machined surface, resulting in a poor surface finish.

These metals readily deform in front of the cutting edge and have to be "sheared" by the tool. What the above paragraph doesn’t tell you is that these materials require tools with sharper cutting edges than those used for machining cast Iron or higher carbon content Steels. The chips tend to compress onto the face of the tool which can result in built-up edge.

The chips formed when cutting these metals are thicker than those produced by Medium Carbon or Alloy Steels at the same Feed Rates and Depths of Cut. These thicker chips are stronger and harder to break.



2.Explain the different types of cutting fluids, their properties and applications.

Functions of Cutting Fluids:

The main functions of cutting fluids in machining process are:

To dissipate the heat generated during machining.

To cool the workpiece by carried away heat by coolant.

To cool the cutting tool by cooling cutting zone.

To reduce the friction and wear of the tool using lubricants.

It reduces power consumption in cutting the material, by reducing wear.

By dissipating heat properly.

By carrying away heat from work material.

Keep the cutting zone free from hot chips. Also to cause chips breakup into small parts.

Desirable Properties of Cutting Fluid:

1. Lubricating Qualities:

This quality reduces frictional force between work and tool. It also prevents the formation of built-up edge.

2. High Heat Carrying (Cooling) Capacity:

Cutting fluid must carry more and more heat from cutting zone quickly. Thus, reducing the temperature of work and tool. This will reduce tool wear, increase tool life and surface finish.

3. Corrosion Resistant:

The cutting fluid should prevent the work material from environmental rusting or corrosion. For this purpose corrosion inhibitor like sodium nitrate is added in cutting fluid.

4. Low Viscosity:

It should have low viscosity, so that chip and dirt can settle quickly.

5. Stability:

It should have long life, i.e., it should not get spoiled quickly, both in use and in storage.

6. Non-Toxic:

It should be non-toxic and should not be injurious to the human skin.

7. Non-Flammable:

It should have high flash point, and should not burn easily.

10. Chemically Stable or Inert:

It should not adversely react with work material.

11. Odourless:

It should be free from undesirable odours.

Types of Cutting Fluids:

A variety of cutting fluids are available to satisfy the requirements of machining processes. Although, there is no all-purpose cutting fluid, some offer considerable versatility while some are for specific application.

The basic types of cutting fluids are following:

1. Water:

Water has high specific heat but is poor in lubrication. Also, it encourages rusting. It is used as cooling agent during tool grinding.

2. Soluble Oils (Emulsions):

Soluble oils or emulsifiable oils are the largest type of cutting fluids used in machining operations.

These are composed of:

i. Soluble oil.

ii. Emulsifiers (Sodium sulfonate, fatty, acid soap, esters).

iii. Additives (Corrosive resistance or coupling agents).

iv. Water (for dilution 1-20%).

Emulsifiers are chemical substances that cause suspension of tiny oil droplets iii the water. Additives are corrosive resistance chemicals or coupling agents. Coupling agents provide a white emulsion with no oil or cream separating out after mixing with water 5% dilution level being the most common dilution level. These fluids have average lubricating abilities and good cooling properties. Soluble oils are suitable for light cutting operations on general purpose machines were low metal remove rates used.

3. Mineral Oils:

Mineral oils are used for heavier cutting operations because of their good lubricating properties. They are commonly found in production machines where high metal removal rates are employed. They are most suitable for steels but should not be used on copper or its alloys since it has a corrosive effect.

4. Straight Oils (Petroleum or Vegetable Oils):

Straight oil is a petroleum or vegetable oil that is used without dilution with water. Paraffin oils, naphthenic oils, vegetable oils are some examples of straight oils. It is said that, straight oils provide excellent lubrication. For environmentally favorable requirements, vegetable oils are preferable due to their ease of biodegradation and disposal. On the other hand, they are of little use since they are liable to decompose and smell badly.

5. Synthetic Fluids:

They are water based fluids and contain no mineral oil. They have a typical particulate size of 0.003 mm. Water provides excellent cooling properties. But creates a problem of corrosion. Also, not effective as lubricant. To prevent rust formation rust inhibitors are added.

6. Semi-Synthetic Fluids:

They are mixture of soluble oils (Emulsions) and synthetics fluids (water based fluids). About 5 to 20% mineral oil is emulsified with water to produce a microemulsion. The partical size varies from 0.01 -0.1 mm. This is small enough to transmit all incidents light.

These types of fluids are used largely due to their advantages of both soluble oils and synthetics.

Some major advantages are:

i. Rapid heat dissipation.

ii. Cleanliness of the system.

iii. Bio-resistance (due to small particle size).

3.Explain various types of cutting tool materials and its applications.

Basic properties that cutting must possess are:

- Tool material must be at least 30 to 50% harder than the work piece material.
- Tool material must have high hot hardness temperature.
- High toughness
- High wear resistance
- High thermal conductivity
- Lower coefficient of friction
- Easiness in fabrication and cheap

Different elements used in cutting tool materials and their properties are

Element	Properties
Tungsten	Increases hot hardness Hard carbides formed Abrasion resistance
Molybdenum	Increases hot hardness Hard carbides formed Improving resistance
Chromium	Depth hardenability during heat treat hard carbides are formed improving abrasion resistance some corrosion resistance
Vanadium	combines with carbon for wear resistance retards grain growth for better toughness
Cobalt	Increases hot hardness, toughness

Carbon	Hardening element forms carbides

Different cutting tool materials used for cutting operations in practice are high carbon steel, high speed steel, non -ferrous cast alloys, cemented carbides, ceramics and sintered oxides, ceremets, diamond, cubic boron nitride, UCON and sialon.

1. High Carbon Steel tools

- Its composition is C = 0.8 to 1.3%, Si = 0.1 to 0.4% and Mn = 0.1 to 0.4%.
- It is used for machining soft metals like free cutting steels and brass and used as chisels etc.
- These tool loose hardness above 250°C.
- Hardness of tool is about Rc = 65.
- Used at cutting speed of 5m/min.

2. High speed steel (H.S.S)
General use of HSS is 18-4-1.
18- Tungsten is used to increase hot hardness and stability.
4 – Chromium is used to increase strength.
1- Vanadium is used to maintain keenness of cutting edge.
In addition to these 2.5% to 10% cobalt is used to increase red hot hardness.
Rest iron

- H.S.S is used for drills, milling cutters, single point cutting tools, dies, reamers etc.
- It looses hardness above 600°C.
- Some times tungsten is completely replaced by Molybdenum.
- Molybdenum based H.S.S is cheaper than Tungsten based H.S.S and also slightly greater toughness but less water resistance.

3. Non – ferrous cast alloys
It is an alloy of
Cobalt – 40 to 50%,
Chromium – 27 to 32%,
Tungsten – 14 to 29%,
Carbon – 2 to 4%

- It can not heat treated and are used as cast form.
- It looses its hardness above 800°C
- It will give better tool life than H.S.S and can be used at slightly higher cutting speeds.
- They are weak in tension and like all cast materials tend to shatter when subjected to shock load or when not properly supported.

4. Cemented carbides

- Produced by powder metallurgy technique with sintering at 1000°C.
- Speed can be used 6 to 8 times that of H.S.S.
- Can withstand up to 1000°C.
- High compressive strength is more than tensile strength.
- They are very stiff and their young's modulus is about 3 times that of the steel.

- High wear resistance.
- High modulus of elasticity.
- Low coefficient of thermal expansion.
- High thermal conductivity, low specific heat, low thermal expansion.

According to ISO the various grades of carbide tool materials grouped as

1. For cutting CI and non ferrous metals are designated as K10 to K50
2. For cutting steel are designated as p10 to p50
3. For general purpose application are designated as M10 to M50.

The advantages of carbide tools are

- They have high productivity capacity.
- They produce surface finish of high quality.
- They can machine hardened steel.
- Their use leads to reduction in machining costs.

5. Ceramics and sintered oxides

- Ceramics and sintered oxides are basically made of Al_2O_3, These are made by powder metallurgy technique.
- Used for very high speed (500m/min).
- Used for continuous cutting only.
- Can withstand upto 1200°C.
- Have very abrasion resistance.
- Used for machining CI and plastics.
- Has less tendency to weld metals during machining.
- Generally used ceramic is sintered carbides.
- Another ceramic tool material is silicon nitride which is mainly used for CI.

6. Cermets

- Cermets is the combination of ceramics and metals and produced by Powder Metallurgy process.
- When they combine ceramics will give high refractoriness and metals will give high toughness and thermal shock resistance.
- For cutting tools usual combination as Al_2O3 + W + Mo + boron + Ti etc.
- Usual combination 90% ceramic, 10% metals.
- Increase in % of metals reduces brittleness some extent and also reduces wear resistance.

7. Diamond

- Diamond has
    1. Extreme hardness
    2. Low thermal expansion.
    3. High thermal conductivity.
    4. Very low coefficient of friction.
- Cutting tool material made of diamond can withstand speeds ranging from 1500 to 2000m/min.
- On ferrous metals diamond are not suitable because of the diffusion of carbon atoms from diamond to work-piece.
- Can withstand above 1500°C.

- A synthetic (man made) diamond with polycrystalline structure is recently introduced and made by powder metallurgy process.

8. Cubic Boron Nitride (CBN)

- The trade name is Borozone.
- Consists of atoms of Nitrogen and Boron and produced by power metallurgy process.
- Used as a substitute for diamond during machining of steel.
- Used as a grinding wheel on H.S.S tools.
- Excellent surface finish is obtained.
-

9. Sialon (Si-Al-O-N)

- Sialon is made by powder metallurgy with milled powders of Silicon, Nitrogen, Aluminium and oxygen by sintering at 1800°C.
- This is tougher than ceramics and so it can be successfully used in interrupted cuts. Cutting speeds are 2 to 3 times compared to ceramics.
- At present this is used for machining of aerospace alloys, nickel based gas turbine blades with a cutting speed of 3 to 5 m/sec

4.Write a short note on tool wear and explain the different wear mechanisms.
The cutting tools fail due to following three conditions.
1. Breakage of tool due to excessive shock and force.
2.Tool wears due to plastic deformation or change in chemical or physical condition of tool.
3. Gradual wear like flank wear, crater wear etc.
The first two wear breakage wear and wear due to plastic deformation are very harmful for both machine and work piece. So, it should be totally eliminated by using favourable condition and taking high factor of safety.
Generally, tools are made by hard and brittle material. It cuts material by plastic deformation. When sharp edge tool rubs over the work piece, shear off some material and give desire shape of work piece. Due to this rubbing and many other mechanism tools are worn out, which is known as tool wear. Every tool has specified tool life which is depends on its material, work piece material, cutting conditions etc.

Tool Wear:

Tool Wear Mechanism:

1. Abrasive wear:

This wear depends upon work hardening of work piece. When the tool cut the work piece, some small chips are forms which act as hard particle. These hard particle acts as small cutting edge like grinding wheel, which cause tool wear.

2. Adhesion wear:

This tool wear is due to sliding of chips over the tool. The chips forms by metal cutting are hard and have high temperature. This is wear is due to rubbing of these chips over the tool. This wear cause due to high friction and high temperature of chips flowing over tool face.

3. Diffusion:

Diffusion means diffuse of hard metal into soft metal due to high temperature of contact surface between hard material and soft material. In tool wear chips act as hard material and tool act as soft material.

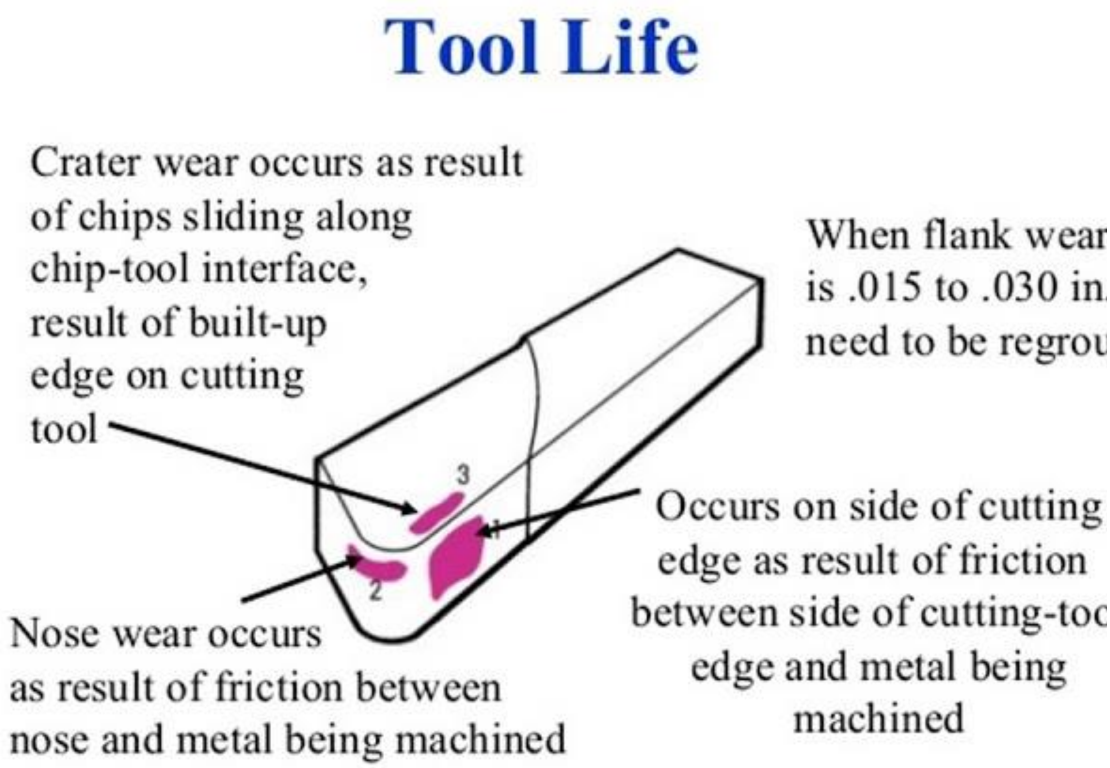
4. Oxidation:

Oxidation means diffusion of oxygen particles in the tool face. It also depends on surface temperature of tool and tool material.

5. Chemical decomposing:

Due to high temperature and pressure there is change in chemical composition of tool which reduces its life.

Types of Tool Wear:



Flank Wear, Crater Wear and Nose Wear

1. Flank wear:

Flank wear is due to abrasive action of discontinuities like debris from built up edge etc. It wears out side and end flank of the tool. It occurs at tool work-piece interface. This wear predominates at low speed.

2. Crater wear:

Crater wear generally occur in machining ductile material due to abrasion and diffusion of metal at face of tool. It occurs at face at a short distance from cutting edge. This wear predominates at high speed.

3. Nose wear:

Nose wear is considered as separate part of wear. It wears out the tool corner. It is the matting part of flank and face which is combination effect of crater wear and flank wear. It is considered as separate wear because the tool corners are very important for proper cutting of work-piece.

Tool wear can be reduced by proper cooling and lubricate because the major cause of tool wear is friction and temperature rise due to friction. Lubrication reduces friction between chips and tool which reduces the tool wear. It can also be reduced by using high hardness and abrasion resistance tool and high resistance to adhesion and diffusion.

5.With a neat sketch elaborate the nomenclature of single point cutting tool.
Single Point Cutting Tool

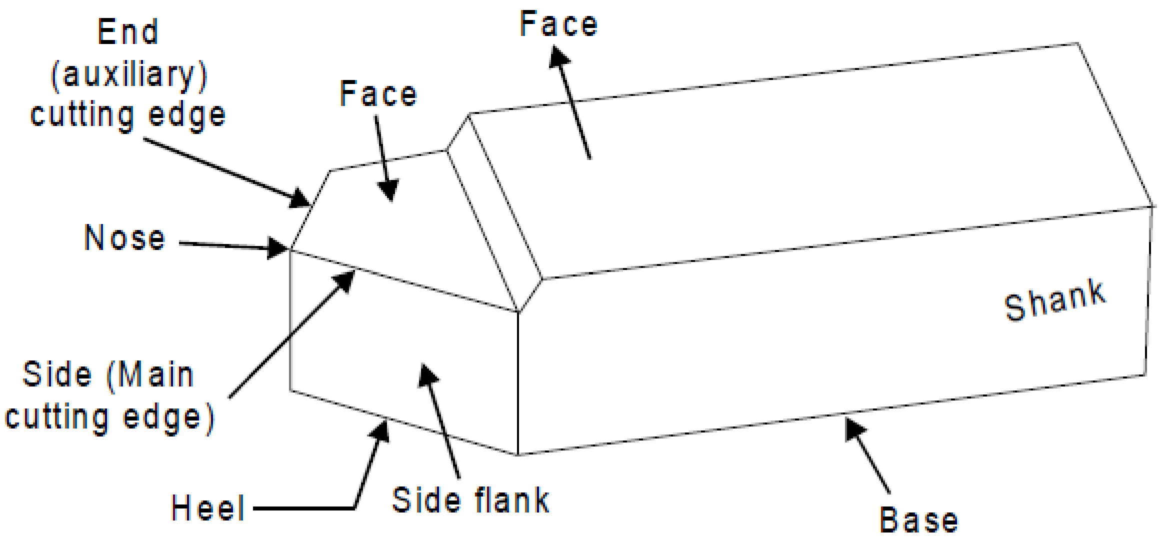
The Single Point Cutting Tool consists of a sharpened cutting part called its point and the shank.

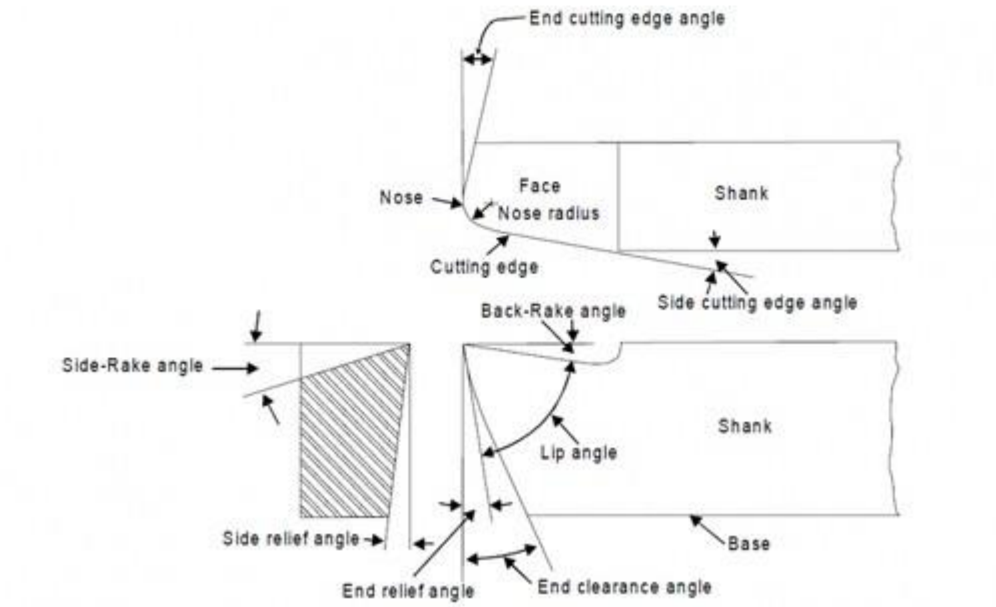
The point of the tool is bounded by the face (along which the chips slides as they are cut by the tool), the side flank or major flank the end flank or minor flank and the base.

As we know we perform several operations on the lathe (like turning, facing) from the single-point cutting tool.

Design and fabrication are very easy for this tool.

This tool can be made at a very cheaper rate as compared to others.





Single Point Cutting Tool Types:
There are only two types of the tool:
1. Single and
2. Multi-Point cutting tool.

1. Single Point cutting tool:
One cutting point or tip is available
Example: Lathe Machine, Planning Machine tool

2. Multi-Point cutting tool:
More than One cutting point or tip is available
Example: Milling cutter, Grinding wheel, drill tool, extra.
Single Point Cutting Tool Material:

This tool can be made from several materials like:
High carbon steel
High-speed steel
Ceramics
Cerements
Diamonds
Cemented carbide
CBN (Cubic boron nitrite)

Single Point Cutting Tool Geometry / Nomenclature:
1. Shank
2. Flank
3. Face
4. Heel
5. Nose
6. Nose radius
7. Cutting Edges

Angle:
1. Side Cutting edge angle
2. End cutting edge angle
3. Side relief angle
4. End relief angle
5. Back Rack angle
6. Side rack angle

Single Point Cutting Tool Geometry / Nomenclature:

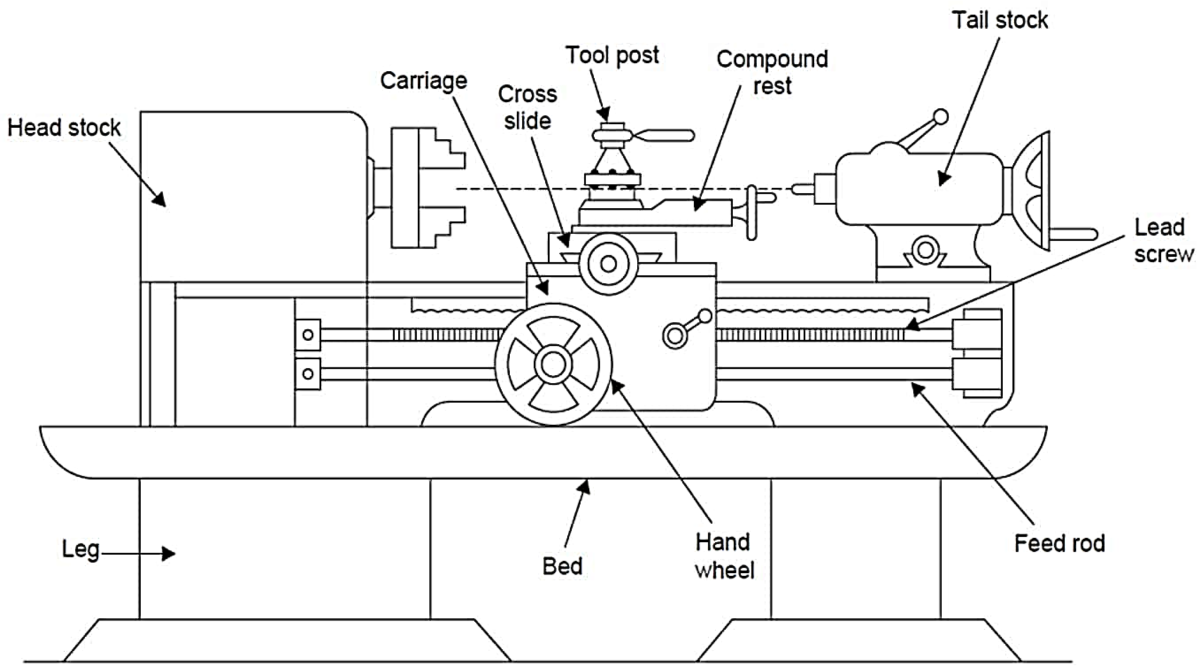
1. Shank:
This is the main body of the tool. The shank is used to hold the tool (i.e tool holder).

2. Flank:
The surface or surface below and adjacent to the cutting edge is called flank of the tool.
3. Face:
The surface on which the chips slide is called the face of the tool.
4. Heel:
It is the intersection of the flan and the base of the tool. It is a curved portion at the bottom of the tool.
5. Nose:
It is the point where the side cutting edge and end cutting edge intersects.
6. Noise radius:
The nose radius will provide long life and also good surface finish with it a sharp point on the nose.
7. Cutting edge:
It is the edge on the face of the tool which removes the material from the workpiece. The tool cutting edge consists of side cutting edge (major cutting edge), end cutting edge (minor cutting edge and the nose).

Angle:
1. Side cutting edge angle:
This angle also is known as the lead angle. This is the angle between the side cutting edge and side of the tool shank.
2. End cutting edge angle:
This is the angle between the end cutting edge and a line normal to the tool shank.
3. Side relief angle:
It is the angle between the portion of the side flank immediately below the side cutting
edge and a line perpendicular to the base of the tool and measured at the right angle to the end flank.

4. End relief angle:
It is the angle between the portion of the end flank immediately below the end cutting
edge and a line perpendicular to the base of the tool and measured at the right angle to the end flank.
5. Back rack angle:
It is the angle between the tool face and a line parallel to the base of the tool and measured in a plane perpendicular through the side cutting edge.
The back-rack angle is positive if the side cutting edge slopes downwards from the point towards the shank and the back-rack angle is negative if the slope is side cutting edge is reversed.
6. Side rack angle:
It is the angle between the tool face and a line parallel to the base of the tool and measured in a plane perpendicular to the base and the side cutting edge.
This angle gives the slope of the face of the tool from the cutting edge.
The side rack angle is negative if the slope is toward the cutting edge. And the side rack angle is positive if the slope is away from the cutting edge.

6.With a neat sketch explain the principal parts of centre lathe.



1. 1. Bed

- The Bed forms the base of a machine.
- It is mounted on the legs of the lathe machine, which are bolted to the floor.
- It is made up of cast iron and its top surface is machined accurately and precisely.

2. 2. Head Stock

- Head stock is an important part of a lathe machine, which is mounted permanently on the inner guide – ways at the left hand side of the bed.
- It consists of a main spindle, a chuck fitted at spindle nose, back gear drive and all gear drive.

3. 3. Main Spindle

- A main spindle is a hollow cylindrical shaft.
- It's face has a standard moarse taper.
- It is used for holding the live centre or collet.
- The spindle rotates on two large bearings housed on the head stock casting.
- The front end of the spindle is threaded, those are used for holding the chuck, face plate, driving plate and catch plate.
- It is know as a spindle nose.

4. 4. Tail Stock

- A tail stock is located on the inner guide – ways at the right side of the bed opposite to the head stock.
- The body of the tail stock is bored and house the tail stock spindle.
- The spindle moves front and back inside the hole.
- It has a taper hole to receive the dead centre or shunk of tools such as drill or reamer.
- It's body made up of cast iron.

5. 5. Lead Screw

- It is used to transmit power to carriage through gear and clutch arrangement in the carriage apron.

6. 6. Live Center

- A Live Center is mounting on bearings and rotates with the work.
- Live centers are using to hold or support a work-piece.

7. 7. Dead Center

- A dead center may be use to support the work piece at either the fixed or rotating end of the machine.
- Dead centers are typically fully harden to prevent damage to the important mating surfaces of the taper and to preserve the 60° angle of the nose.

8. 8. Carriage

- A carriage is located between the head stock and tail stock on the lathe bed guide – ways.
- It can be moved along the bed either towards or away from the head stock.
- It has several parts to support, move and control the cutting tool.

i. Saddle

- It is H – shaped casting.
- The saddle connects the pair of bed guide – ways as a bridge.

- It fits over the bed and slides along the bed between head stock and tail stock.
- The saddle can be moved by providing hand feed or automatic feed.

9. ii. Apron

- The front portion of a carriage call as apron. It consists of all control keys.

- The handle operates the carriage. It has a housing, which has a set of gears and split nut.
- Automatic feed and threading control are on the apron.

iii. Tool Post

- It is located on the top of the compound slide. It is used to hold the tools rigidly.
- Tools are selected according to the type of operation and mounted on the tool post and adjusted to a convenient working position.

iv. Cross slide

- It is situated on the saddle and slides on the dovetail guide – ways at right angles to the bed guide – ways.

- It carries compound rest, compound slide and tool post.

- Cross slide hand wheel is rotated to move it at right angle to the lathe machine axis.
- The cross slide hand wheel is graduate on its rim to enable to give known amount of feed as accurate as 0.05 mm.

v. Compound Rest

- It is a part which connects to cross slide and compound slide.
- It is mounted on the cross slide by tongue and groove joint.

- The compound rest can be swiveled to the required angle while turning tapers.
- A top slide known as compound slide is attached to the compound rest by dovetail joint.

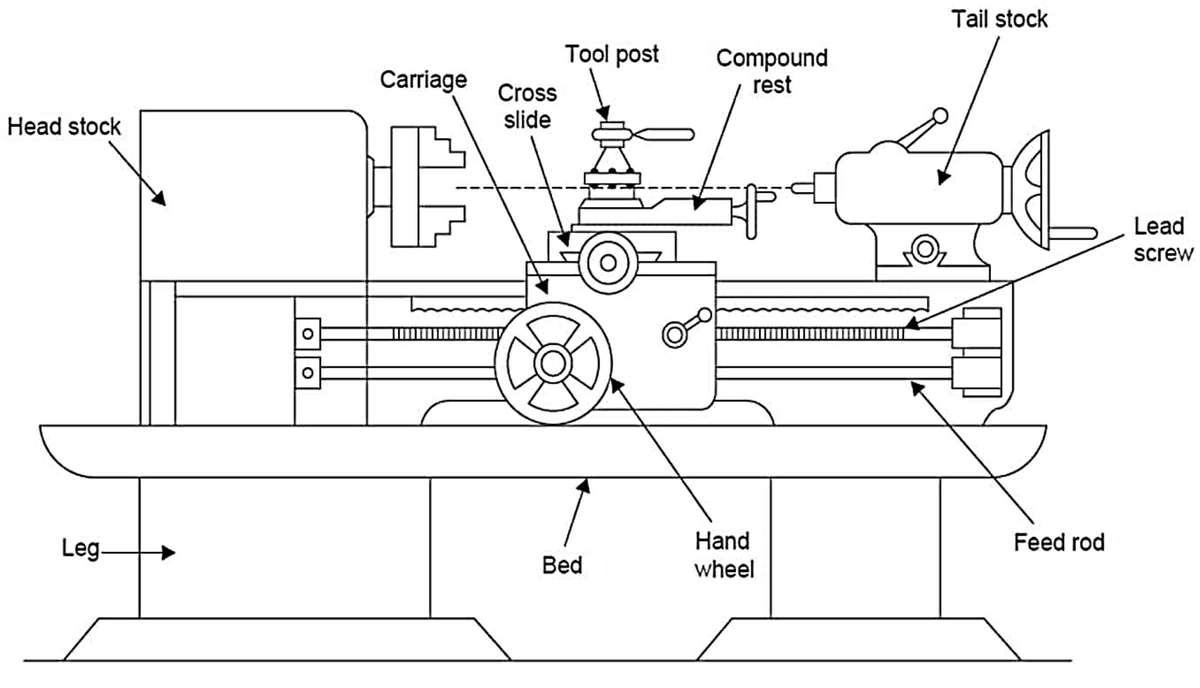
1.

2.

3. vi. Compound Slide

- Compound slide is a T -shaped rounded slot, which is fixed with cross slide upper surface by two bolts, which is related to a micrometer sleeve and screw handle with the outer edge of screw.
- Taper turning can be possible by setting the compound slide at half of a required angle.
- This slide is only used for less long job taper turning.
- The automatic feed is not possible in compound slide.

7.Mention the specifications of centre lathe with a neat sketch.



2. ***Specifications of Lathe Machine:***

1. a. Center distance

b. Height of center

c. Type of bed

2. a. Swing in gap

b. Gap in front of face place

c. Swing over cross slide

d. Swing over bed

3. a. Spindle bore

b. Spindle speed range

c. Spindle nose

d.Taper nose

4. a. Longitudinal feeds

b. Cross feed

c. Lead screw pitch

d. Metric thread pitches

5. a. Top slide travel

b. Cross slide travel

c. Tool section

6. a. Taper in sleeve bore

b. Tail stock sleeve travel

7. Motor horsepower in **RPM (Revolution per minute).**

8. Shipping dimension

1. Feed

- The rate at which the cutting tool crosses the work piece in the direction **perpendicular to the work piece axis** so calls as feed.

2. Depth of cut

- It is the perpendicular distance measured from the machined surface to the **UN – cut** surface of the work piece.

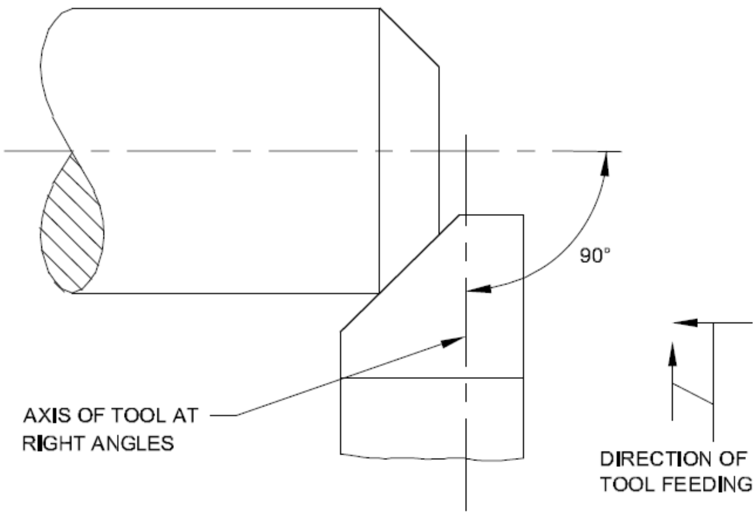
3. Cutting Speed

- The speed at which the metal is removing from the work piece with the help of tool so call as **cutting speed.**

8.Explain the various Taper Turning Methods

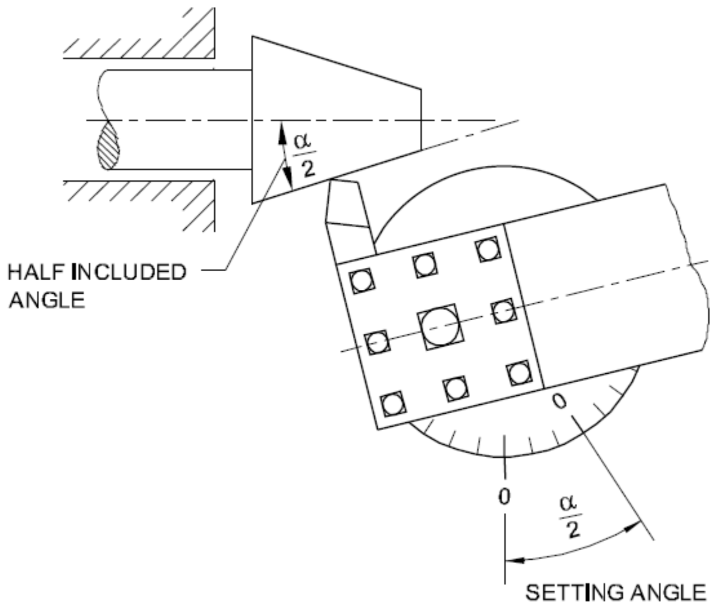
1. Form Tool method
2. Swivelling compound slide method
3. Tailstock offset method
4. Taper turning attachment method

1. 1. Taper Turning By Form Tool method



Form tool method is used in mass production for producing a small length of taper where accuracy is not the criterion. The form tool should be set at right angles to the axis of the work. The carriage should be locked while turning taper by this method.

2. 2. Taper Turning By Swivelling Compound slide method

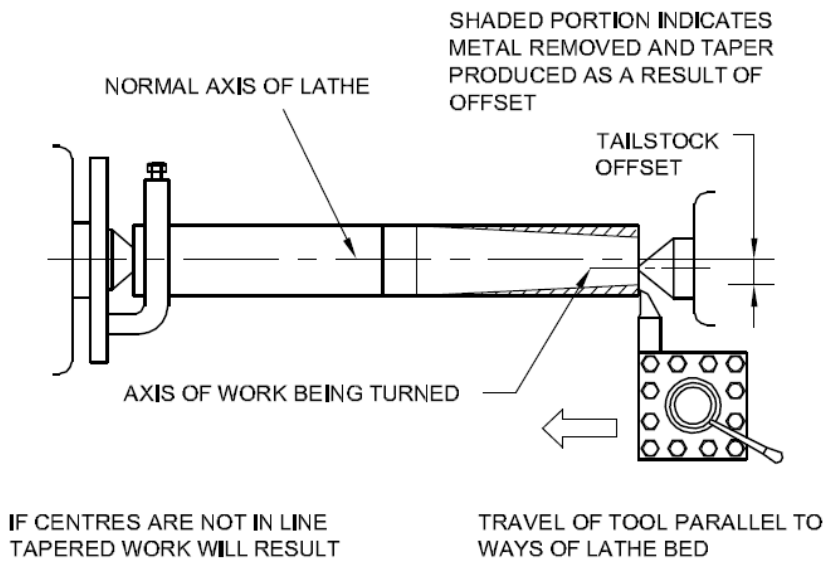


In this method the top slide of the compound rest is swivelled to half the included angle of the taper, and the taper is turned.

Advantages of Taper Turning by Swivelling Compound slide method

- Both internal and external taper can be produced.
- Steep taper can be produced.
- Easy setting of the compound slide.
- Disadvantages
- Only hand feed can be given.
- Threads on taper portion cannot be produced.
- Taper length is limited to the movement of the top slide.

3. 3. Taper Turning By Tailstock offset method



In this method the job is held at an angle and the tool moves parallel to the axis. The body of the tailstock is shifted on its base to an amount corresponding to the angle of taper. The taper can be turned between centres only and this method is not suitable for producing steep tapers.

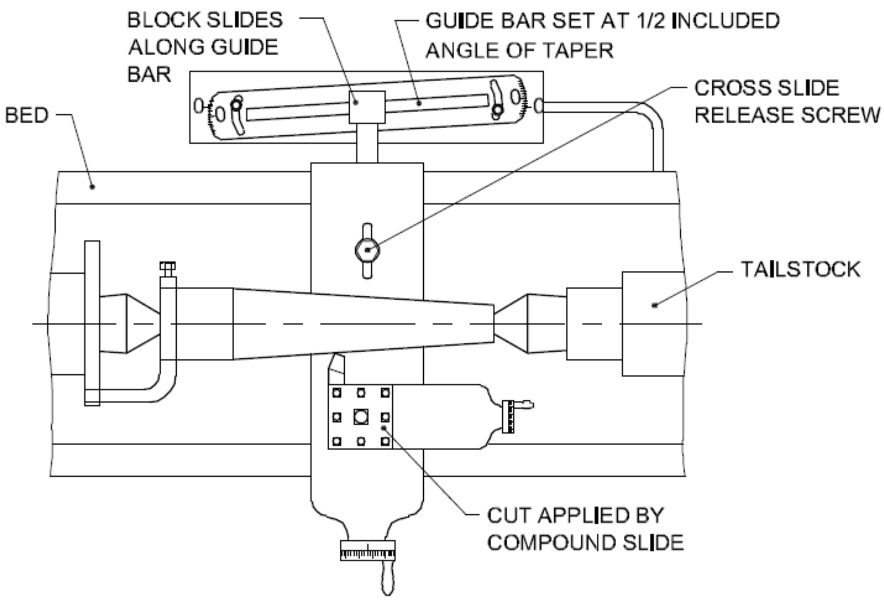
Advantages of Taper Turning By Tailstock offset method

- Power feed can be given.
- Good surface finish can be obtained.
- Maximum length of the taper can be produced.
- External thread on taper portion can be produced.
- Duplicate tapers can be produced.

Disadvantages of Taper Turning By Tailstock offset method

- Only external taper can be turned.
- Accurate setting of the offset is difficult.
- Taper turning is possible when work is held between centres only.
- Damages the centre drilled holes of the work.
- The alignment of the lathe centres will be disturbed.
- Steep tapers cannot be turned.

4. 4. Taper Turning By Taper Turning Attachment Method



This attachment is provided on a few modern lathes. Here the job is held parallel to the axis and the tool moves at an angle. The movement of the tool is guided by the attachment.

Advantages of Taper Turning By Taper Turning Attachment Method

- Both internal and external tapers can be produced.
- Threads on both internal and external taper portions can be cut.
- Power feed can be given.
- Lengthy taper can be produced.
- Good surface finish is obtained.

- The alignment of the lathe centres is not disturbed.
- It is most suitable for producing duplicate tapers because the change in length of the job does not affect the taper.
- The job can be held either in chuck or in between centres.

Disadvantages of Taper Turning By Taper Turning Attachment Method

- Only limited taper angles can be turned.

9.Discuss any two special attachments on lathes with neat sketches.

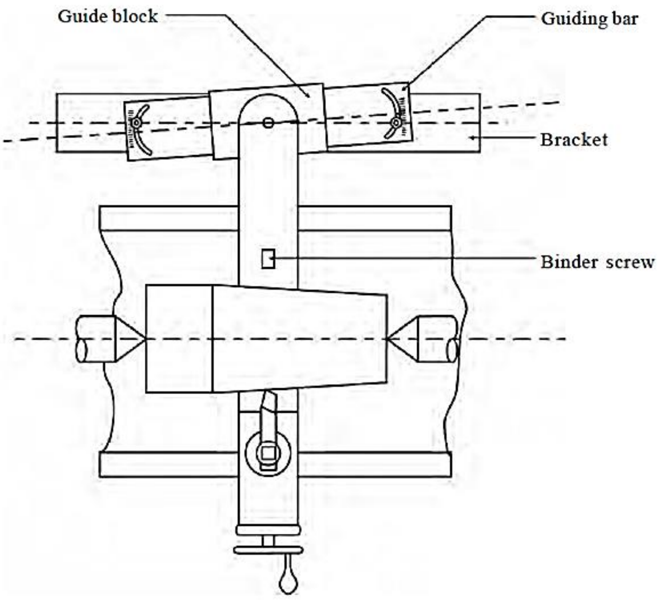
Following are the List of Lathe Attachments

1. Taper Turning Attachment for Lathe
2. Milling Attachment for Lathe
3. Grinding Attachment for Lathe
4. Gear Cutting Attachment for Lathe
5. Spherical Turning Attachment for Lathe
6. Copying Attachment for Lathe

5. 1. Taper Turning Attachment for Lathe

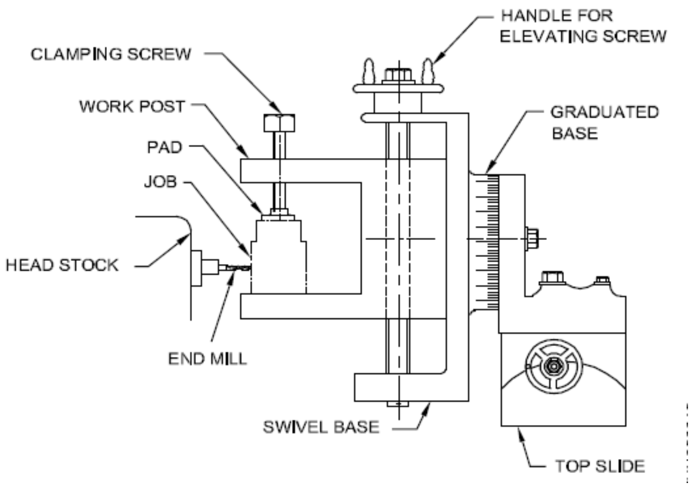
Many modern lathes have a taper bar fitted at the back of the bed. This can be set to different angles to the spindle axis. The bar carries a sliding block which, during taper turning, is attached by a link to the back of the cross-slide. The lead screw of the cross-slide is released so that it no longer controls the setting of the depth of cut and the slide is now free. When the saddle is moved along the bed, the cross-slide follows the taper bar, so that the tool moves parallel to the bar and a taper is produced. The top slide is swung through 90° to lie at right angles to the work so that it can be used to apply the depth of cut.

The length of the taper bar enables accurate settings to be carried out, with the help of the degree scale with an angle vernier incorporated. The taper is produced by the movement of the saddle under power feed, giving improved and controllable surface finish and a long taper is possible. It is, however, limited to the half-included angle of the taper of about 15° (30° included angle).



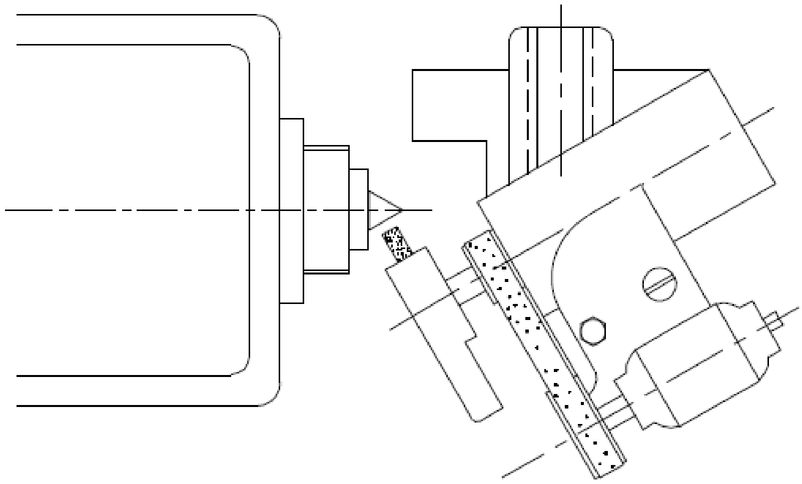
Taper turning by taper attachment method

2. Milling Attachment for Lathe



This attachment is fitted on to the cross-slide of a lathe in the place of the compound rest. The Milling attachment holds the job at right angles to the milling cutter,which is mounted in the chuck or collet. In the other type of attachment , the workpiece is held between centres. The milling cutter and the indexing head are mounted on the compound rest. It is provided with a driving unit. Both these attachments have provisions to feed in all the three directions, and it is, therefore, possible to perform operations like keyway cutting, angular milling, Tee slot cutting, and thread milling etc.

6. 3. Grinding Attachment for Lathe



GRINDING A CENTER ON THE LATHE

With the help of a good electric grinding attachment the lathe can be used for re-sharpening reamers and milling cutters, grinding hardened bushings and shafts, and many other grinding operations.

The V bed ways of the lathe bed should be covered with a heavy cloth or canvas to protect them from dust and grit from the grinding wheel, and the lathe spindle bearings should also be protected. A small pan of water or oil placed just below the grinding wheel will collect most of the grit.

A large, powerful grinder is most satisfactory for external grinding. The wheel should be at least 100mm in diameter and the grinder should be mounted directly on the compound rest of the lathe.

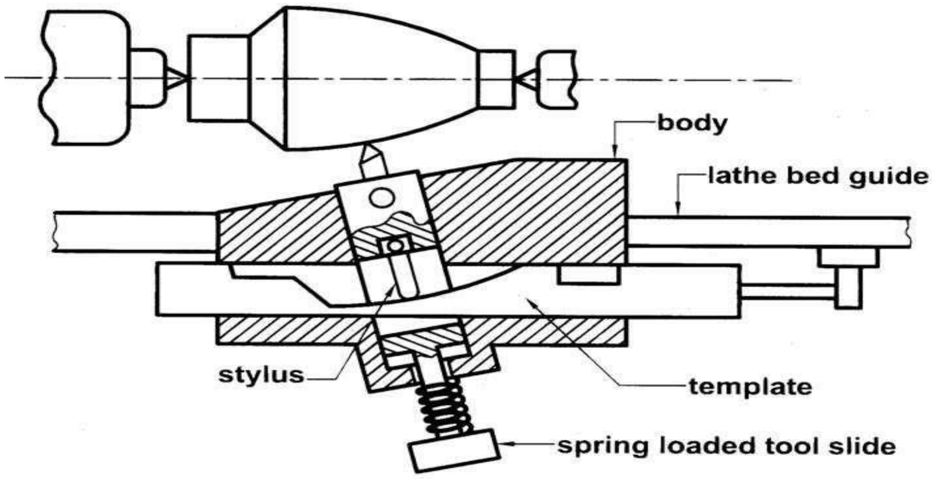
7. 4. Gear Cutting Attachment for Lathe

The gear cutting attachment mounted on the lathe will cut spur and bevel gears. It may also be possible to do linear indexing, external keyway cutting, splining, slotting and all regular dividing head light milling works.

This attachment is very useful for cutting small gears and work involving light machining.

8. 5. Copying Attachment for Lathe

The copying attachment is generally fixed to certain standard centre lathes. This attachment works on the hydraulic system. Copying lathes are used to produce a particular type of jobs in large quantity.



The job is held on a chuck or between chuck and centre or in between centres. A masterpiece of the job to be produced is held separately parallel to the job axis. The cutting tool used for turning the job is connected to a stylus (tracer) which is switched on and the automatic feed is engaged when the stylus will move from the tail join stock to the headstock with an upward pressure. Since the stylus is in contact with the outer surface of the master piece, the movement of the stylus is guided by the shape of the masterpiece. Hence, similar pieces can be produced in large quantities with the help of the copying attachment.

10. Enumerate the Merchant's theory with a neat diagram.
Merchant's theory/ Merchant's circle diagram/Three Angle Relationship

Metal cutting

The process in which a thin layer of excess metal is removed from a workpiece by a wedge-shaped single point or multipoint cutting tool through a process of extensive plastic deformation at the chip tool interface. The material removal happens by shear.

Merchant's circle Merchant's theory and merchant circle diagram is used to analyse the forces acting in metal cutting. The analysis of main forces which balance each other for a smooth cutting to occur. Each system is a triangle of forces. In orthogonal metal cutting, shear angle is the angle between shear plane and the cutting velocity. The shear angle increases when rake angle is increased and friction angle is decreased.

Need of analysis of forces

Analysis of cutting forces is helpful in

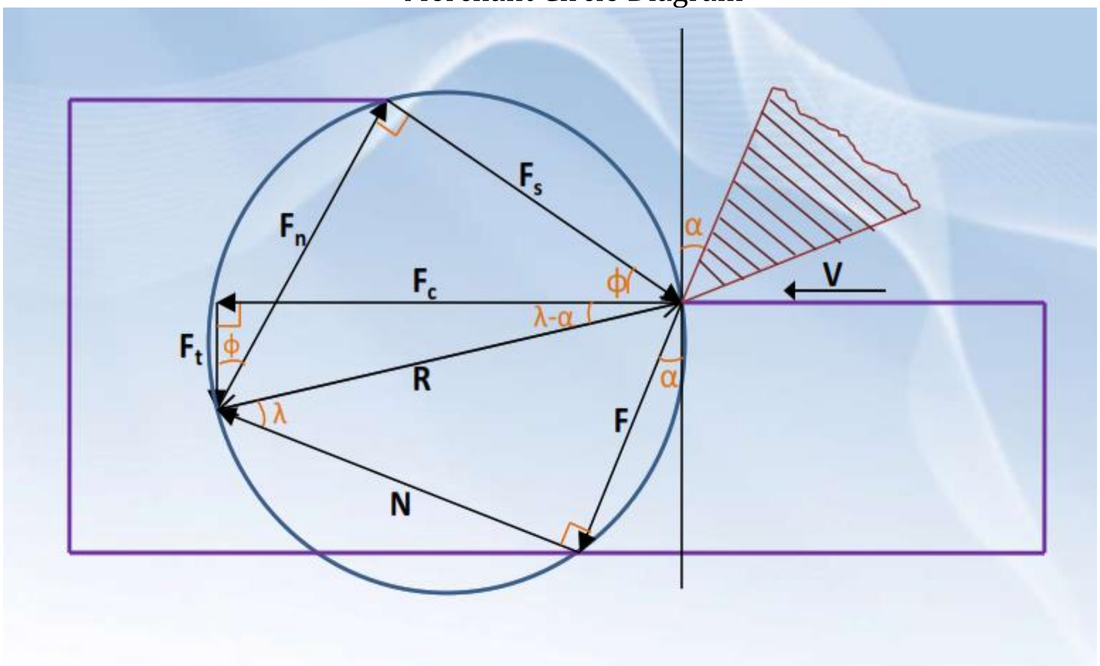
- Design of stiffness for the machine tolerance.
- In finding if the work piece can withstand the cutting force
- In study of ehaviour and machinability characterization of the work piece.

- Estimation of cutting power consumption during design of the machine tool.
- Condition monitoring of the cutting tools and machine tool.

Assumptions for Merchant's circle diagram

- Tool edge is sharp.
- The work material undergoes deformation across a thin shear plane.
- There is uniform distribution of normal and shear stress on shear plane.
- The work material is rigid and perfectly plastic.
- The shear angle ϕ adjusts itself to minimum work.
- The friction angle λ remains constant and is independent of ϕ.
- The chip width remains constant.
- The chip does not flow to side, or there is no side spread.

Merchant Circle Diagram



In the diagram,

F_c-Horizontal Cutting force
F_t-Vertical Feed force
F_s- Shear force
F_n- Normal to shear force
F- Frictional force
N- Normal to Frictional force
R- Resultant force
α- Rake angle
Φ- Shear angle
λ- Friction angle
r- Chip thickness ratio
μ- Coefficient of friction
b- width of chip
t- uncut chip thickness
t_c- chip thickness

Chip thickness Ratio, $r = \frac{Uncut\ chip\ thickness}{\text{Chip thickness after cut}} = \frac{t}{t_c}$

Shear plane angle, $A_s = \frac{b\ t}{\sin\Phi}$

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

Coefficient of friction, $\mu = \frac{F}{N} = \frac{F_c\ tan\alpha + F_t}{F_c - F_t\ tan\alpha}$

Forces

$F = F_c \sin\alpha + F_t \cos\alpha$
$N = F_c \cos\alpha + F_t \sin\alpha$
$F_t = F_n \cos\Phi - F_s \sin\Phi$
$F_c = F_n \sin\Phi + F_s \cos\Phi$
Shear force
$F_s = F_c \cos\Phi - F_t \sin\Phi$
$F_n = F_c \sin\Phi + F_t \cos\Phi$
$F_s = R\cos(\Phi + \lambda - \alpha)$

Merchants Three Angle Relationship, $\Phi = 90^o + \alpha - \lambda$

Machining constant, $C_m = 2\Phi + \lambda - \alpha$

Advantages of Merchant's circle

- Easy, quick and reasonably accurate determination of several other forces from a few forces involved in machining.
- Friction at chip-tool interface and dynamic yield shear strength can be easily determined.
- Equations relating the different forces are easily developed.

Limitations of Merchant's circle

- Merchant's Circle Diagram (MCD) is valid only for orthogonal cutting.
- By the ratio, F/N, the MCD gives apparent (not actual) coefficient of friction.
- It is based on single shear plane theory.

11. State and discuss the parameters that influence the life of tool.

The **tool life** can be defined in three different ways.

1. The actual machining time between two successive regrinding of a cutting tool is called tool life. It is most commonly expressed in minutes.
2. Volume of material removed in mass production.
3. Number of work pieces machined (in mass production).

The **life of cutting tool** is affected by the various factors mentioned below:

1. Properties of Work Piece Material:

- With the increase in hardness of work piece, forces and power consumption increases and tool wear increases. So tool life decreases.
- When ductility of work piece increases, forces and power consumption decreases, tool wear decreases. So tool life increases.
- But there is no quantitative relationship available between properties of work and tool life.

2. Tool Geometry:

As the tool geometry changes, like when rake angle increases, the tool life will increase. But there is no quantitative relationship between tool geometry and tool life.

3. Use of Cutting Fluid:

- When the cutting fluid is used during machining it is acting as a lubricant in friction zone and carrying away the heat during machining.
- So forces in machining with the use of cutting fluid. It increases by 25 to 40 %.

4. Process Parameters:

1. Cutting speed
2. Feed
3. Depth of cut

- Because of uniqueness of process parameters, the researchers tried to establish relationship between process parameters and tool life.
- Taylor has assumed that cutting velocity is the major parameter influencing the tool life.

3. Taylor's Tool Life Equation:

VT^n = constant = C

where, V = Cutting velocity in m/min
T = tool life in minutes
C = Taylor's constant = Cutting velocity for 1 minute tool
n = Taylor's exponent depending mainly on cutting tool material
n = 0.05 to 0.1 for H.C steels.
n = 0.1 to 0.2 for H.S.S
n = 0.2 to 0.4 for carbides
n = 0.4 to 0.6 for ceramics
n = 0.7 to 0.9 for diamond

Modified Taylor's Equation:

$$VT^n f^p d^q = c$$

f = Feed mm/rev
d = depth of cut in mm
p, q are constants < 1

$q < p$ indicates that tool life is more sensitive to the uncut slip chip thickness than to the width of cut.

12. Describe the mechanism of metal cutting

Mechanism of chip formation in machining

The form of machined chip depends mainly upon:

• Work material
• Material and geometry of the cutting tool
• Levels of cutting velocity and feed and also to some extent on depth of cut
• Machining environment or cutting fluid that affects temperature and friction at the chip-tool and work-tool interfaces.

Knowledge of basic mechanism(s) of chip formation helps to understand the characteristics of chips and to attain favourable chip forms.

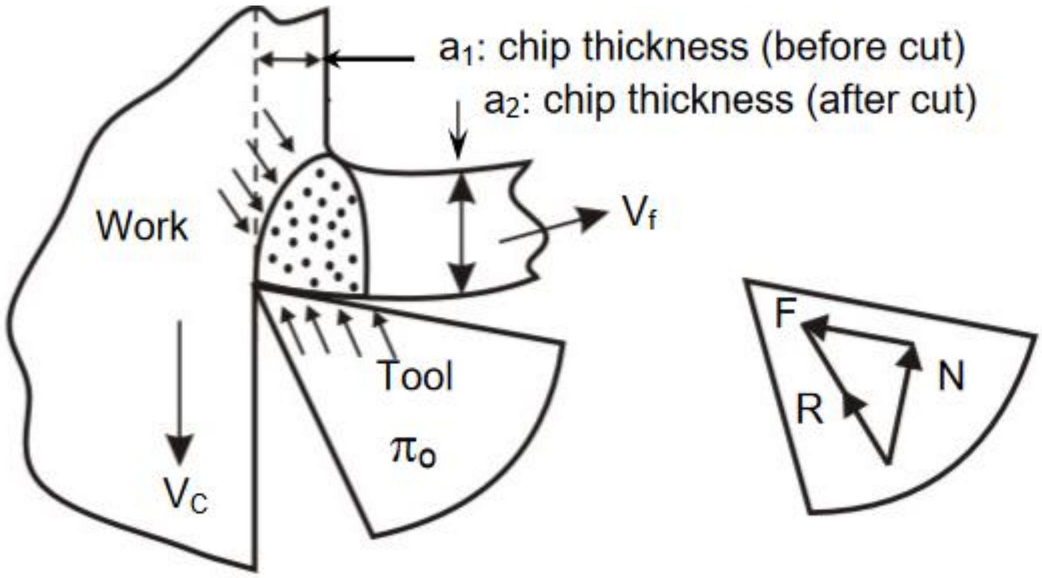
The basic mechanics of forming a chip are the same regardless of the base material. As the cutting tool engages the workpiece, the material directly ahead of the tool is sheared and deformed under tremendous pressure. The deformed material then seeks to relieve its stressed condition by fracturing and flowing into the space above the tool in the form of a chip. The real difference is how the chip typically forms in various materials.

Regardless of the tool being used or the metal being cut, the chip forming process occurs by a mechanism called plastic deformation. This deformation can be visualized as shearing. That is when a metal is subjected to a load exceeding its elastic limit.

The crystals of the metal elongate through an action of slipping or shearing, which takes place within the crystals and between adjacent crystals.

Mechanism of chip formation in machining ductile materials

During continuous machining the uncut layer of the work material just ahead of the cutting tool (edge) is subjected to almost all sided compression as indicated in Fig.

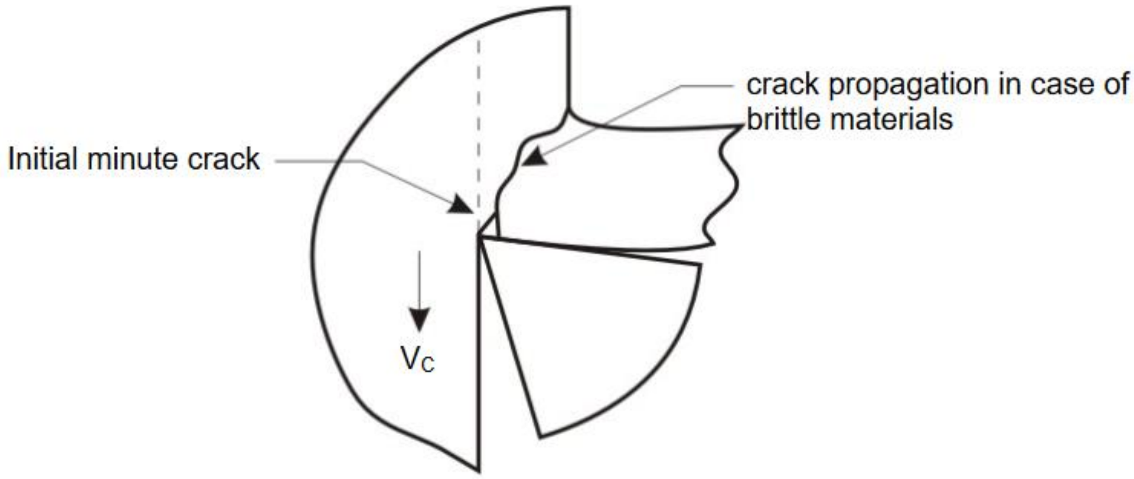


Mechanism of chip formation in machining brittle materials

The basic two mechanisms involved in chip formation are

- Yielding – generally for ductile materials
- Brittle fracture – generally for brittle materials

During machining, first a small crack develops at the tool tip as shown in Fig. due to wedging action of the cutting edge. At the sharp crack-tip stress concentration takes place. In case of ductile materials immediately yielding takes place at the crack-tip and reduces the effect of stress concentration and prevents its propagation as crack. But in case of brittle materials the initiated crack quickly propagates, under stressing action, and total separation takes place from the parent workpiece through the minimum resistance path as indicated in Fig. Machining of brittle material produces discontinuous chips and mostly of irregular size and shape.



13. Explain the effect of temperature on machining.

2. Thermal Aspects of Machining

Considerable heat is generated at the cutting edge of the tool due to friction between tool and work, and the plastic shearing of metal in the form of chips, when the tool is machining metal on a machine tool. The heat is evolved at three zones. A, B and C shown in Fig.

In zone A (shear zone), maximum heat is generated because of the plastic deformation of metal, and practically all of this heat is carried away by the chip as machining is rapid and continuous process. A very minor portion of this heat (5-10%) is conducted to workpiece.

In zone B, known as friction zone, the heat is generated mainly due to friction between moving chip and tool face and partly due to secondary deformation of the built-up edge. In zone C, known as work-tool contact zone, the heat is generated due to burnishing friction and the heat in this zone goes on increasing with time as the wear land on the tool develops and goes on increasing.

The direction of maximum heat flow from these zones to chip of workpiece is indicated by the arrows in Fig. and some heat always flows in other directions also.

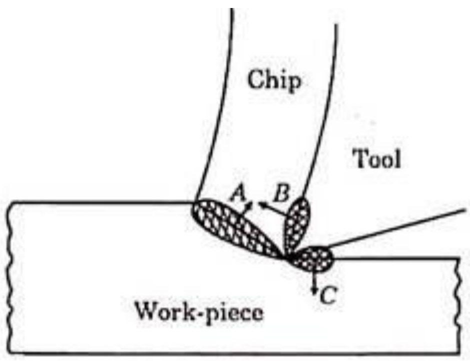


Fig. 22.27. Evolution of heat at three zones *A*, *B* and *C*.

It will be noted that each of these three zones leads to rise of temperature at the tool chip interface and it is found that the maximum temperature occurs slightly away from the cutting edge, and not at the cutting edge. This temperature plays a major role in the formation of crater on the tool face and leads to failure of tool by softening and thermal stresses.

The heat generated in metal cutting (Q) tangential

$$Q = \frac{\text{cutting force (kg)} \times \text{cutting speed (m/min)}}{427} \text{ kcal/min}$$

and the heat dissipated per minute by the chip (Q_c)

$$Q_c = \frac{\text{Weight of chips} \times \text{specific heat of work material} \times \text{increase in termperature}}{1000} \text{ kcal/min.}$$

The ratio (Q_c/Q) is indication of percentage of heat that can be dissipated by the chips. This ratio is fairly independent of cutting speed except at very low speed (of the order of 400°C) but the temperature of the tool rake face or tool-chip interface increases with increase in cutting speed and is about twice the temperature of the chips.

The distribution of heat in chips, tool and work versus cutting speed is shown in Fig and it is found that distribution of heat in chips, workpiece and tool is in the ratio of 80: 10: 10, when cutting with carbide cutters at speeds above 30 m.p.m.

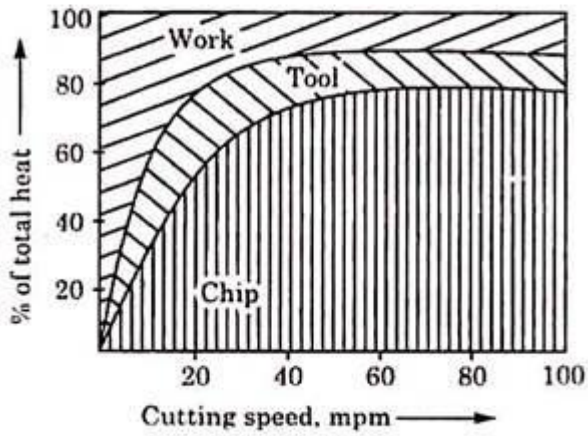


Fig. 22.28. Distribution of heat in chip, tool and work.

The various factors which lead to maximum tool temperature are cutting speed, feed, properties of material etc. These machining variables affect the size of shear zone and chip tool contact length and thereby, the area over which heat is distributed. Shorter length of contact of chip with tool results in severe temperature rise.

Cutting temperature depends upon several factors like workpiece and tool material, cutting conditions, cutting fluid and tool geometry. If a material has high tensile strength and hardness, more energy is required for chip formation and more heat is generated. If thermal conductivity is high then temperature developed will be lower. Cutting temperature is also dependent on cutting condition (in order of seriousness), cutting speed, feed, depth of cut.

At very high speeds the cutting fluid is not able to reach tool-chip interface and as such cutting fluid does not affect the chip-tool interface temperature. The speed at which the cutting fluid becomes ineffective decreases as the depth of cut is increased. Temperature variation of 20°C only has been noted for rake angle change from – 10° to + 30°. It increases with increase in approach angle and radius of tool.

Factors affecting Temperature:

The various factors influencing cutting temperature are:

(i) Workpiece and Tool Material:

Tensile strength and hardness of workpiece material have considerable influence on cutting temperature. Materials with higher thermal conductivity produce lower temperature than tools with lower conductivity.

(ii) Cutting Conditions:

The cutting speed has predominant effect on the cutting temperature. Feed has little effect, and depth of cut the least.

(iii) Cutting Fluid:

At high speeds, such as employed for carbides, cutting fluid has negligible effect on tool-chip interface temperature. The fluid is carried away by the outward flowing chip more rapidly than it could be forced between the tool and the chip.

(iv) Tool Geometry:

While rake angle has only a slight influence on the temperature, it increases considerably with increase in approach angle.

14. Explain 'Merchant force circle' along with assumptions.

Assumptions for Merchant's circle diagram

- Tool edge is sharp.
- The work material undergoes deformation across a thin shear plane.
- There is uniform distribution of normal and shear stress on shear plane.
- The work material is rigid and perfectly plastic.
- The shear angle ϕ adjusts itself to minimum work.
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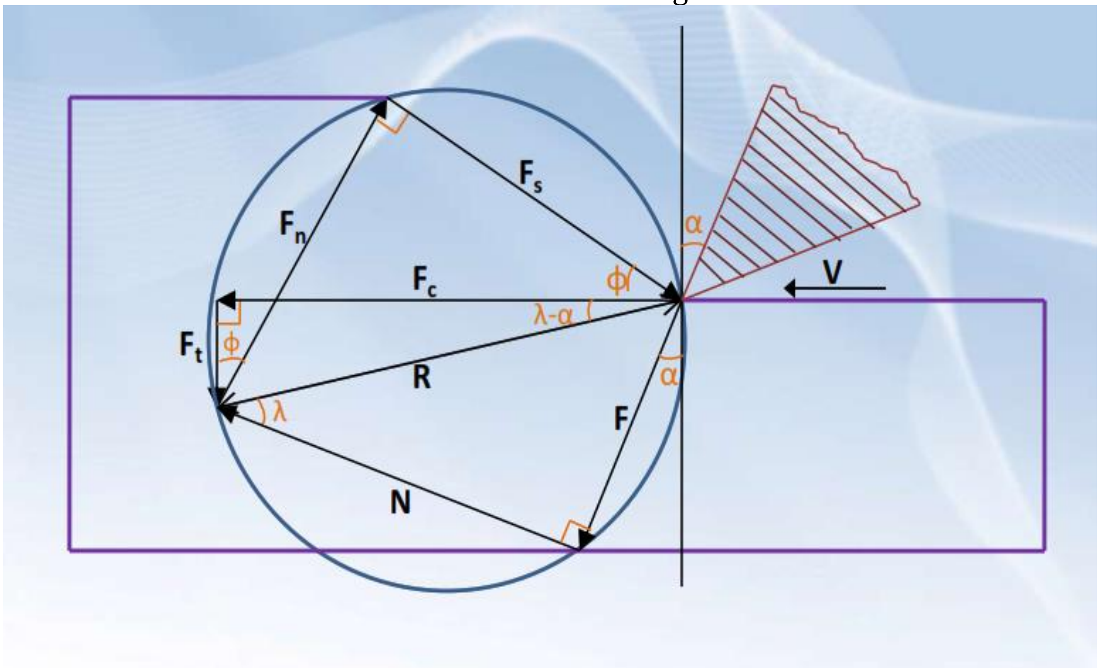
Merchant Circle Diagram



In the diagram,

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Coefficient of friction, $\mu = \frac{F}{N} = \frac{F_c\ tan\alpha + F_t}{F_c - F_t\ tan\alpha}$

Forces

$F = F_c \sin\alpha + F_t \cos\alpha$
$N = F_c \cos\alpha + F_t \sin\alpha$
$F_t = F_n\cos\Phi - F_s\sin\Phi$
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$F_s = F_c \cos\Phi - F_t \sin\Phi$
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15. Describe the work holding devices in a lathe.

1. Type 1. Chuck:

It is the most important device for holding the workpiece, particularly of short length and large diameter or of irregular shape which can't be conveniently mounted between centres. It can be attached to the lathe by screwing on the spindle nose.

(a) Independent or Four Jaw Chuck:

It has four jaws and each jaw is independently actuated and adjusted a key for holding the job. This type of chuck is used for irregular shapes, rough castings of square or octagonal in such jobs, where a hole is to be positioned off the centre.

(b) Three Jaw or Universal Chuck:

In this case, all the three jaws move simultaneously by turning a key and thus the workpiece may be automatically held in the centre of chuck-opening. It is used for holding round, hexagonal bar or other symmetrical work.

(c) Collet Chuck:

It is mostly sued for holding bars of small sizes (below 63 mm) and is normally used where production work is required such as in capstan lathe or automats.

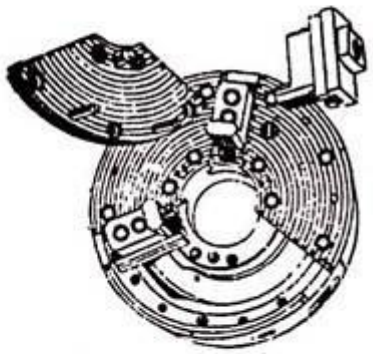

Fig. 12.17. Universal chuck.

(d) Magnetic Chuck:

They are either electrically operated or are of permanent magnet type. In lathe it does not find widespread use.

Other types of chucks are air or hydraulically operated chucks, drill chucks, etc.

Centres:

Next to chucks, lathe centres are used for work holding during turning operation. A centre hole of particular depth and shape is made at each end of the workpiece. The lathe centres act as supports for the workpiece and take up the thrust due to metal cutting.

These are made of very hard materials to withstand wear and resist deflection. The included angle of centre is 60° for general purpose work and 75° for heavy work. The shanks of all the centres are machined to the Morse (0 to 6) or Metric (4 to 6) standard tapers.

The various types of centres are:

(i) Ordinary centre, which is used for most general work;

(ii) Tipped centre, which contains a hard alloy tip brazed into a steel shank;

(iii) Ball centre, which has a ball shape at the end of centre instead of a sharp point, and is used to minimise the wear and strain on the ordinary centre while taper turning by set over method;

(iv) Half centre in which case less than half of the centre is ground away, thus facilitating facing of the bar ends without removal of the centre;

(v) Rotating dead centre is used in tailstock for supporting heavy work revolving at a high speed.

2.

3.

4. Type 3. Collets:

A collet is used for holding small semi-finished or finished parts so that additional operations may be performed. It is a practical device for quickly and accurately chucking symmetrical workpiece. Collets are available in several shapes, i.e., round, square and hexagonal holes to accommodate corresponding shapes of workpiece.

The front portion is made conical and a transverse slope is made in three-fourth of length. The other end is threaded and has a key way to prevent the collet from turning in the collet sleeve.

A tapered collet sleeve is inserted into the spindle nose. The collet fits and is drawn into the sleeve by a hollow draw bar that fits through the spindle. Collet action is controlled by either a lever (pull type) or a hand wheel (screw-type). These extend through the spindle from the back end.

The outside taper of the hardened jaws of the collet fits accurately against the taper of the sleeve. The body is spring tempered. This permits the jaw sections to be drawn together against the work surface, to hold the workpiece securely and concentrically. Collets are furnished in sets.

5. Type 4. Carriers and Catch Plates:

Carriers are also known as driving dogs and used to drive the workpiece when it is held between two centres. These are attached to the end of the workpiece by a set screw. Catch plates are either screwed or bolted to the nose of the threaded, stock spindle.

A projecting pin from the dog fits into the slot provided in catch plate. This imparts a positive drive between the lathe spindle and workpiece. Fig. 12.19 shows three types of lathe dogs commonly used.

6. Type 5. Face-Plate:

Mounting work on a face plate provides an ideal way of supporting certain types of works. Flat plates may be screwed to the face-plate for operations such as facing, spot fating, drilling and boring. If the work has several holes, it must be re-centred about each successive hole.

Facing:

It is the lathe operation of finishing the ends of the work, to make the ends flat and smooth and to make the piece of the required length. For this purpose, usually the work is held in a chuck. If considerable material is to be removed later in the turning operation, it is better not to face the exact length until all the rough turning cuts are taken.

A side tool is used for facing operation. To obtain a smooth finish the point of the side tool is slightly rounded with an oilstone, or so ground as to present a short flat surface to the work. The length of this flat surface should be greater than the amount of the cross-feed per revolution of job. The work may be roughed by feeding from the centre hole outward or from the circumference toward the centre. The finishing cut is made from the centred hole outward.

For facing operation, centre holes are drilled deeper for better support during the roughing operation. Usually a right-cut facing tool with 58° point angle is used which gives a slight clearance between the centre point and the work face. (Refer Fig. 12.35).

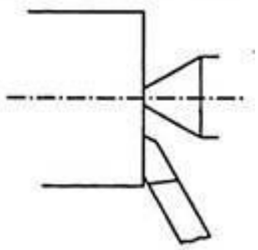

Fig. 12.35

It is important to ensure that during facing operation the cutting tool point is not damaged by running it into the centre point. If the work is to be faced on the centres and several pieces are to be faced, it is advisable to use a half-centre for facing. (Refer Fig. 12.36).

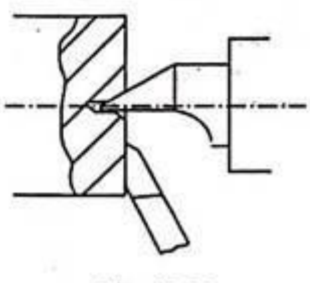

Fig. 12.36

Faceplate Work:

Workpiece which cannot be turned between centres or chucked because of their unusual shapes, may be clamped to a faceplate, or mounted on an angle plate bolted to a faceplate, so that the surfaces to be worked are concentric with the lathe centres.

A faceplate is a plate which is so machined that it will be square with the lathe centres when mounted on the spindle. It generally has four T slots as well as four elongated holes to accommodate clamp bolts. The various accessories used in connection with faceplate work to facilitate the accurate fastening or clamping of the work in position on the faceplate are:

i. Square head bolt,

ii. Shouldered stud,

iii. U-Clamp,

iv. End measuring rod,

v. Parallel strip,

vi. Angle plate,

vii. Stop block,

viii. Indicator,

ix. Weight for counter balance.

7. Type 6. Mandrel:

It is a hardened piece of round bar with centres and flats at each end. It is used for holding and obtaining a hollow piece of work that has been previously drilled or bored. It is held between two centres and should be true with accurate centre holes for machining outer surface of the workpiece. It is made of high carbon steel to avoid distortion and wear.

Its ends are made slightly smaller in diameter and flattened to provide effective gripping surface of the lathe dog set screw. It is tapered about 0.5 mm per metre so that work can be forced on it with a press fit and then removed after working.

It is used for holding the bored jobs (gear blanks, pulleys or tubes) on a lathe for the purpose of turning outside surface of the job. Several types of mandrels are in common use. Some common types are shown in Fig. 12.19.

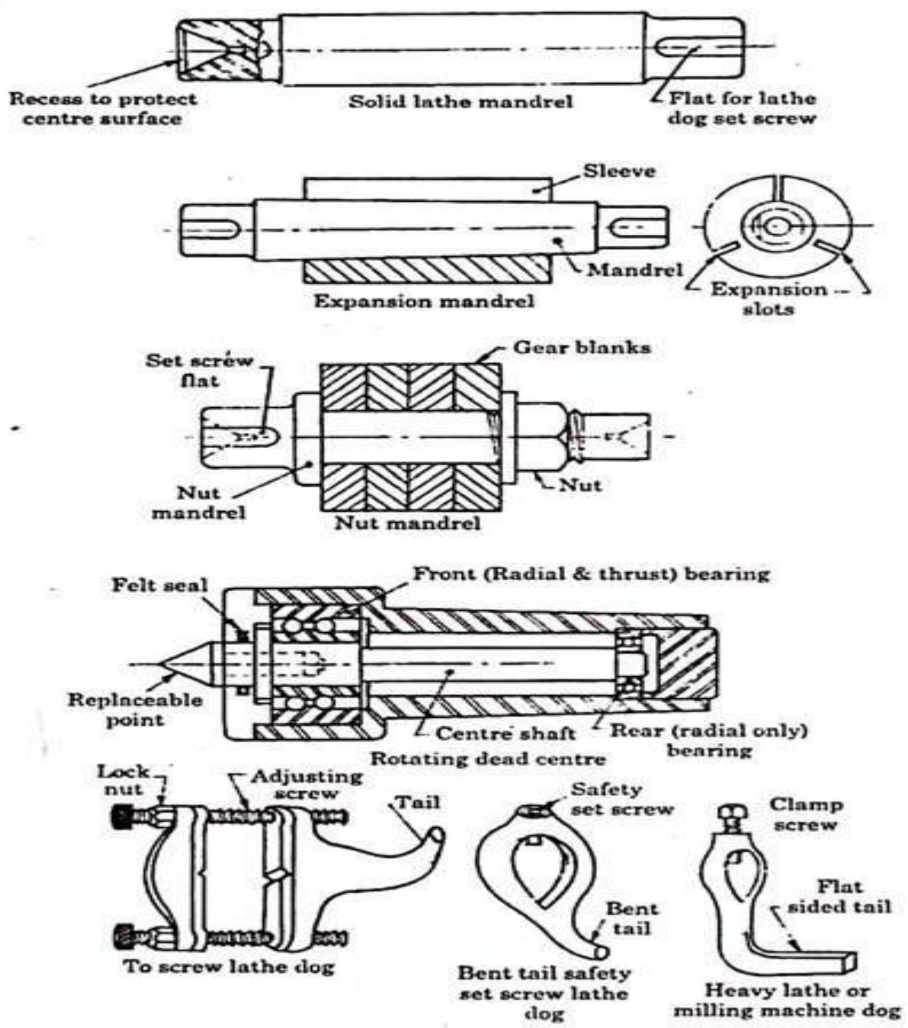

Fig. 12.19

Types of Mandrels:

i. Plain (suitable for one size of bore).

ii. Stepped (having steps of different diameters).

iii. Collar (provided with solid collars. Helps in reducing weight of mandrel).

iv. Screwed (used for mounting workpiece with internal threads).

v. Cone (used for workpiece of different hole diameters).

vi. Gang (with one fixed collar at one end and movable collar at other end).

vii. Expansion (provided with three longitudinal slots, two of which are cut nearly through and third splits it completely).

viii. Taper shank.