Unit-3

Machine tools: Lathe, Drilling and Grinding M/c

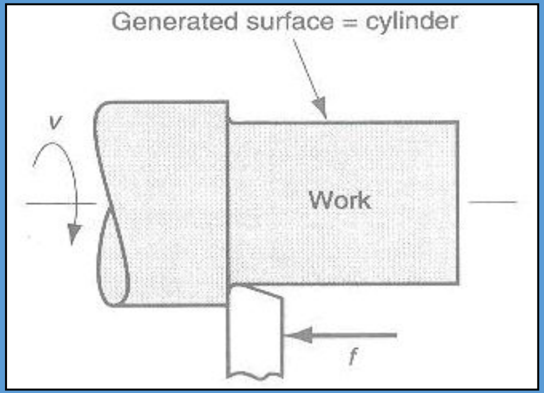
Manufacturing processes

What is a machine tool?

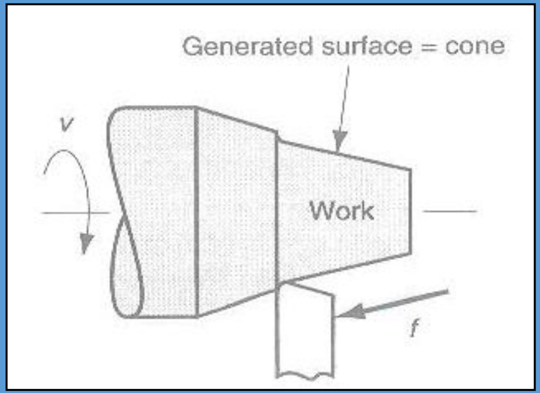
- **A machine tool is a machine for shaping or machining metal or other rigid materials, usually by cutting, grinding, shearing or other forms of deformation.**

*** Machine tools employ some sort of tool that does the cutting or shaping.**

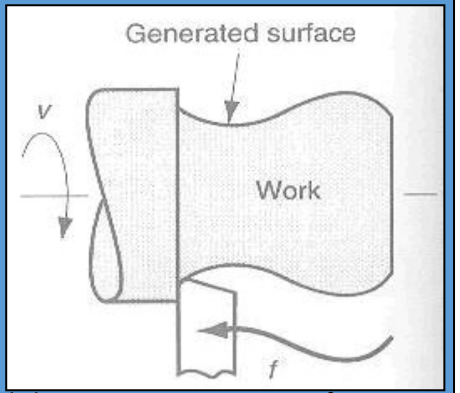
Generating Shape in Machining



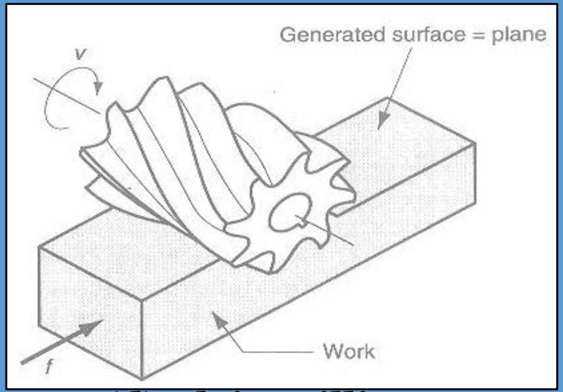
(a) Straight Turning



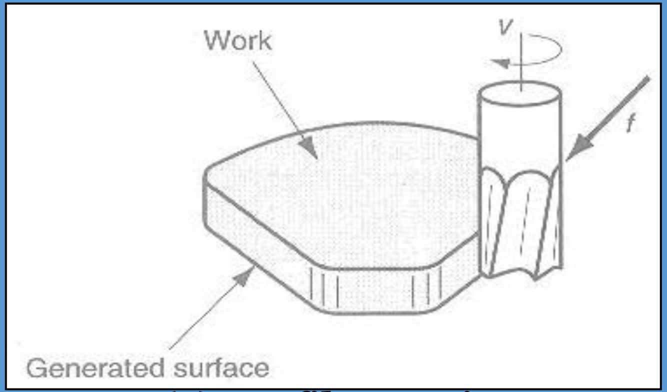
(b) Taper Turning



(c) Contour Turning

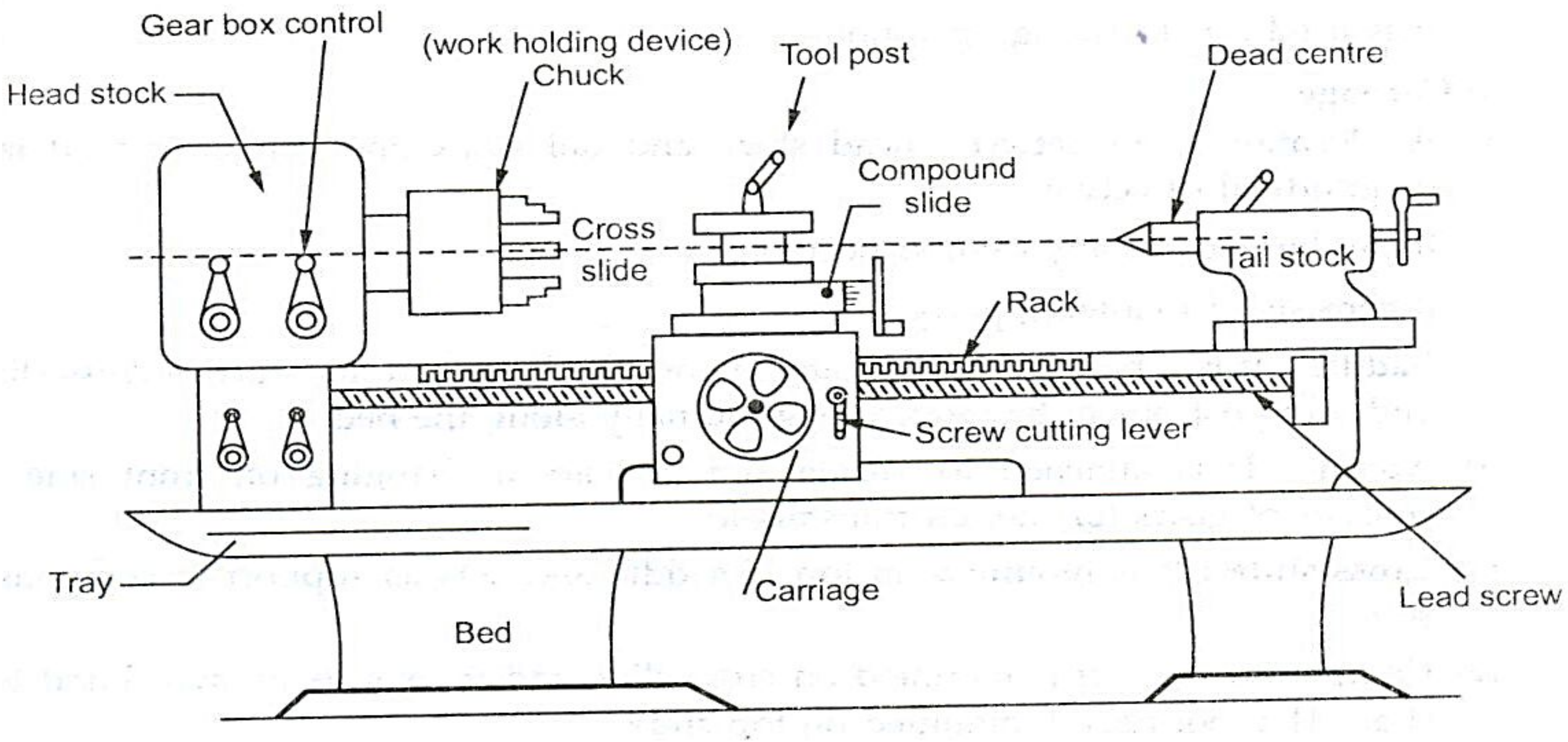


(d) Plain Milling

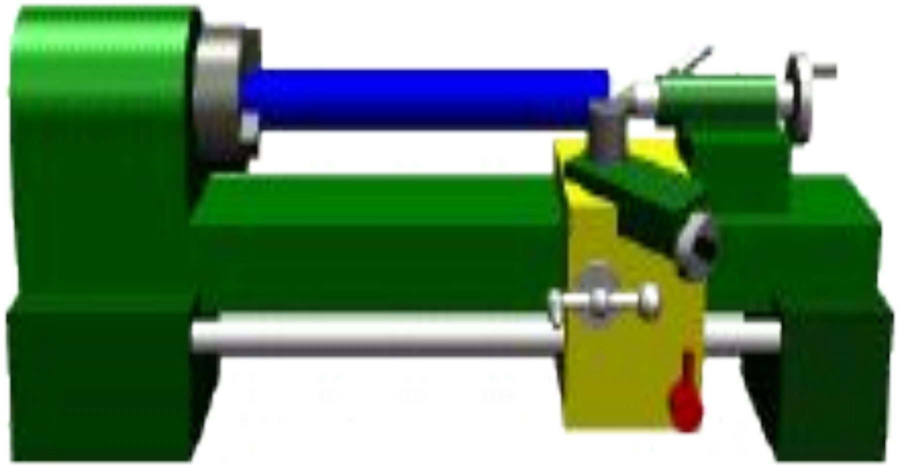


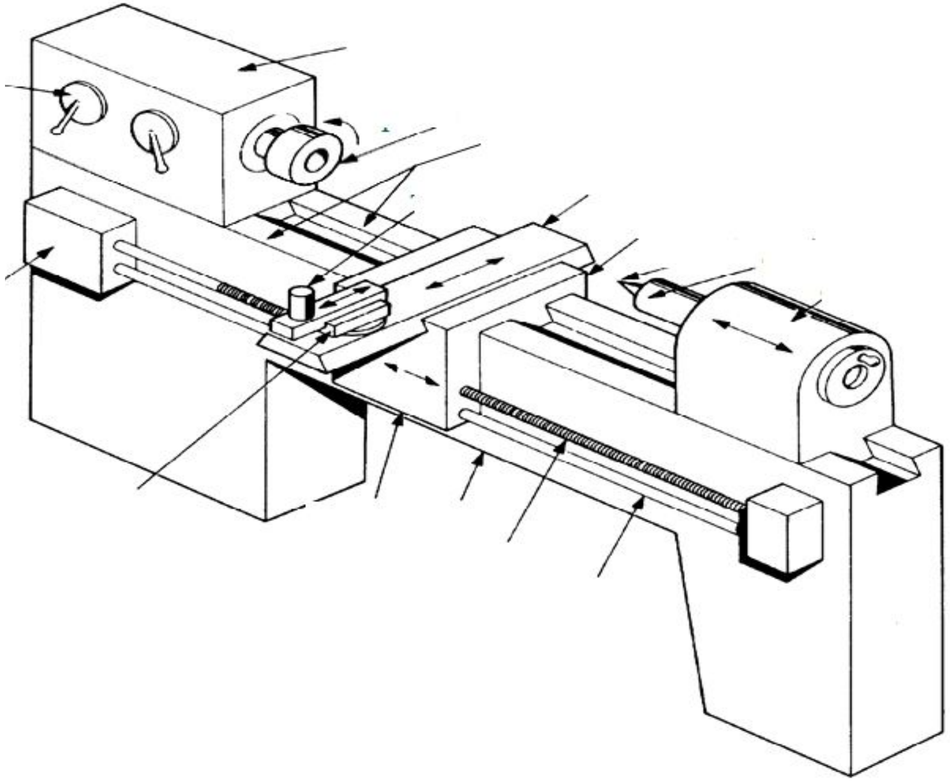
(e) Profile Turning

Lathe machine

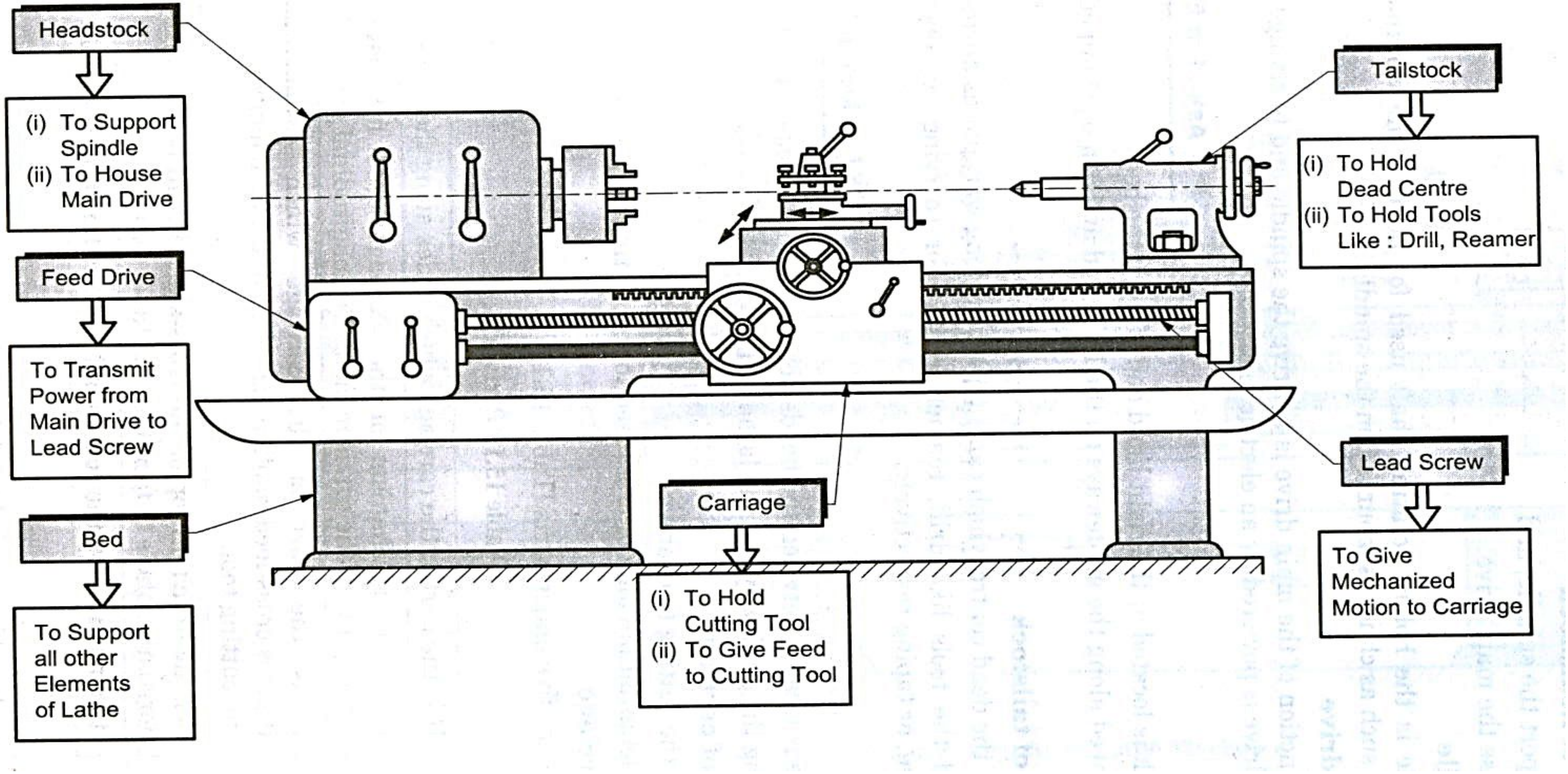


3-D view





Lathe Machine Parts – Functions



Lathe Machine Parts – Functions

- Lathe Bed
  - Base of Lathe Machine
  - Supports all other parts
  - Usually made up of CI (Cast Iron)
  - Absorbs shocks/vibrations (if any)
  - Two guide ways
- Headstock
  - Also called as Live Center of Lathe
  - Permanently fixed to left hand side of lathe
  - Supports spindle which holds chuck
  - Houses main drive (gear box)
  - Provides multiple speeds to work-piece (or job)
  - All Geared headstock, Back Geared Headstock
  - Headstock with Cone Pulley Arrangement

Lathe Machine Parts – Functions

- Tailstock
    - Also called as Dead Center of Lathe
    - Located on right hand side Lathe Machine
    - Movable along guide ways (removable as well)
    - Holds Dead Center which supports long work pieces / shafts
    - Useful for drilling, reaming or tapping operations
- Carriage
    - Located between Headstock and Tailstock of Lathe
    - Slides along guide ways on lathe bed
    - Holds cutting tool
    - Provides longitudinal and cross feed to cutting tool
    - Carriage consists of Saddle, Apron, Cross Slide, Compound Rest and Tool Post

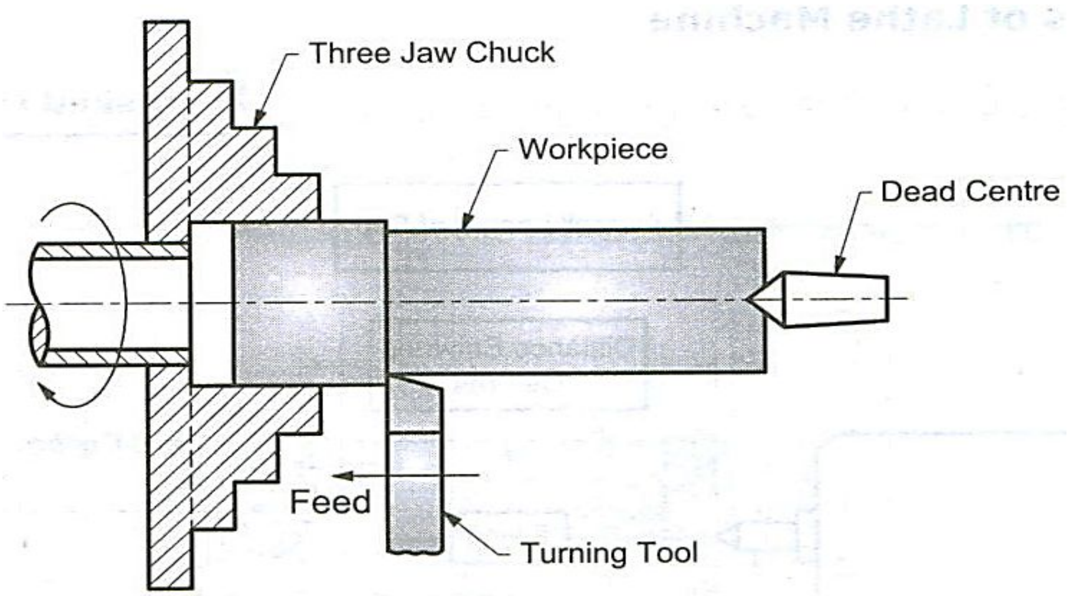
Lathe Machine Parts – Functions

- Lead Screw
  - Very Important part of Lathe
  - Long threaded shaft driven by feed drive
  - Provides mechanized/automatic motion to carriage for screw threads on the job
  - Lead Screw is MUST for Threading Operations on Lathe
  - Split Nut or Half Nut Mechanism converts rotary motion of lead screw to linear motion of carriage

- Feed Drive
  - Unit to transmit power and motion from main drive to lead screw
  - Useful to get the desired reduction ratio

Lathe Machine Operations – Turning

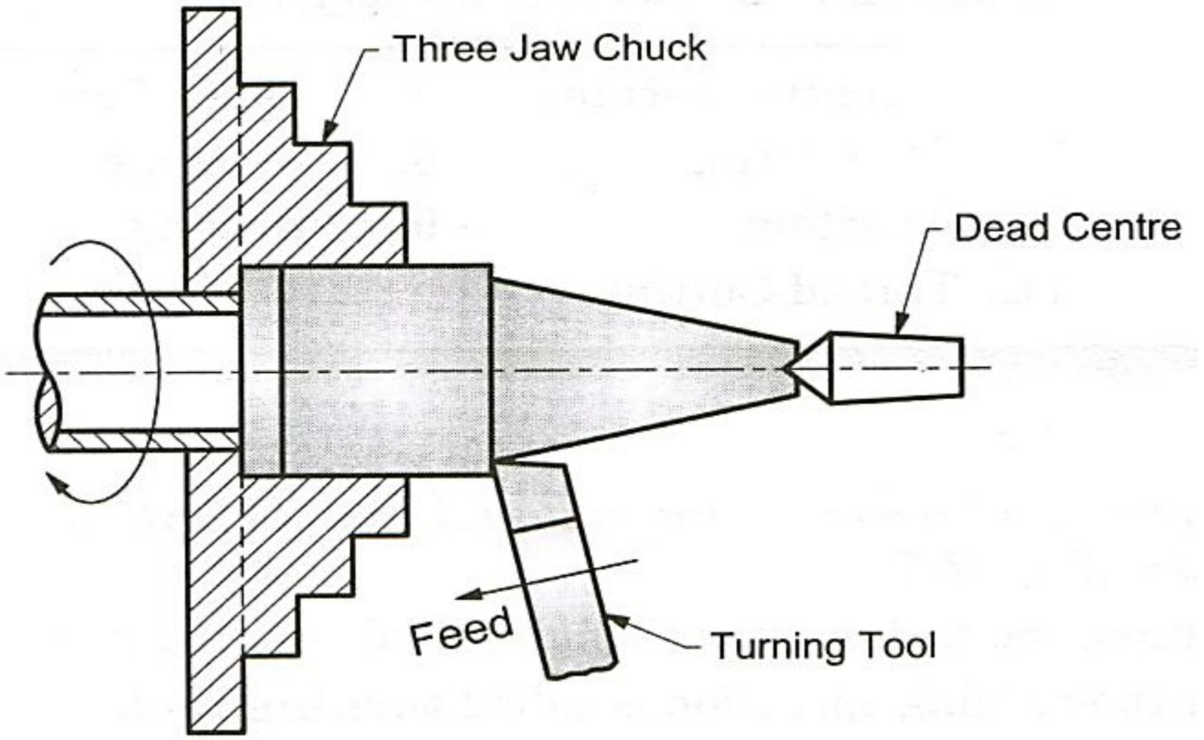
- **Turning**
  - Most basic operation done on lathe machine
  - Job or work piece is turned (rotated) using rotary motion of spindle, hence lathe is also called Turning Machine!
  - Lathe operator is called “Turner”!
  - Removal of material from a cylindrical work-piece or job
  - To reduce diameter of cylindrical job
  - Tool motion parallel to the axis of lathe
  - Tool used is called “Turning Tool” and it is “Single Point Cutting Tool”
  - Rough turning, using roughing tool or knife tool
  - Finish turning using finishing tool



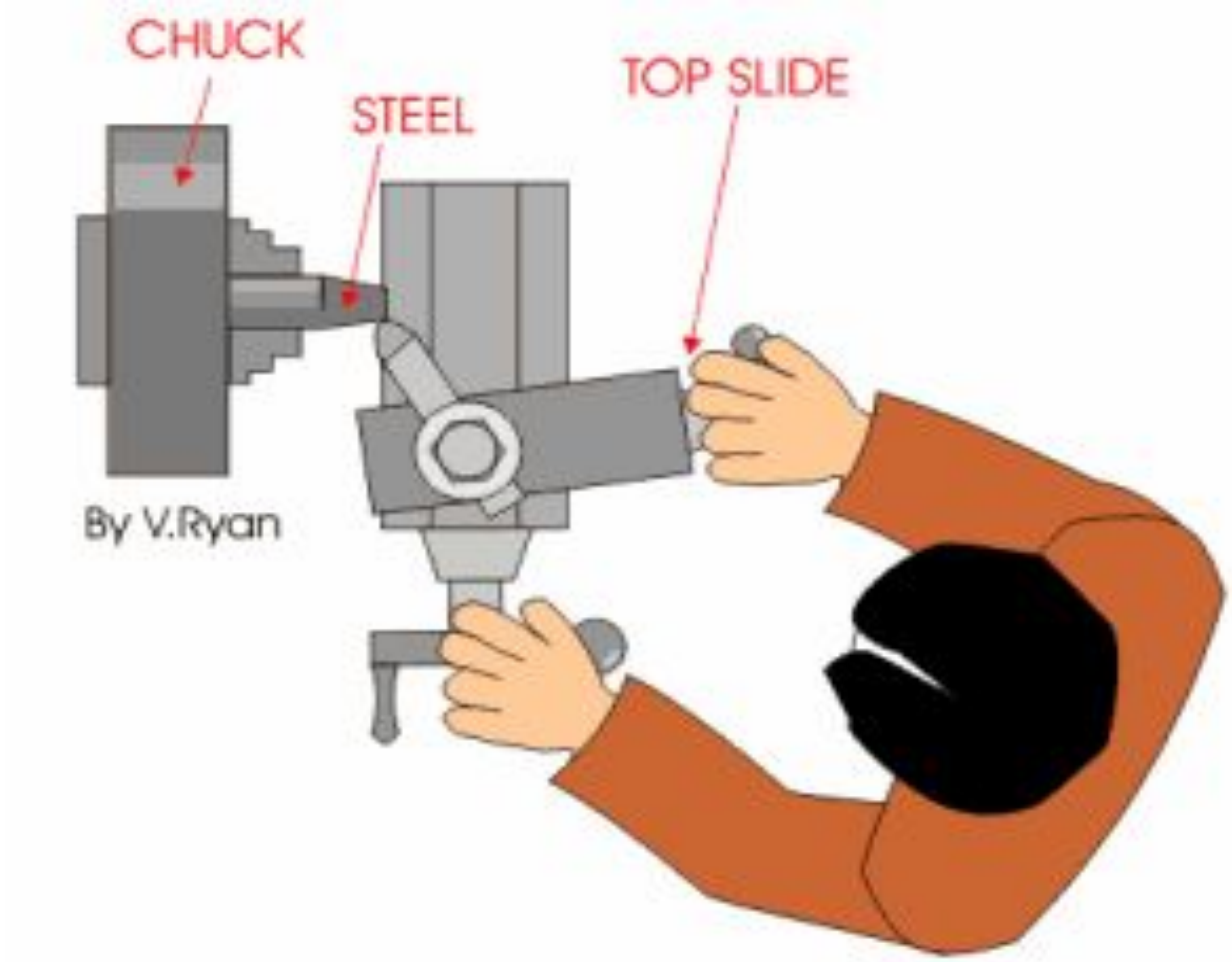
Turning

Lathe Machine Operations – Taper Turning

- Taper Turning
  - To reduce diameter of work piece uniformly along the length of work piece
  - Taper turning using “form tool”
  - Taper turning by “tailstock set over” method
  - Taper turning using “taper turning attachment”
  - Taper turning by “swiveling the compound rest”

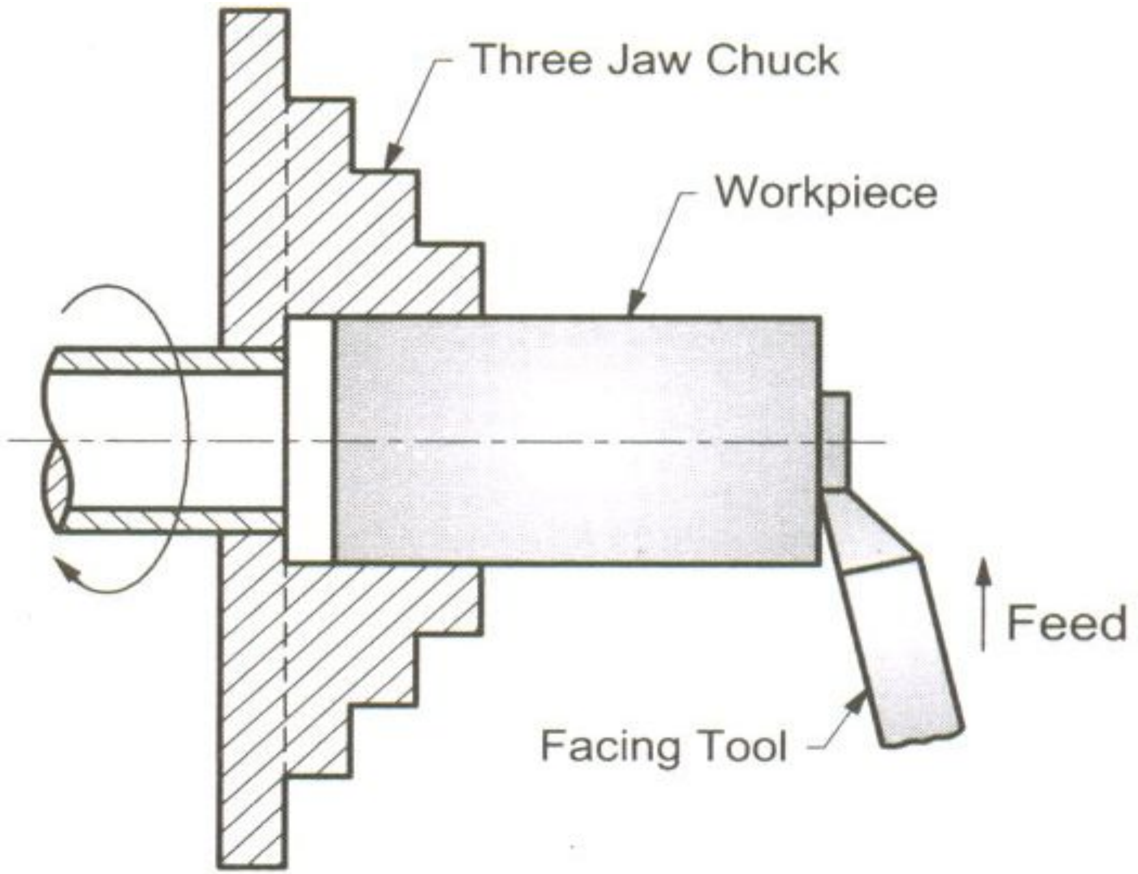


Lathe Machine Operations – Taper Turning

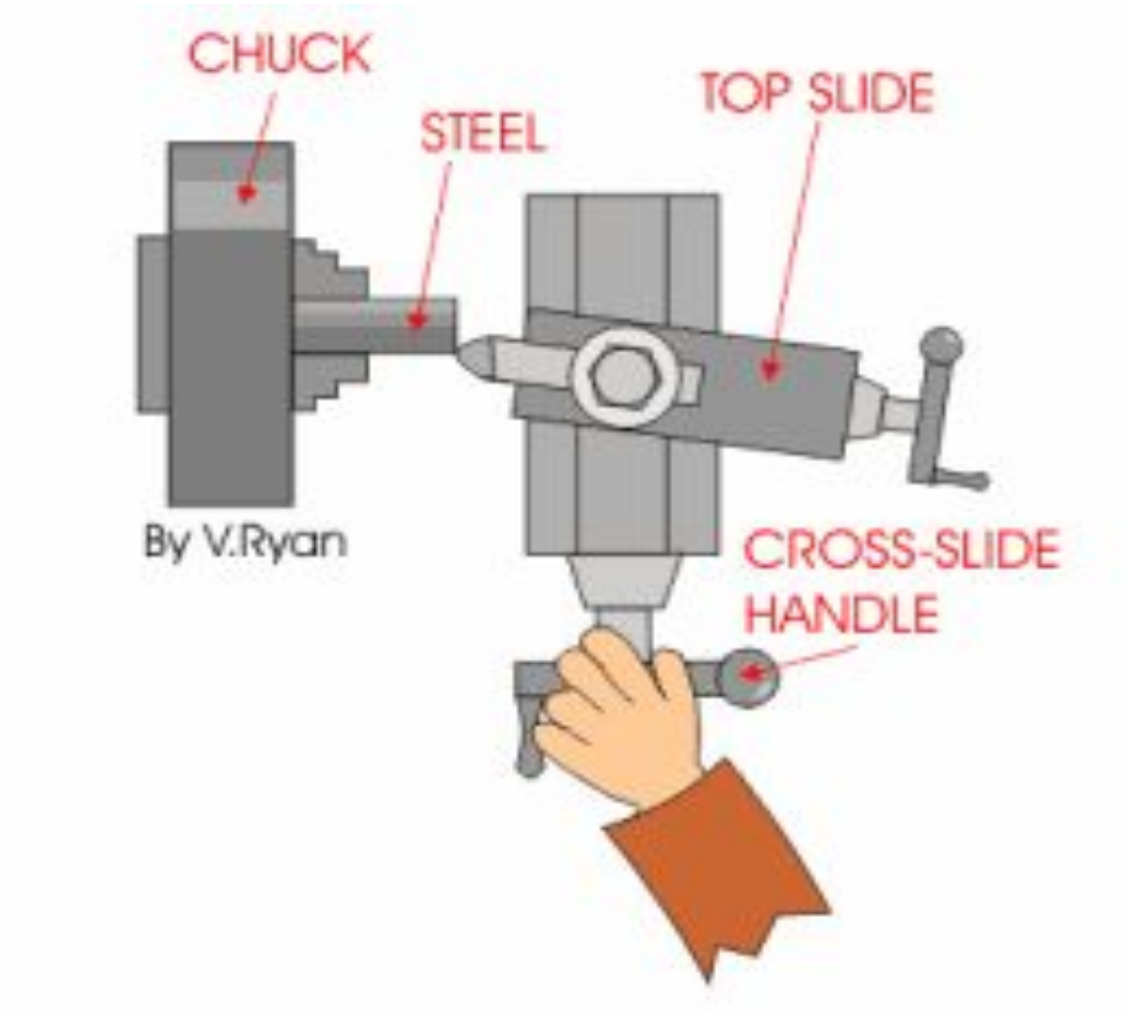


Lathe Machine Operations – Facing

- **Facing**
  - **Removal of material from end surface of the work piece or job**
  - **To have a reference plane to mark and measure the step lengths of work**
  - **To have a face at right angle to the axis of the work**
  - **To reduce length of job**
  - **To maintain the total length of the work**
  - **Facing Tool is used**
  - **Tool motion is perpendicular to axis of lathe**
  - **To produce flat surface (especially after parting off operations)**

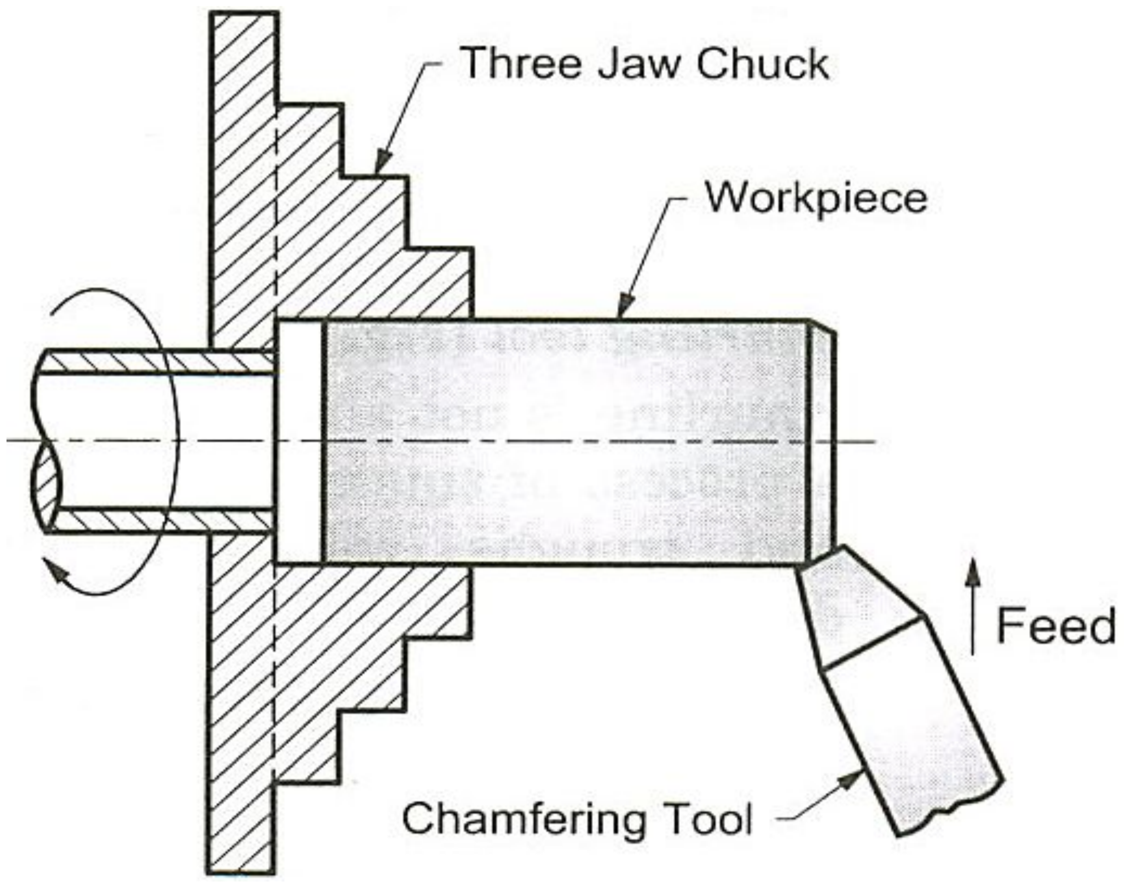


Lathe Machine Operations – Facing



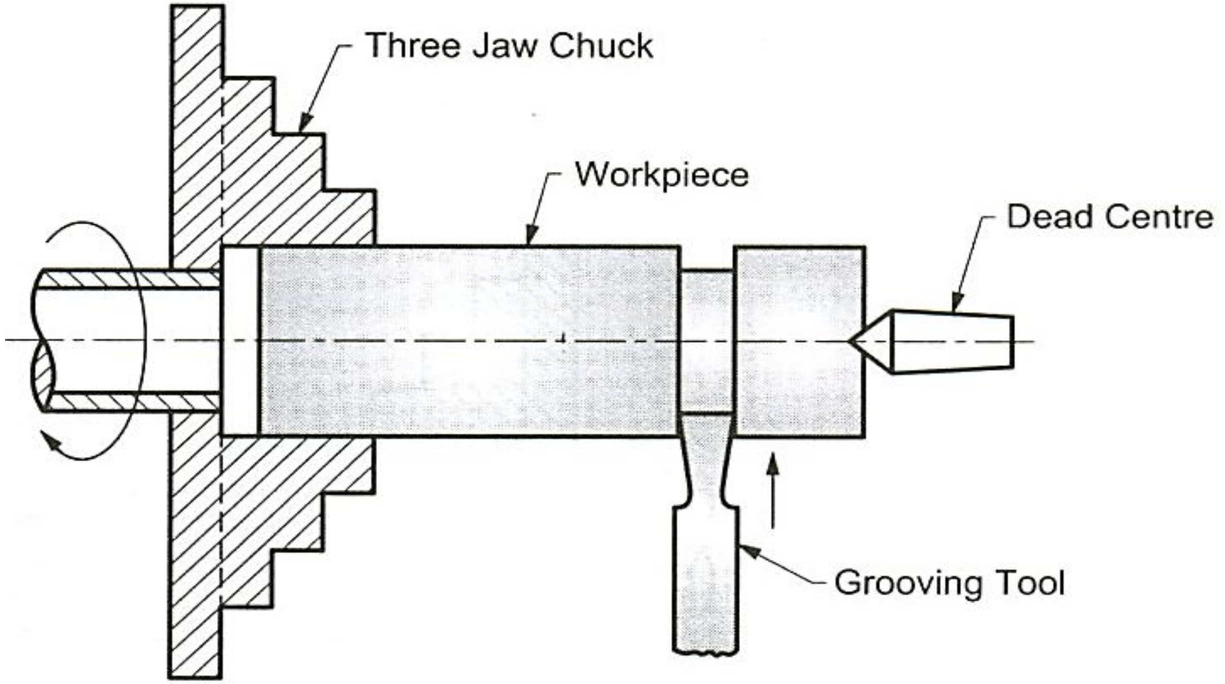
Lathe Machine Operations – Chamfering

- **Chamfering**
  - **Process of beveling the sharp edges of work piece**
  - **Chamfered jobs avoids injuries to hands of persons handling the job**
  - **Provides aesthetic look to the work piece**
  - **Chamfering tool is used**
  - **To permit easy assembly of mating parts (shaft & hole)**
  - **Chamfer specified as CH 2 x 45 (2 mm deep at an angle of 45 degrees**
  - **Form Tool Method**
  - **Filling Method**
  - **Compound Slide Method**



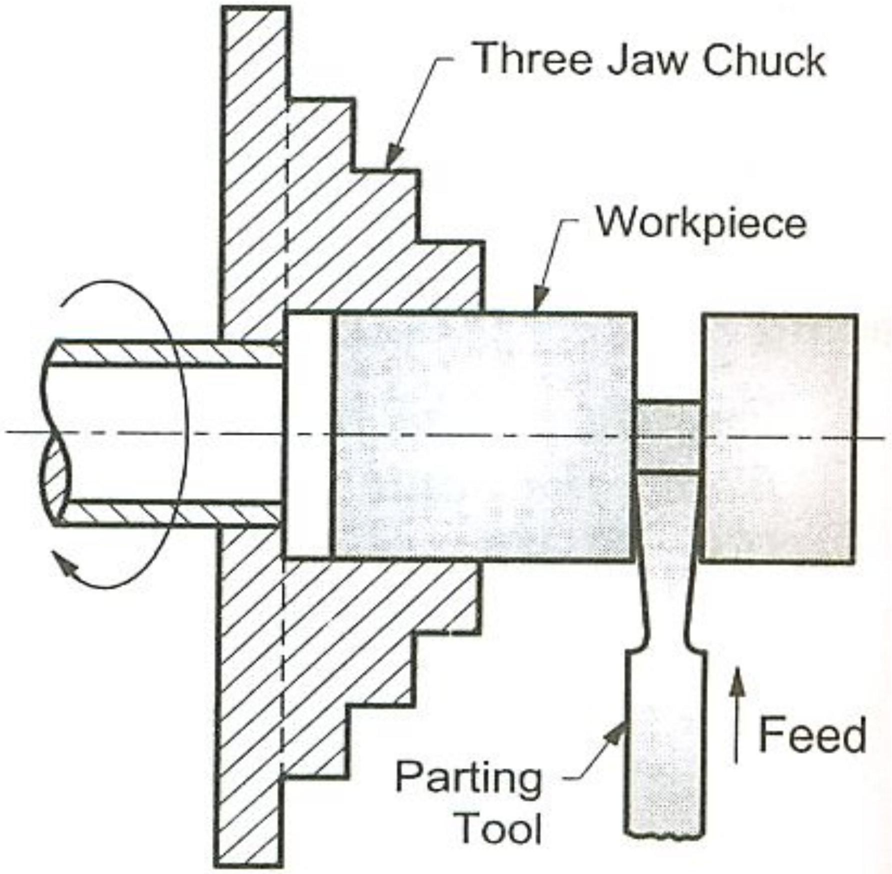
Lathe Machine Operations – Grooving

- Grooving or Groove Cutting
  - To create narrow groove on cylindrical work piece
  - Shape of tool is replicated as shape of groove
  - Operation also known as Form Turning!
  - Square Groove, Round Groove and 'V' Type Grooves



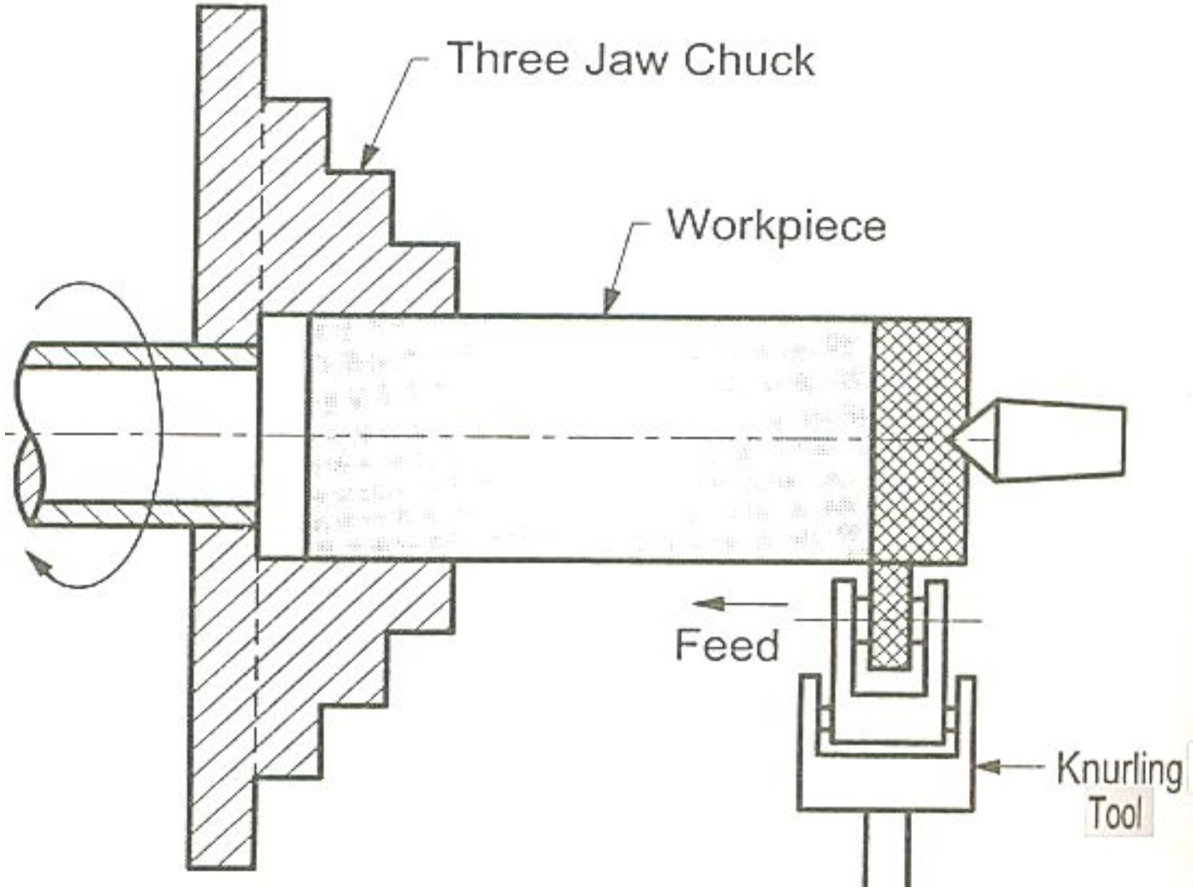
Lathe Machine Operations – Parting

- Parting
  - Process of cutting work piece into 2 parts
  - Parting tool is used
  - Extension of grooving operation where feed is provided till axis of work piece
  - Care needs to be taken when work piece splits into two parts



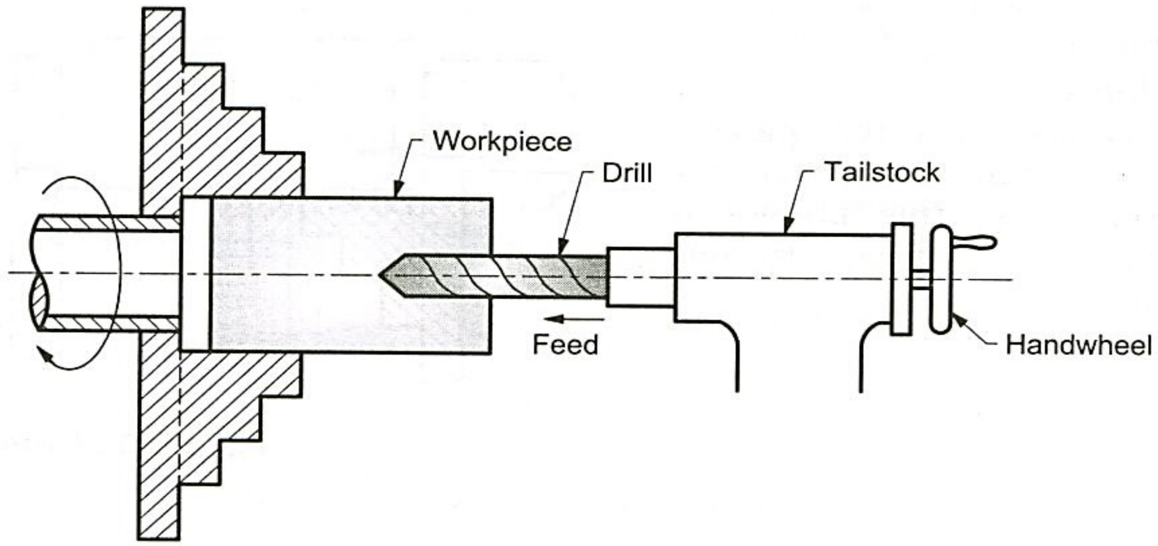
Lathe Machine Operations – Knurling

- **Knurling**
  - **Process of embossing a diamond shaped regular pattern on the surface of job**
  - **Tool used is called “Knurling Tool”**
  - **Parallel or Straight Knurling**
  - **Diamond or Criss-Cross Knurling**
  - **Concave or Convex Knurling**
  - **Squeezing metal into peaks and valleys using plastic deformation**
  - **Provides non-slip grip to the job**
  - **Aesthetic or Decorative look**



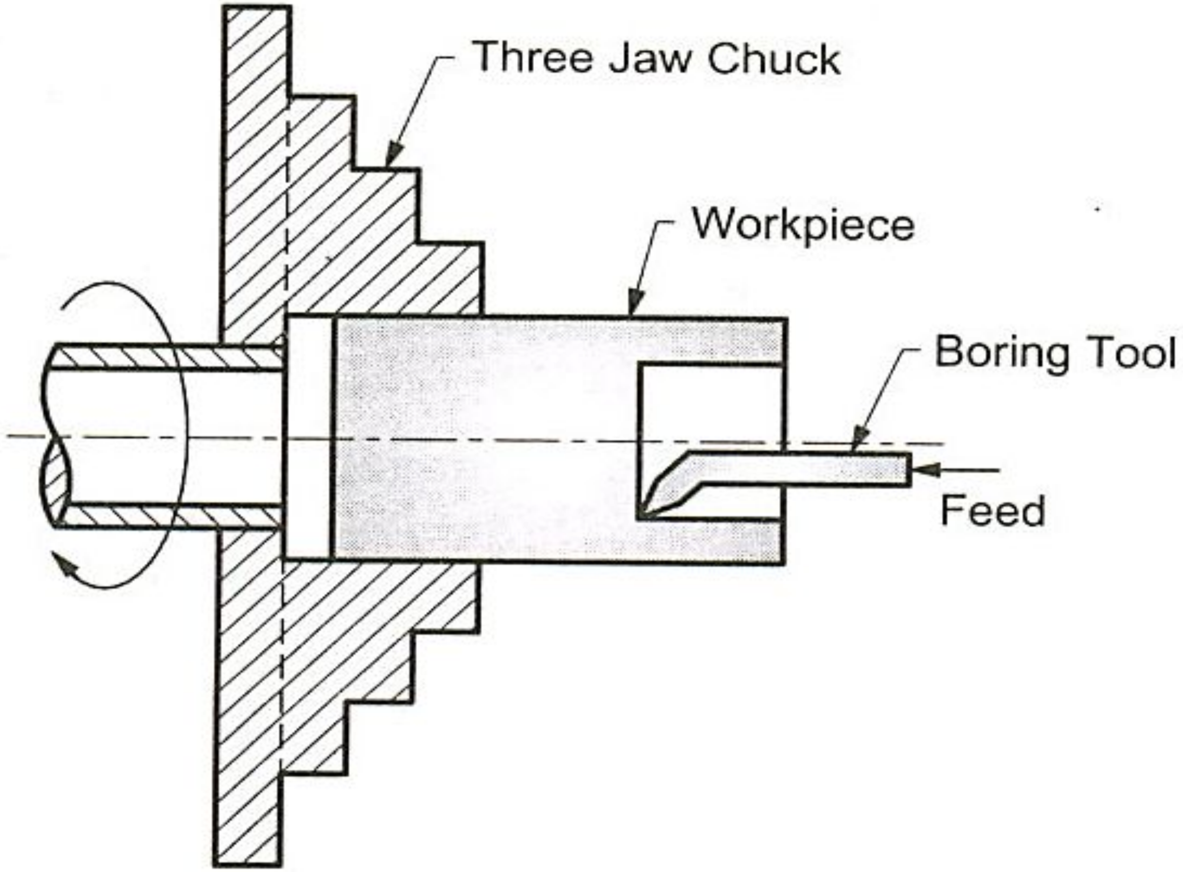
Lathe Machine Operations – Drilling

- Drilling
    - Process of making a circular hole in cylindrical job
    - Tailstock is used to hold cutting tool which is called as “Drill”
    - Drill is feed against rotating job by rotating hand wheel of tailstock in clockwise direction
    - After making hole, the drill is withdrawn by rotating the tailstock handle in anti-clockwise direction

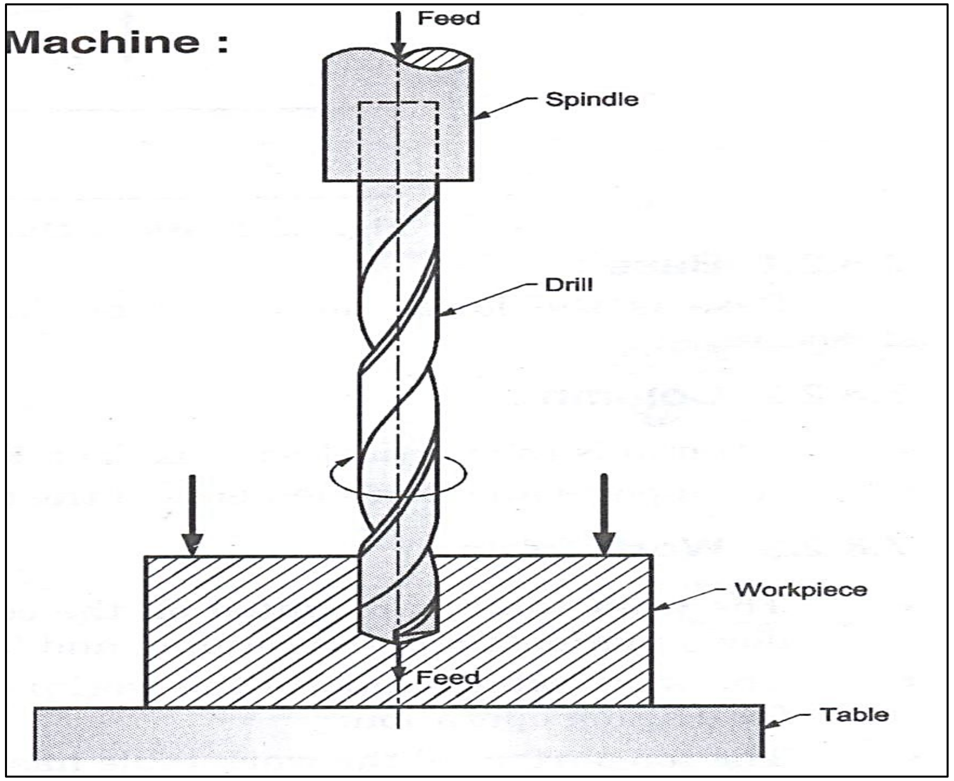


Lathe Machine Operations – Boring

- Boring
  - Process of enlarging already existing hole in the job
  - Tailstock is used to hold the tool
  - Skill of operator plays imp role
  - Tool used is called as “Boring Tool”!



Drilling machine-Working principle



- Drilling is an operation through which holes are produced in a solid material using a rotating tool.
- The machine tool used for this purpose is called as *drilling machine.*
- In drilling operation, the workpiece is clamped firmly on the worktable by using nuts and bolts.
- The drill is press fitted in a drill chuck.

- The rotating drill is made of harder material than that of workpiece and it is fed against the stationary workpiece by either hand or power feed.
- During this process, the material is removed in the form of chips.
- It is important to note that, during the process, high amount of heat is generated hence continuous supply of coolant is required.
- In a drilling machine, holes are produced quickly and at low cost.

Basic elements of drilling machine

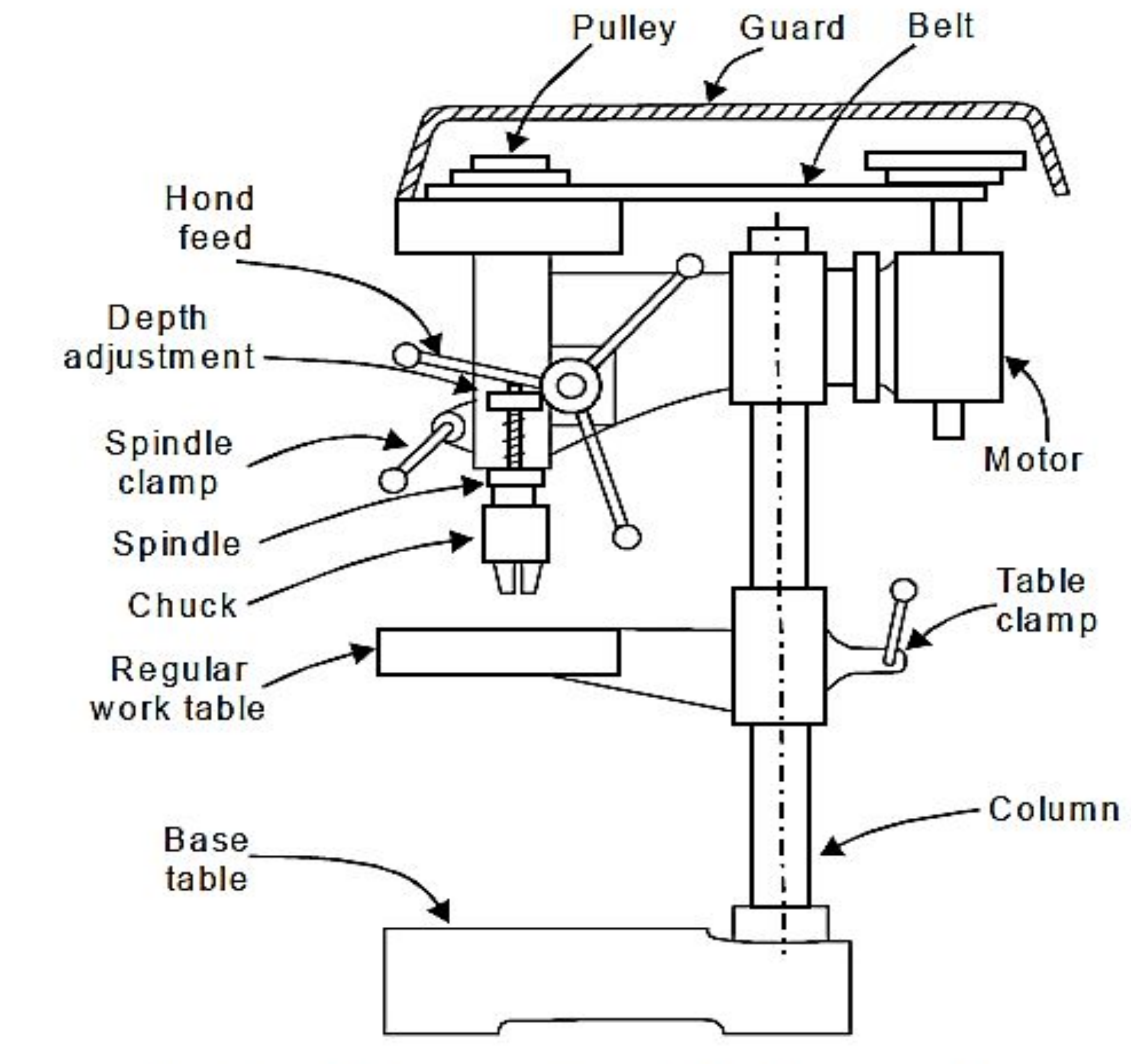


Fig. 22.1 Construction of drilling machine

Basic elements of drilling machine

Base

- It is part of machine which supports the entire structure.
- Generally, base it made from the casting.

Column

- It is the vertical member of machine which supports the table and head containing all the driving mechanisms.
- It may be made of round section or box section.

Work table

- It is mounted on the column. It is may be round or rectangular in shape.
- It is used for clamping the workpiece directly over its face and provided with T-slots.
- It has vertical as well as swing or circular motion.

Basic elements of drilling machine

Drill head

- Drill head carries driving and feeding mechanism from the spindle.
- The driving mechanism is used for driving the drill spindle which consists of an electric motor, gear box, etc. whereas, feeding mechanism is used for feeding the drill into the workpiece.
- The drill head is mounted on the top of the column.

Spindle drive

- Spindle is hollow part, in which drill (tool) is inserted.
- During the operation, spindle rotates as well as moves up and down, hence the drill also rotates as well as moves up and down.

Drilling machine operations

Boring

- Boring is the process of enlarging already drilled hole by using an adjustable cutting tool which is called as *boring tool.*
- This operation is used for finishing a drilled hole accurately and bring it to the required size as well as to correct the roundness of a hole.
- Boring tool has only one cutting edge.

Counter-boring

- This operation is used for enlarging only limited portion of a hole and called as *counter-boring.*
- The tool used for this purpose is called as *counterbore.*

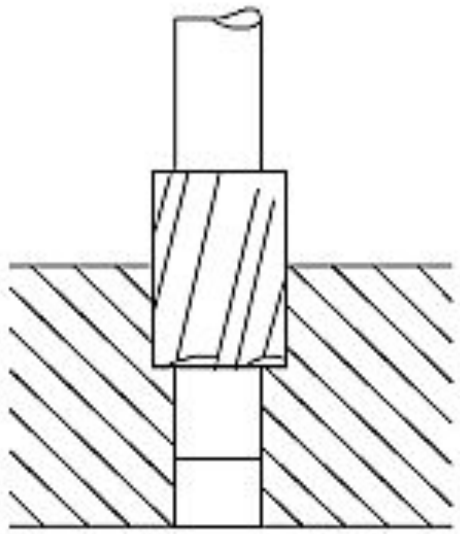


Fig. 22.9 Counter boring operation

Drilling machine operations

Counter-sinking

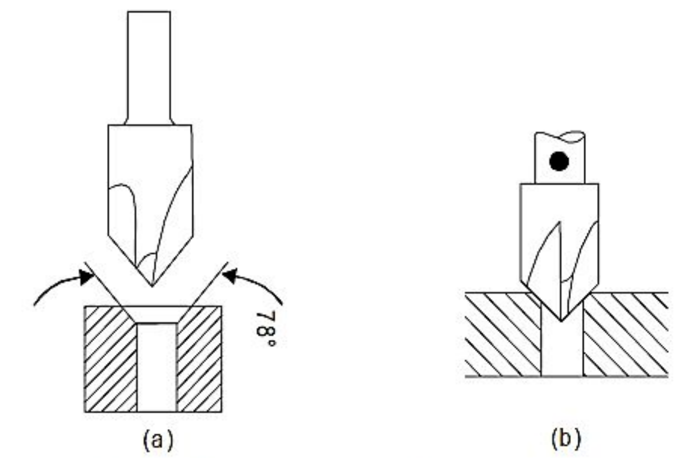
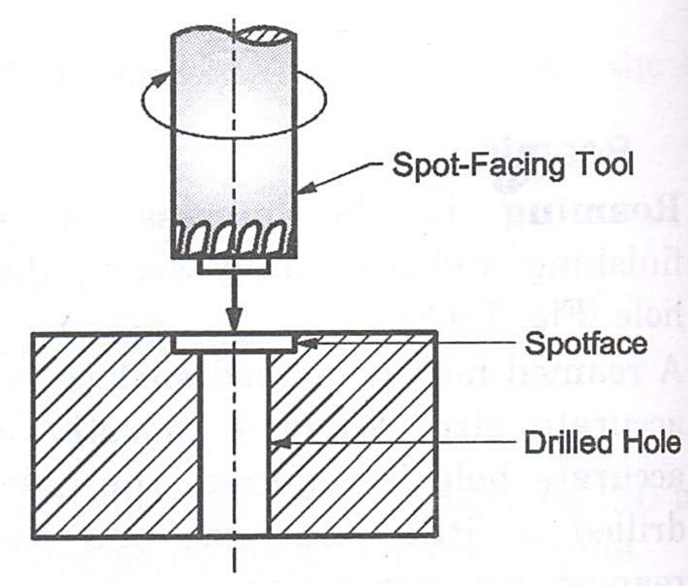


Fig. 22.10 Counter sinking operation

- It is used for enlarging the end of a hole and to give it a conical shape for a short distance.
- The tool used in this operation is called as countersunk.
- These tools have included angles of 60^0 , 82^0 ,90^0



- It is the operation of smoothing and squaring the surface around a hole for the seat of a nut or head of the screw.
- The hole may be spot faced below or above the rough surface.

Drilling machine operations

Tapping

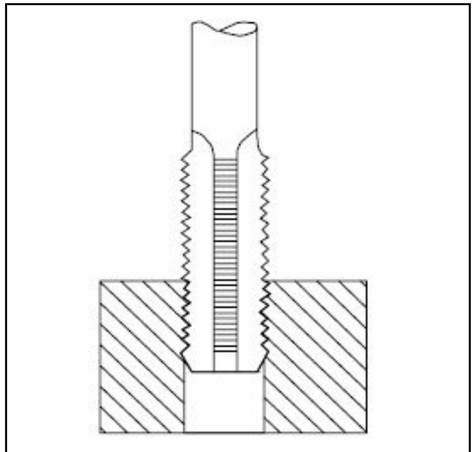
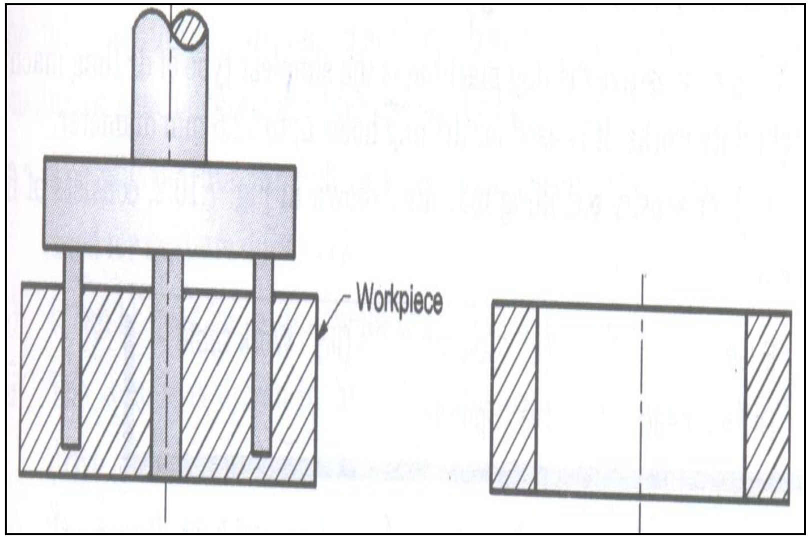


Fig. 22.11 Tapping operation

- Tapping is an operation of cutting internal threads by using a cutting tool called as tap.
- For tapping purpose, the machine should be equipped with a reversible motor or some other reversing mechanism.
- A tap in fed to a already drilled hole along the axial direction to produce internal threads.



- When large diameter holes are required in sheet metal, then trepanning operation is carried out.
- It is carried out by using trepanning tool.
- A small hole, to suit the pilot is drilled at the centre of the required position.
- The adjustable arm is extended so that the edge of the high speed-steel cutting tool produces the required hole size.

Grinding machine-Working principle

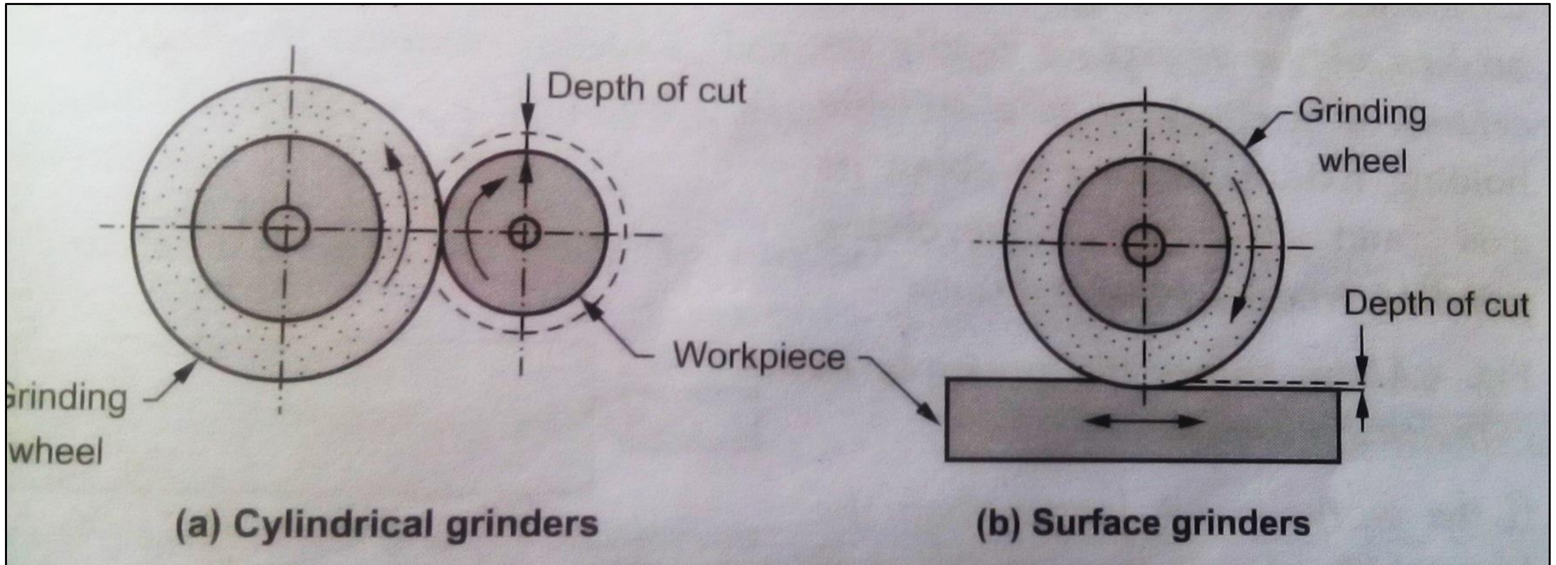


Fig. 6.4.1 Working principle of grinding machine

- Grinding is the process of removing the material by the abrasive action of a revolving wheel on the surface of a workpiece.
- Grinding wheel consists of a sharp crystals which are called as abrasives, held together with the bonding materials.
- During the process, a high speed revolving grinding wheel is brought in contact with the workpiece and material from it is removed by using abrasive action.

Cylindrical grinding machine

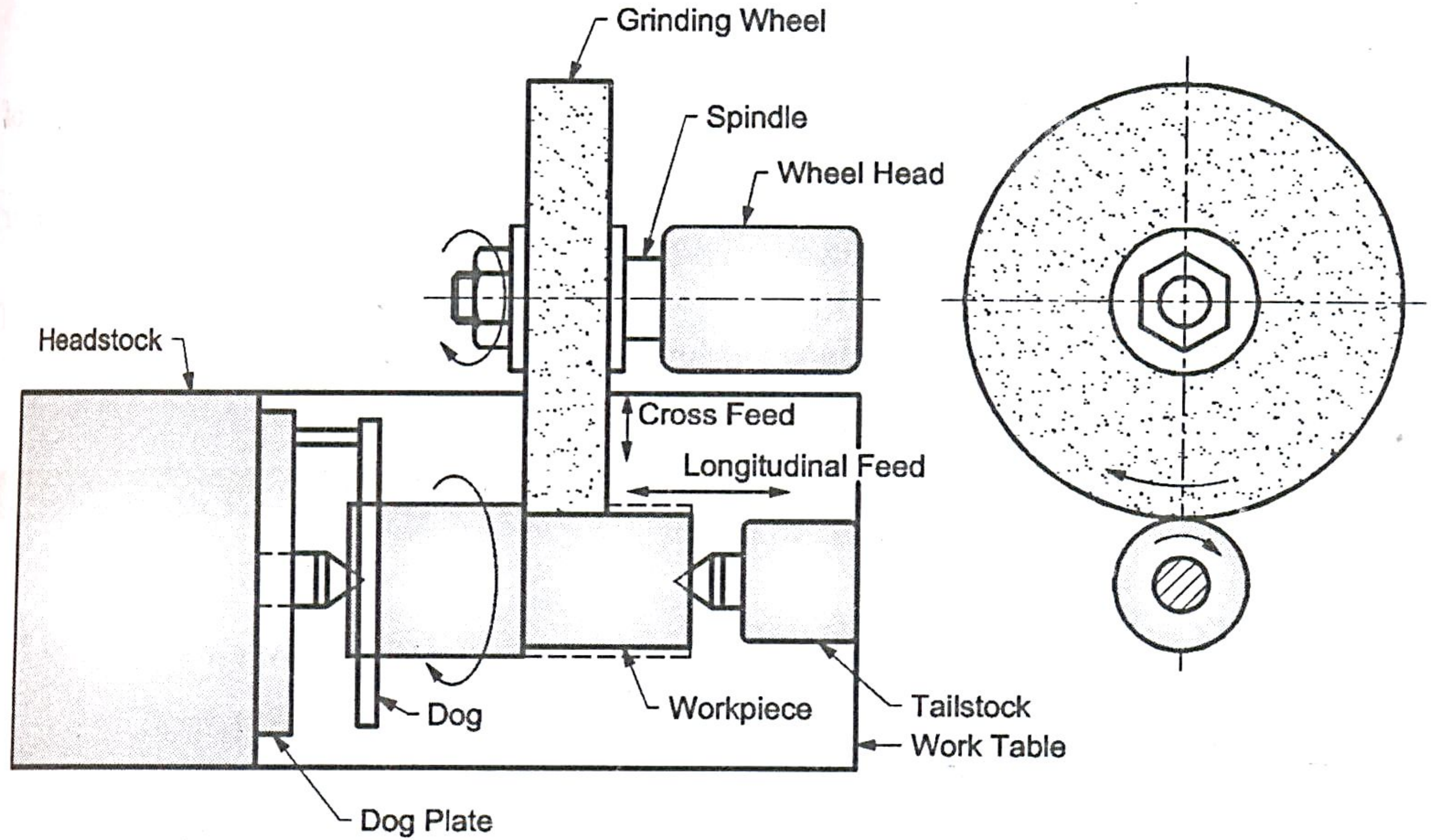


Fig. 7.12.1 : Cylindrical Grinding Machine

Centreless grinding machine

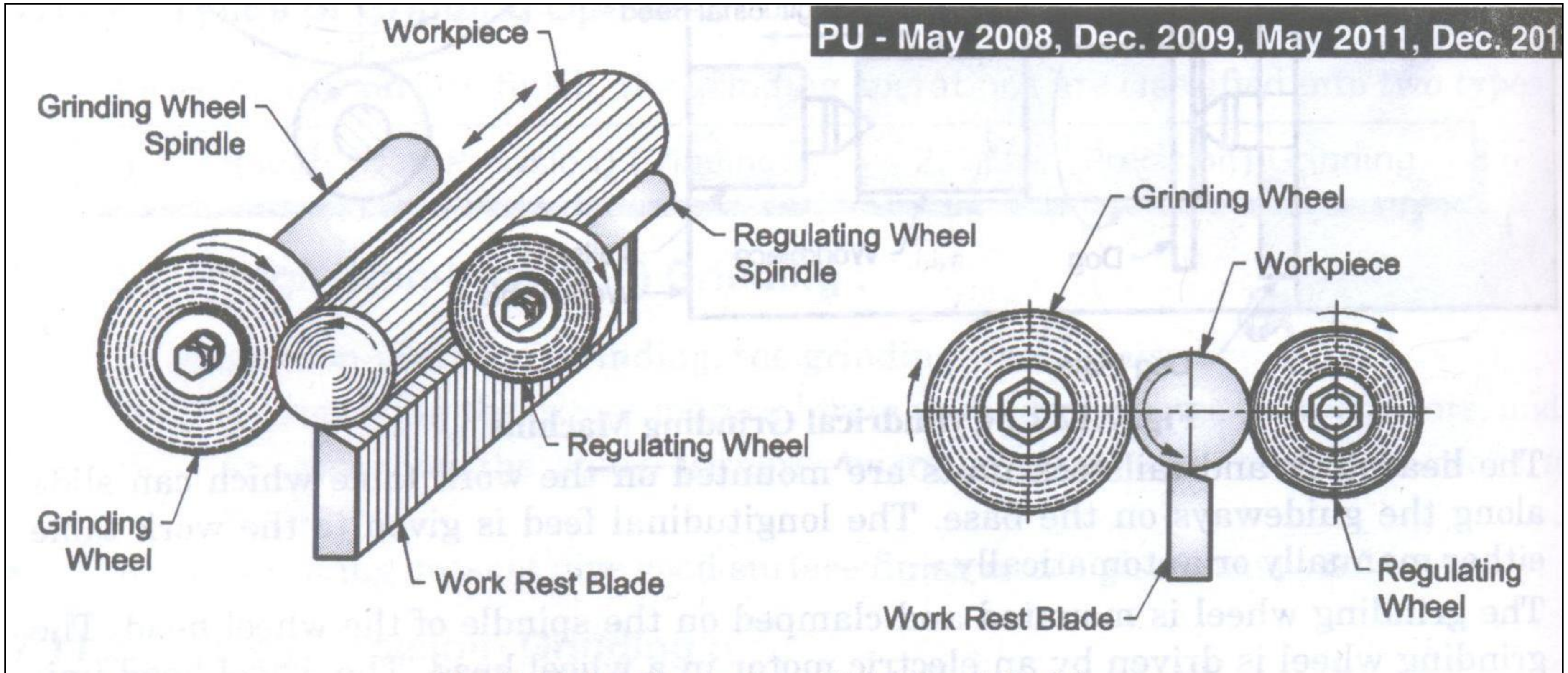


Fig. 7.12.3 : Centreless Grinding Machine

Surface grinding machine

1. **Reciprocating table**
   i. Horizontal spindle
   ii. Vertical spindle
2. **Rotary table**
   i. Horizontal spindle
   ii. Rotary spindle

Reciprocating table type surface grinders

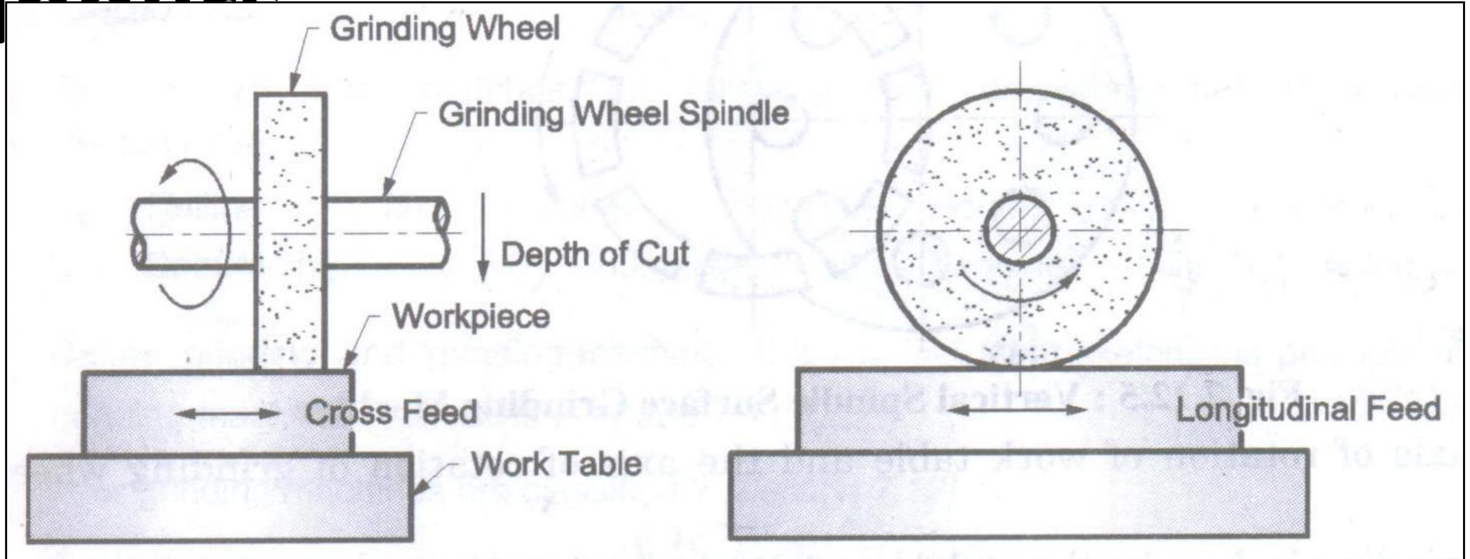
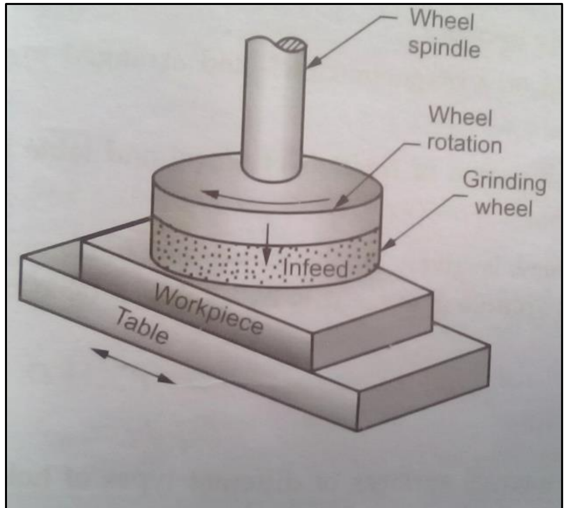
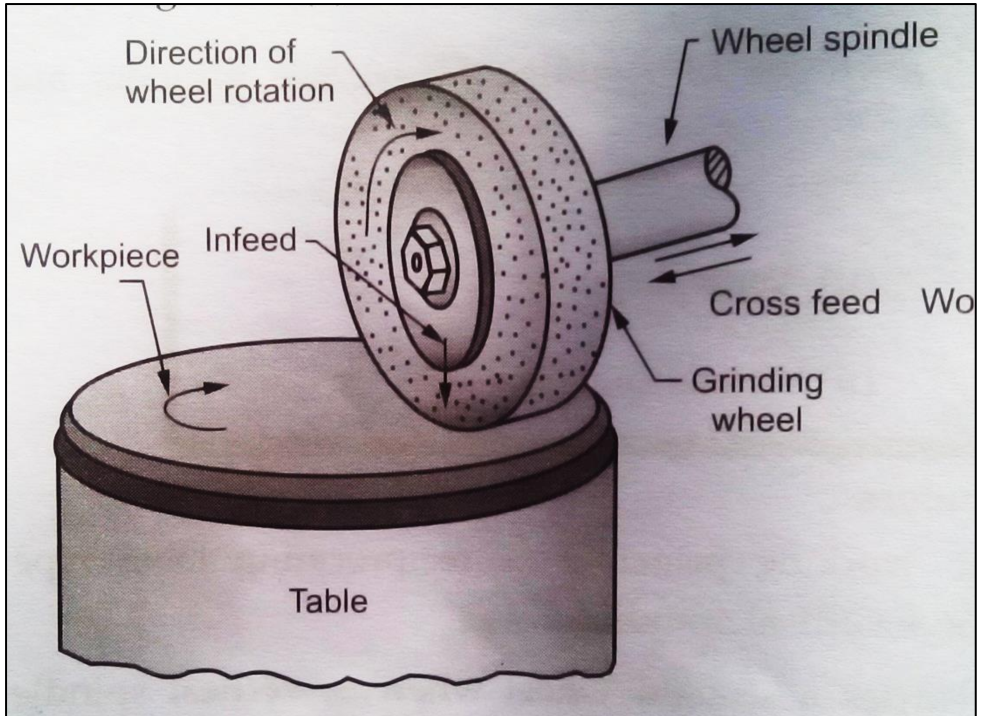


Fig. 7.12.4 : Horizontal Spindle Surface Grinding Machine

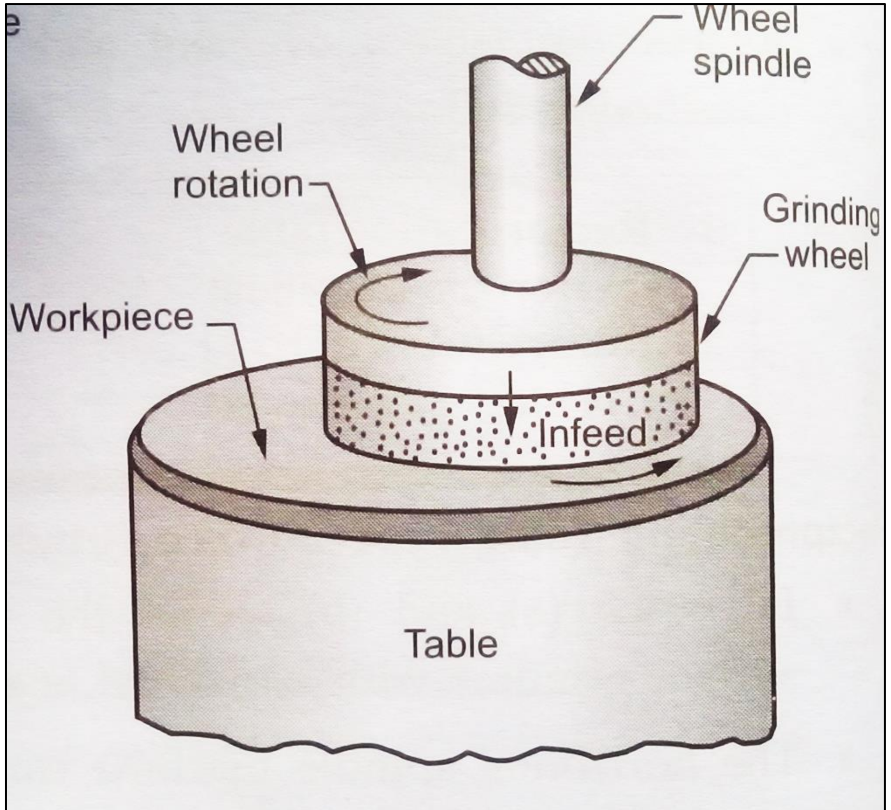


(a) Vertical spindle reciprocating table surface grinder

Rotary table type surface grinders



(a) Horizontal spindle rotary table surface grinder



(b) Vertical spindle rotary table surface grinder

Internal grinding machine

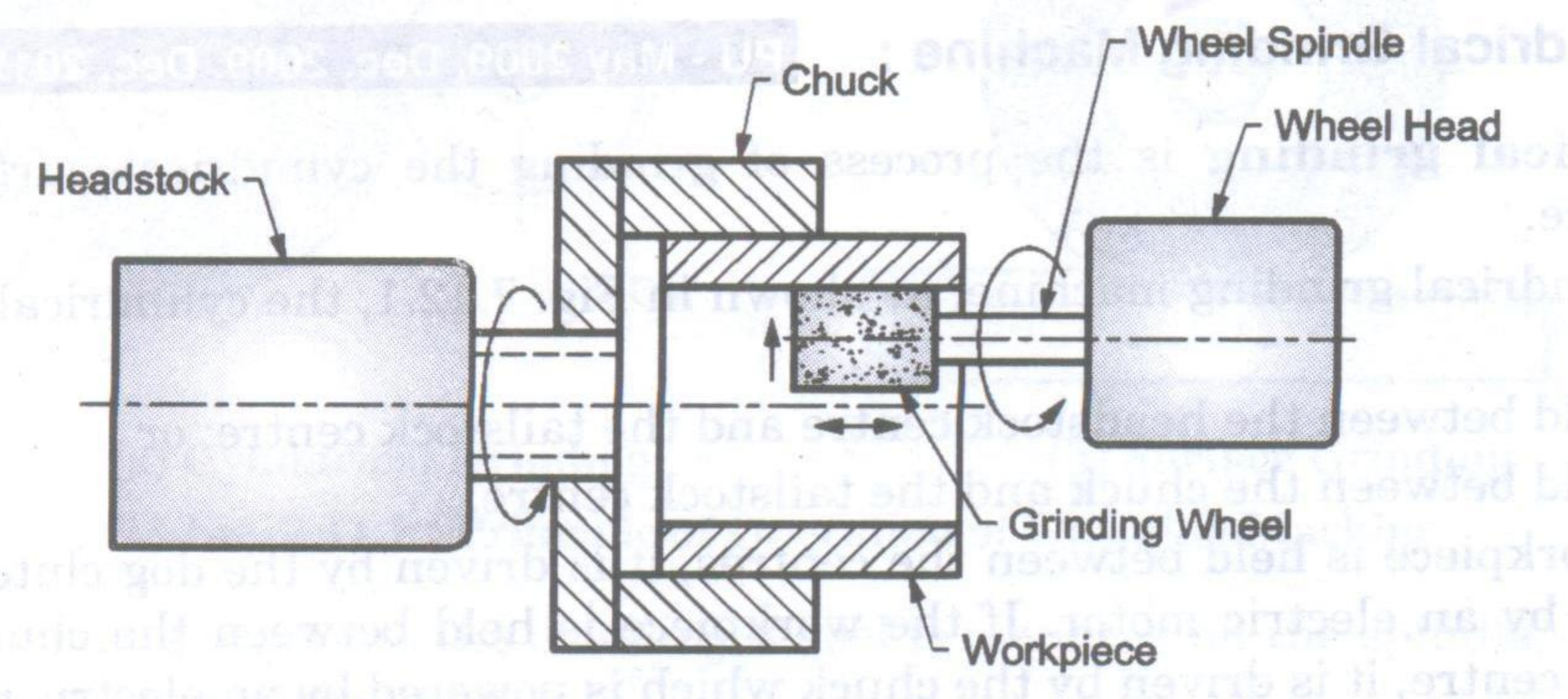
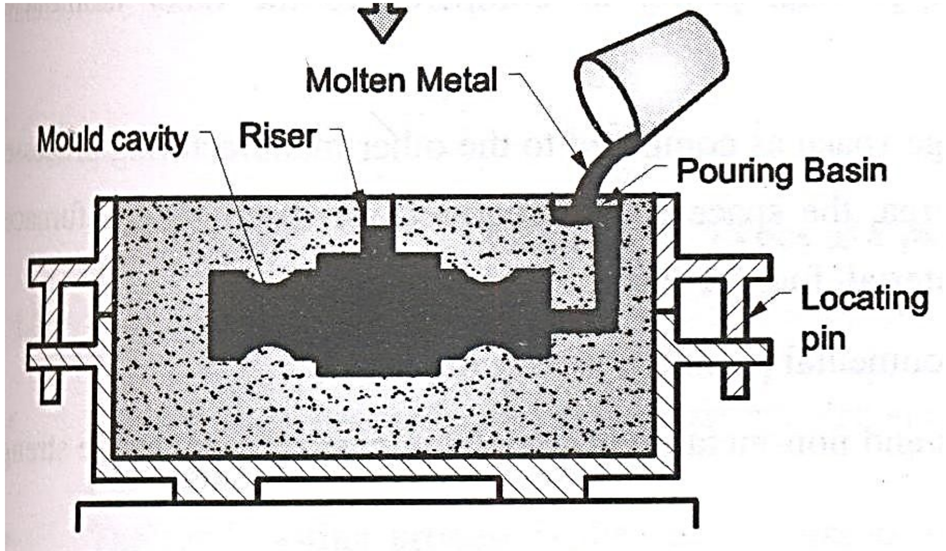


Fig. 7.12.2 : Internal Grinding Machine

Manufacturing processes

Casting

- *Casting* is the process in which the parts of desired shape are produced by pouring the molten metal or alloy into a cavity and then allowing the metal or alloy to cool and solidify.
- This solidified piece of metal or alloy is called as casting.
- *Casting* or *founding* is the most popular method of producing metal or alloy parts of nearnet shape.



Types of Casting:

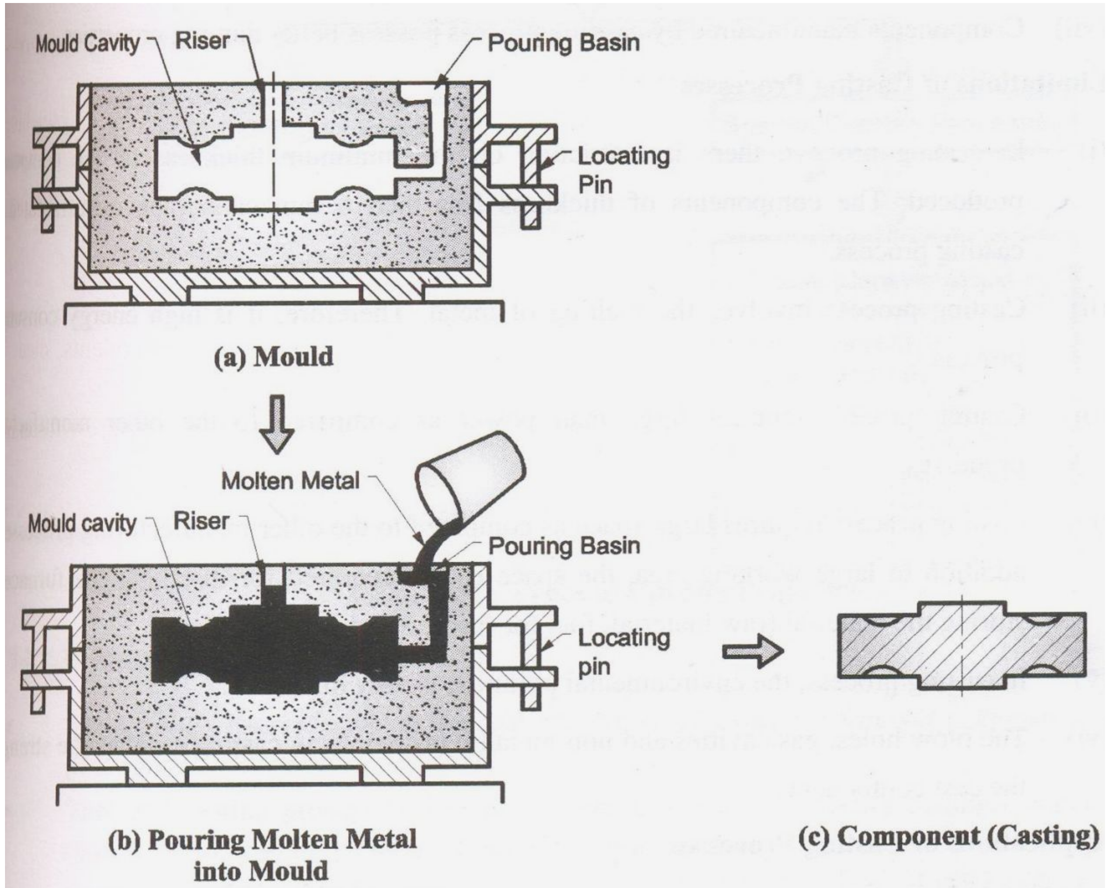
1. Sand Casting.
2. Investment Casting.
3. Die Casting.
4. Centrifugal Casting

Features of casting process:

- Cast Components are brittle.
- Close dimensional controls are not expected .
- No restriction on the size of the component
- No restriction on the type of metal or alloy used.
- Surface finish is un satisfactory, Machining is required.
- Extremely thin sections can not be cast.
- Large variations in section thickness of components are not allowed.
- Economically suitable for both job and mass production.

Steps involved in casting process

1. Pattern making
2. Sand preparation
3. Core making
4. Melting
5. Pouring
6. Finishing
7. Testing
8. Heat treatment
9. Re-testing



Advantages and disadvantages of casting

- **Advantages:**
  - Complex shapes can be easily produced by casting process.
  - Provides better vibration damping capacity to components.
  - Flexibility of design in terms of shape, size and quality of product.
  - Very heavy and bulky parts can be manufactured.
  - It produces machinable parts.
  - Used for small as well as mass production.

Advantages and disadvantages of casting

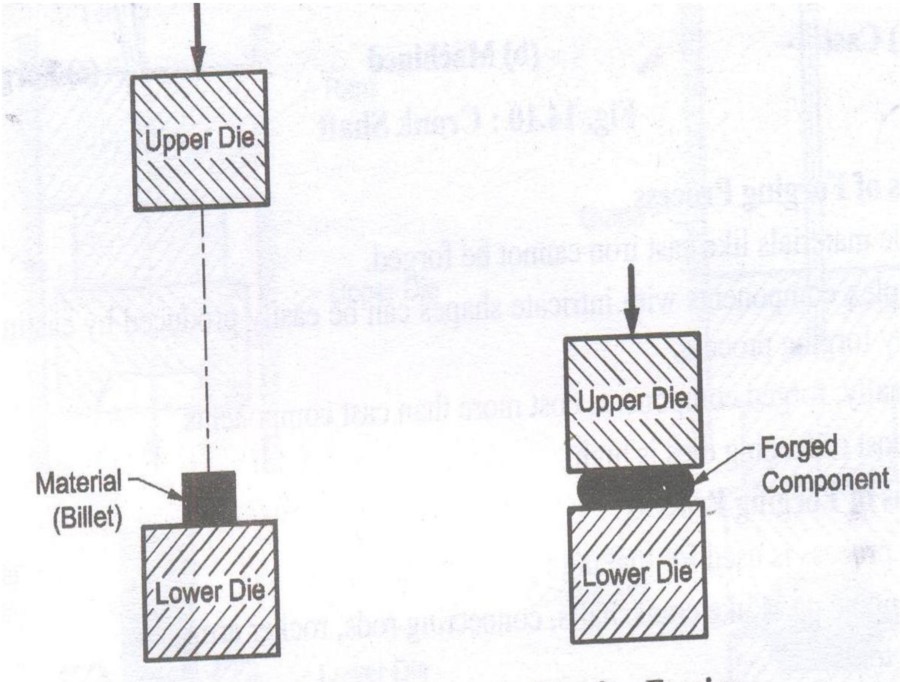
- **Disadvantages:**
  - Cast components are generally brittle i. e. weak in tension.
  - Defects like cracks, blow holes, etc. make casting weak and unsuitable for use.
  - Cast components require more machining.
  - Welding of cast components is difficult.
  - Accuracy of cast components is less.
  - During heating of metal, pollution of atmosphere takes place.

Applications of casting process

- Automobile parts (pistons, cylinders, clutch and gear housings, gear blanks, etc.)
- Machine parts (pulleys, gear blanks, beds, frames, etc.)
- Aircraft parts (Engine blades, motor housings, etc.)
- Turbine vanes, power generators, pump parts, filters, valves, etc.
- Agricultural parts, railway crossings, sanitary fittings, etc.
- Construction, communication and atomic energy applications.

Forging process

- Forging is the process in which the desired shape and size is obtained through plastic deformation of metal under the action of externally applied force at high temperature.
- It is the metal forming process which is done by either hand or by machine.



(a) Before Forging (b) After Forging

- The metals which are used in forging process must possess the required ductility
- The commonly used forging materials are: Aluminium alloys, copper alloys, low carbon steels, alloy steels, nickel alloys, tungsten alloys, magnesium alloys, titanium alloys, etc.

Types of forging

1. Hand forging

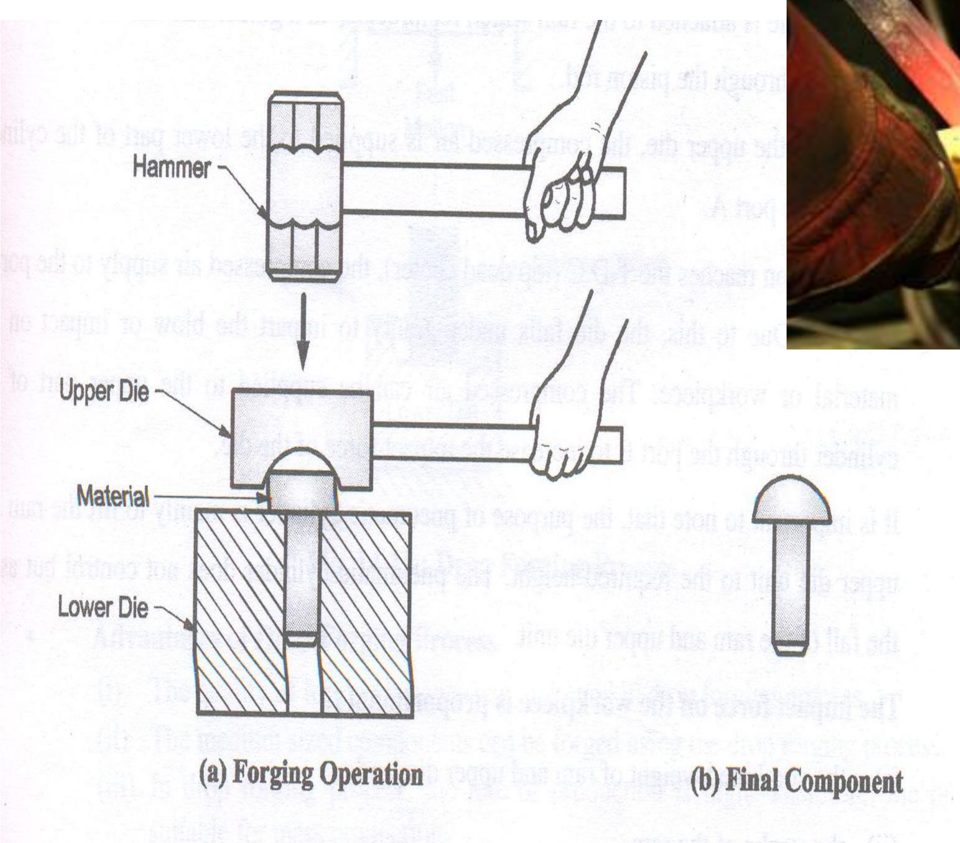
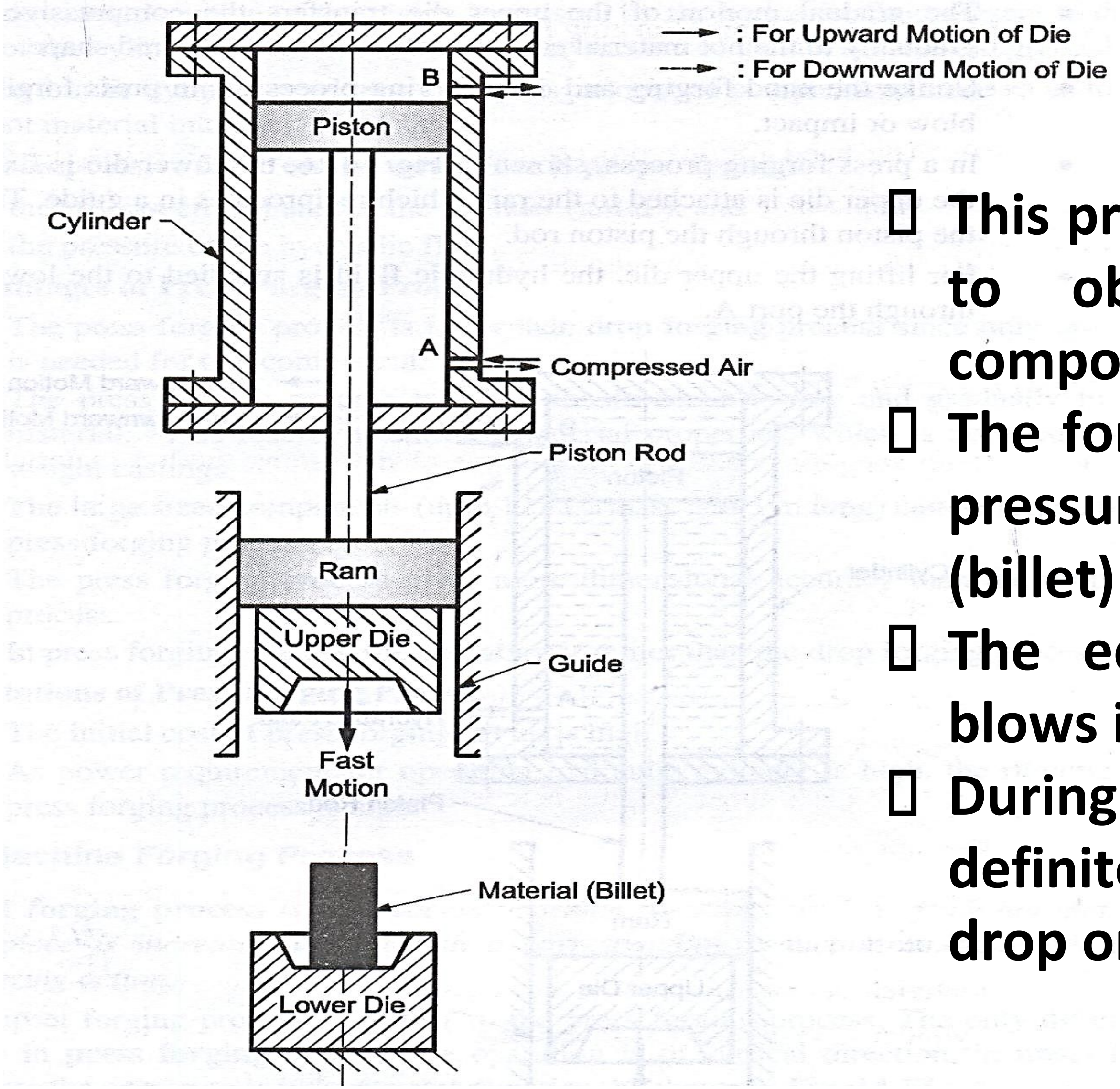


Fig. Hand forging

- It is the process of deforming the hot material into the required shape by the application of repeated blows of hammer held in hand.
- This process is only used for making simple components of small size.

Types of forging

2. Drop forging



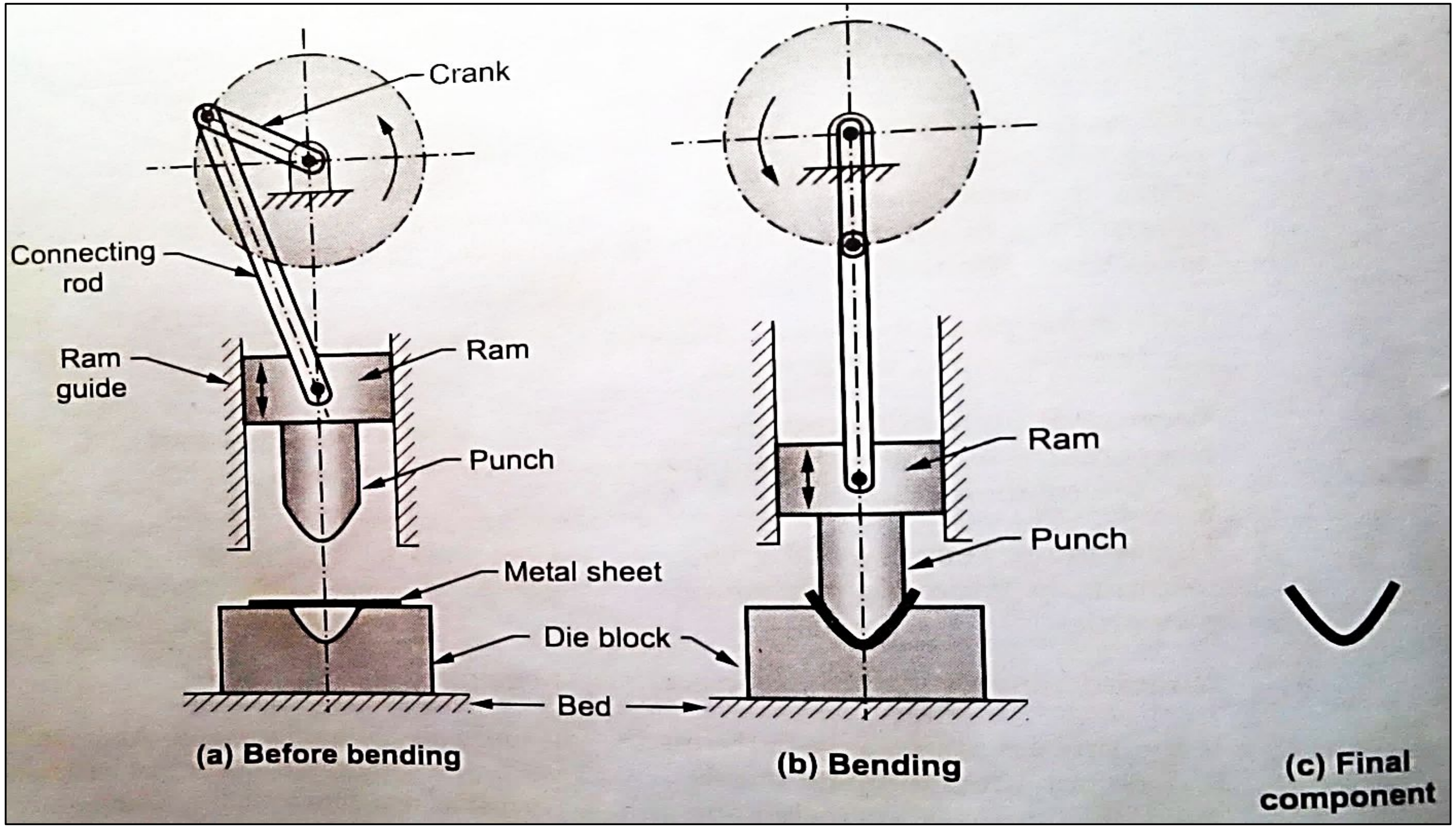
- This process utilizes closed impression die to obtain required shape of the components.
- The forging is produced by the impact or pressure which forces the hot metal (billet) to form the shape of the dies.
- The equipment used for applying the blows is called as drop hammer.
- During the process, the ram is raised to a definite height and then it is allowed to drop or fall freely under its own weight.

Applications of forging

- Manufacturing of car axles
- Connecting rods
- Crankshafts
- Leaf springs
- Crane hooks
- Jet engine blades
- Rail-road equipments
- Agricultural machinery etc.

Sheet metal working

- Sheet metal working or press working is a chipless manufacturing process by which various components are produced from sheet metal.
- Thickness of metal sheet varies from 0.1-10 mm.



Sheet metal working operations

Sheet metal working

Metal cutting operations

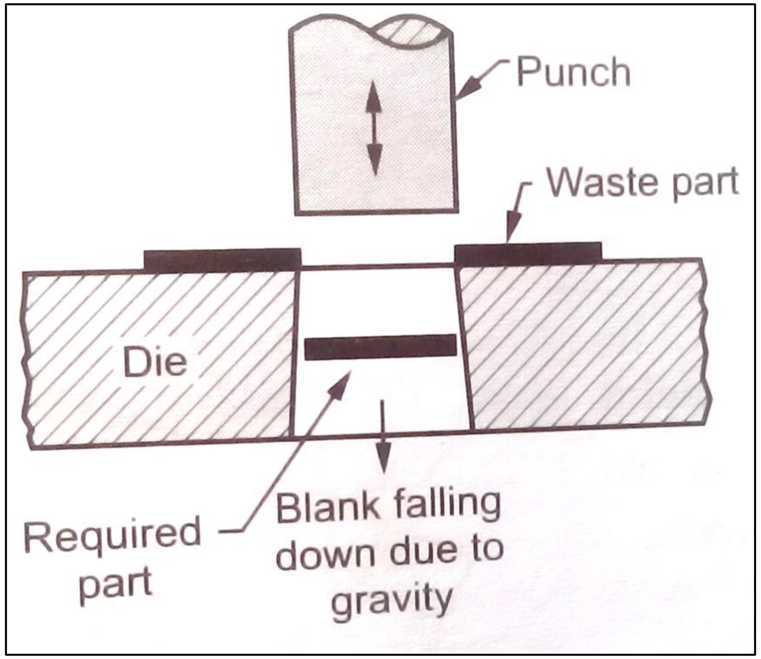
1. Blanking
2. Punching
3. Notching
4. Perforating
5. Slitting
6. Lancing
7. shaving

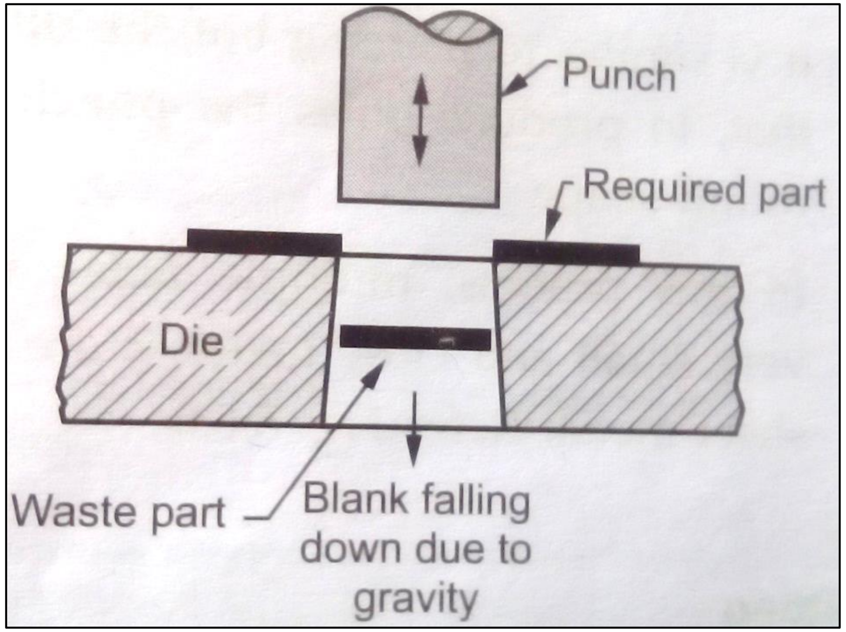
Metal forming operations

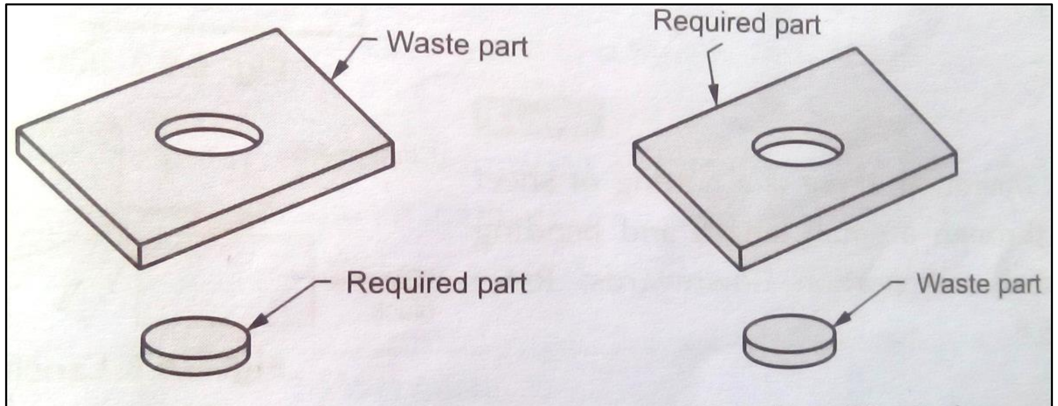
1. Bending
2. Drawing
3. Embossing
4. Forming
5. Coining

Sheet metal working operations

- **Blanking**
- **Punching (piercing)**





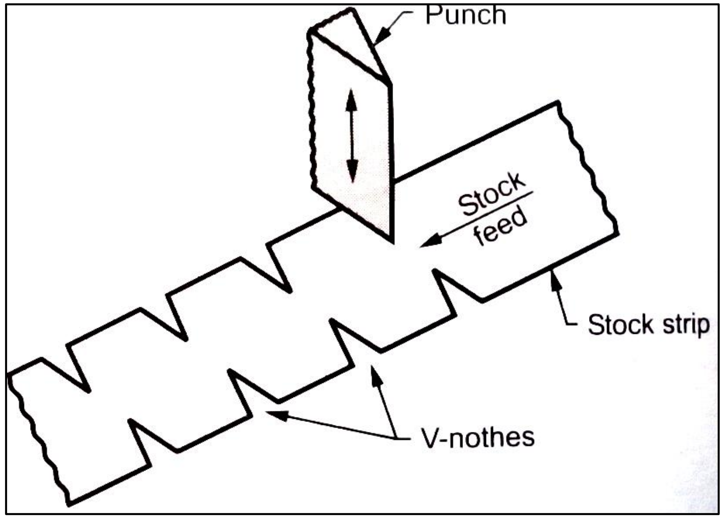


(a) Blanking (b) Punching (Pirecing)

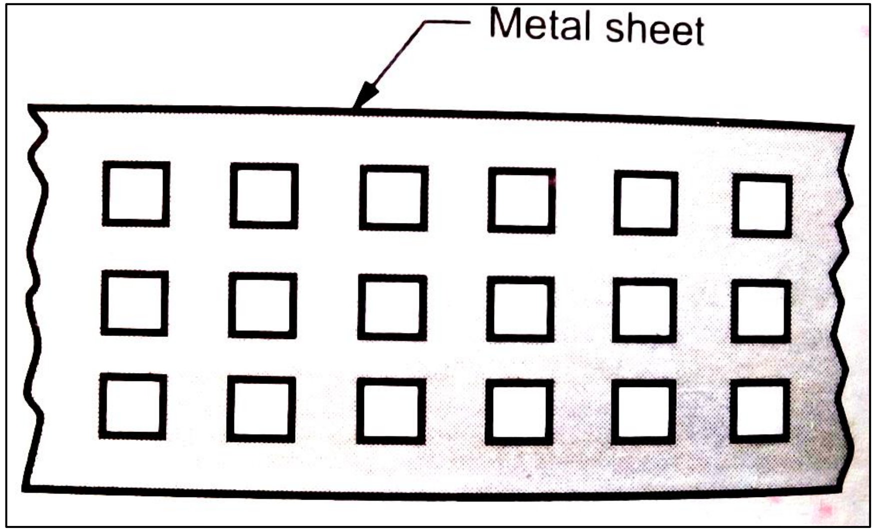
Fig. Blanking and punching

Sheet metal working operations

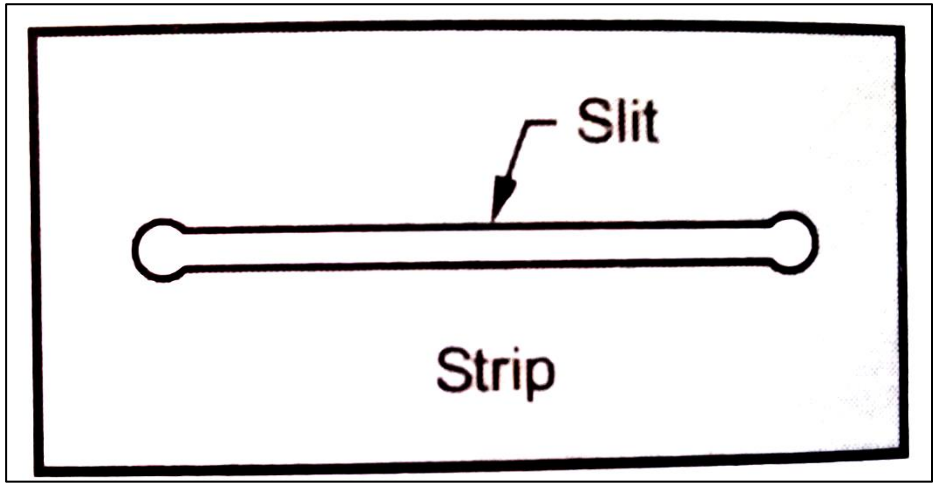
Notching



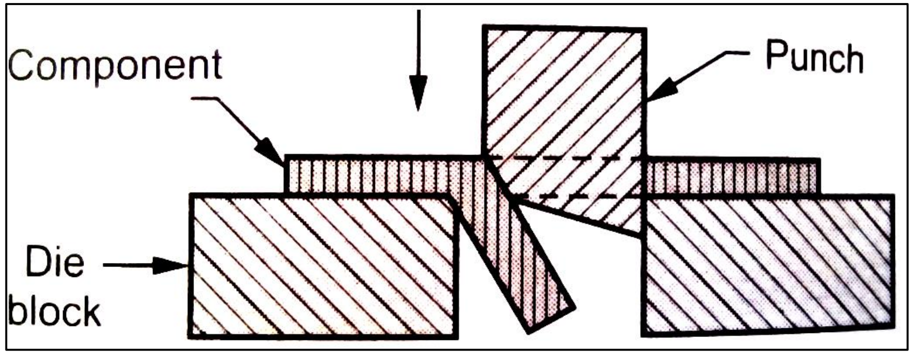
Perforating



Slitting

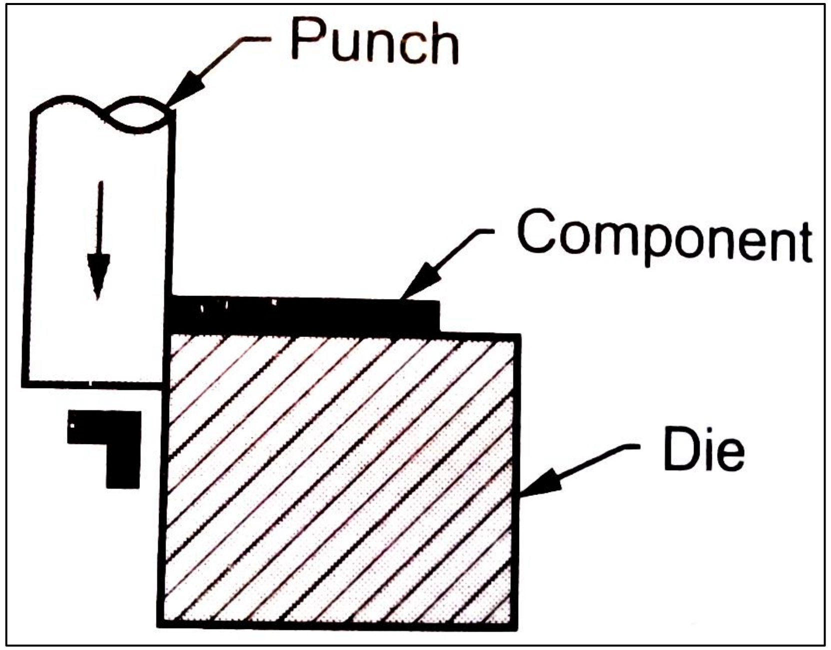


Lancing

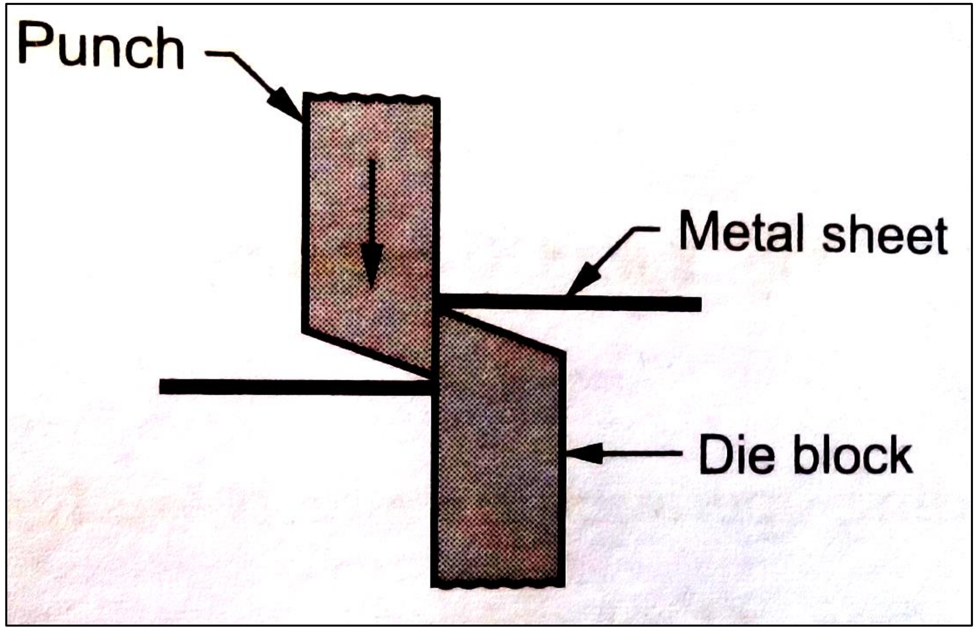


Sheet metal working operations

- **Shaving**



- **Shearing**



Sheet metal working operations

▯ Bending

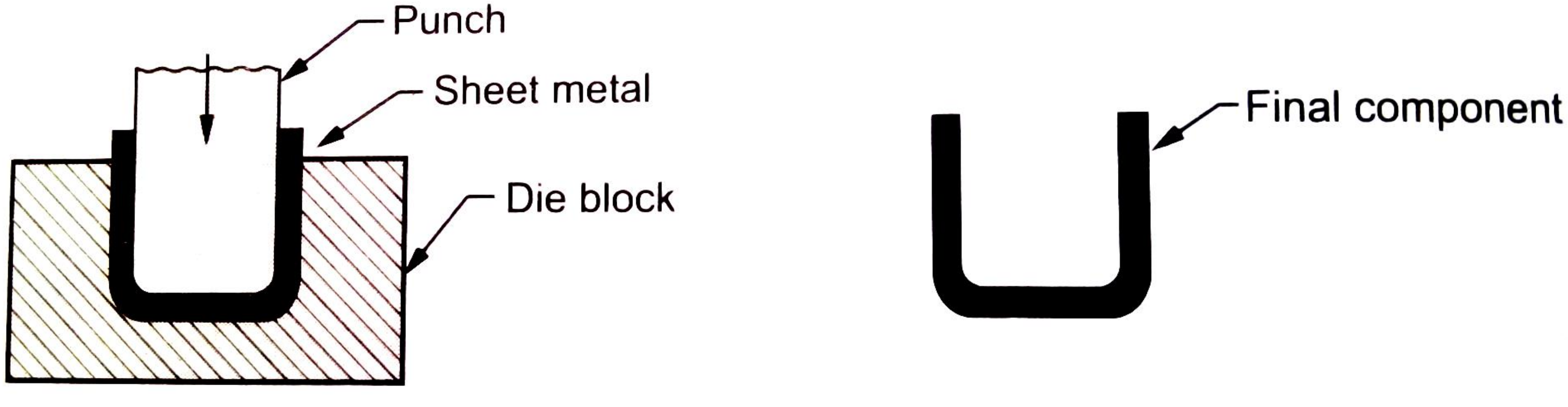


Fig. 5.6.11 U-bending

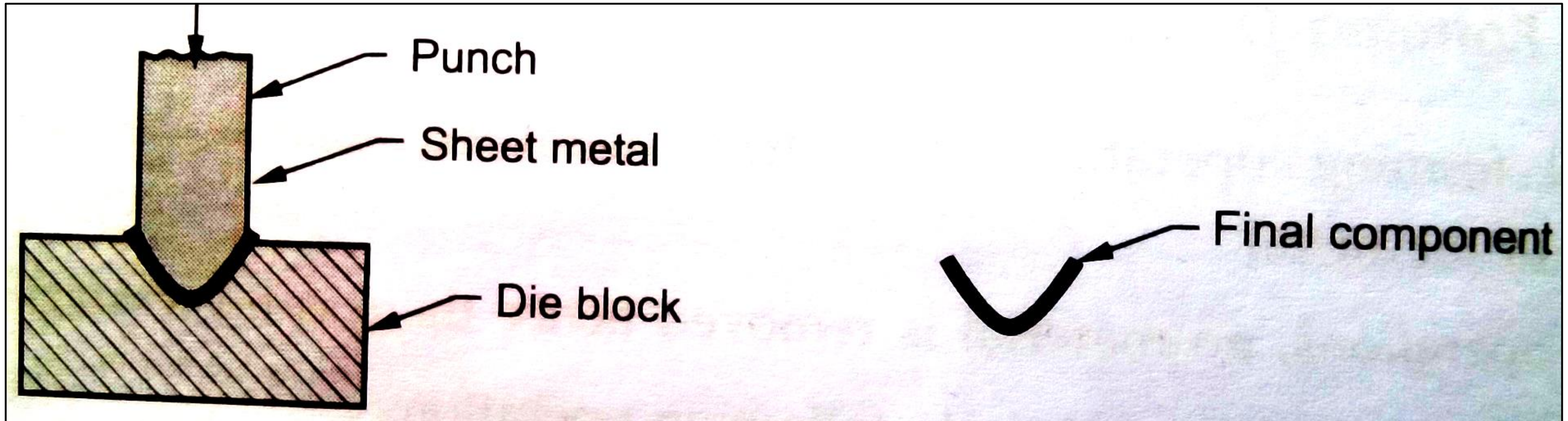


Fig. 5.6.12 V-bending

Sheet metal working operations

Bending

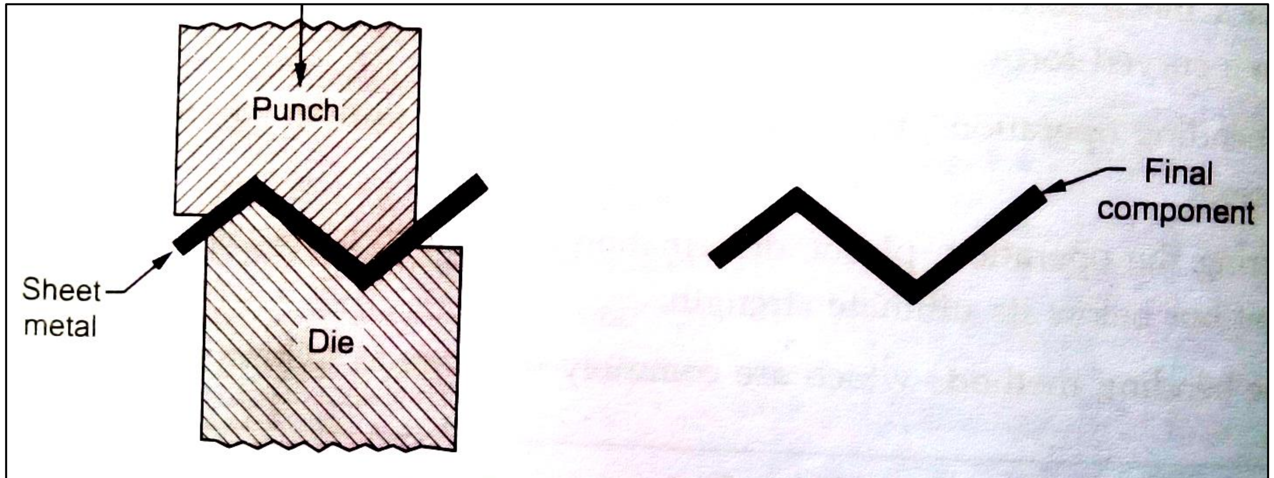


Fig. 5.6.13 Angle bending

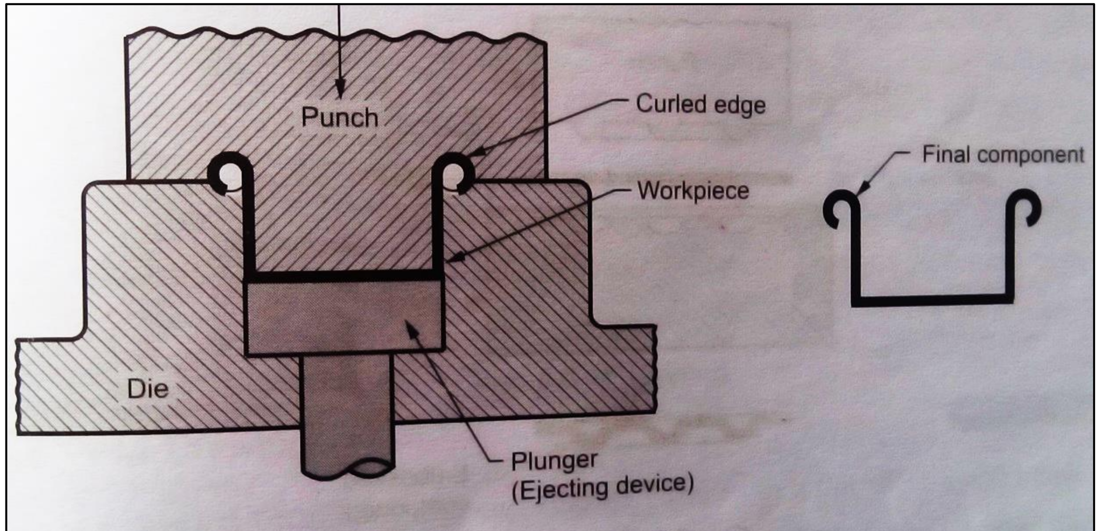


Fig. 5.6.14 Curling

Sheet metal working operations

Drawing

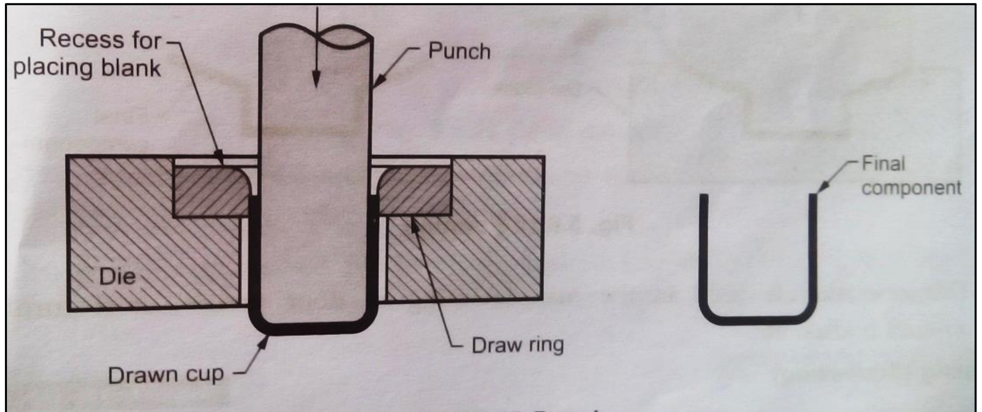


Fig. 5.6.15 Drawing

Embossing

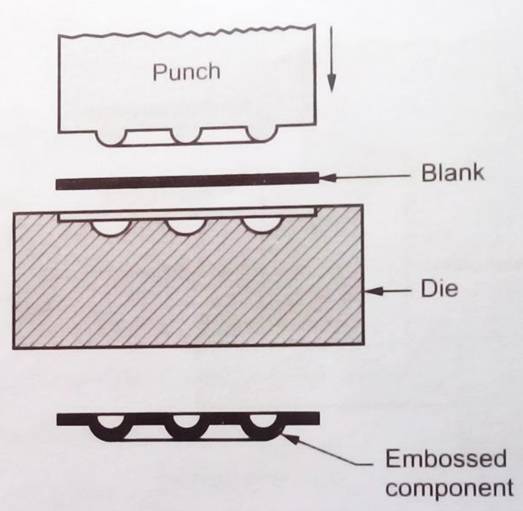


Fig. 5.6.16 Embossing

Forming

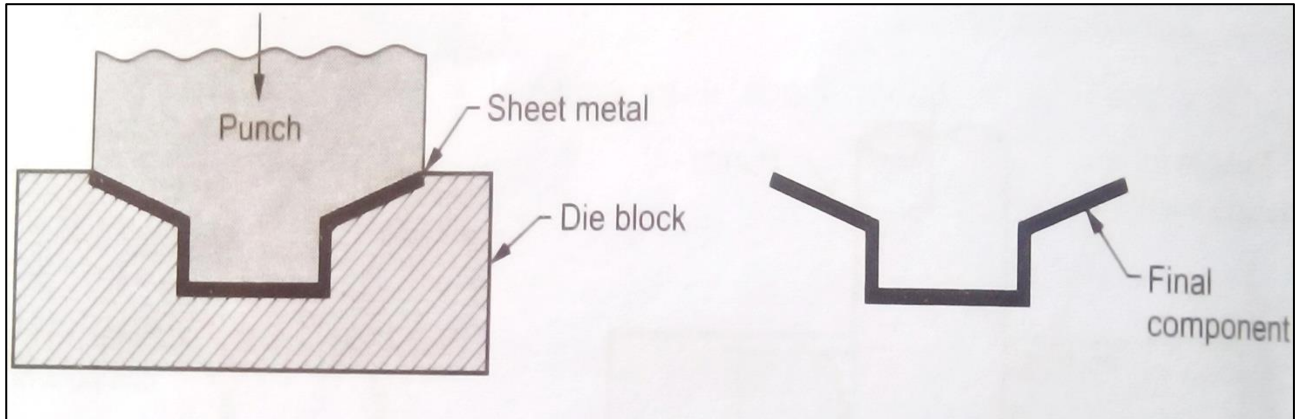


Fig. 5.6.17 Forming

Sheet metal working operations

Coining

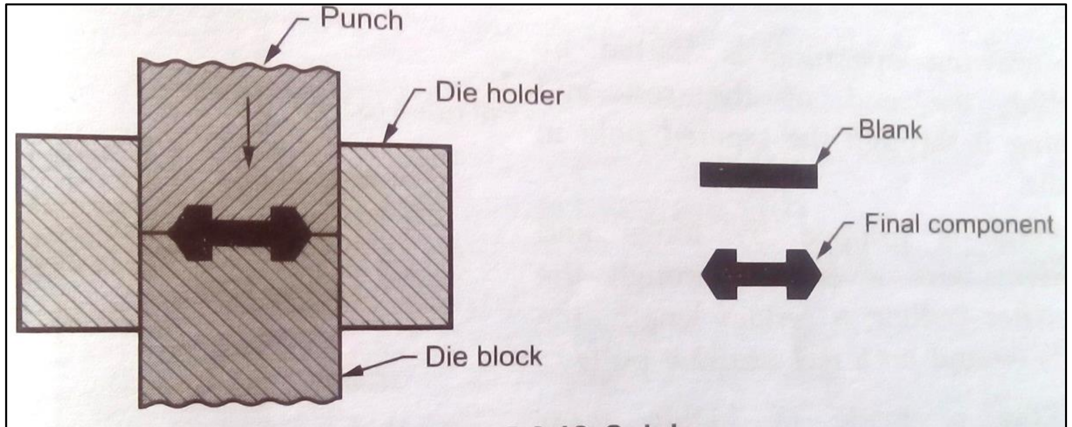


Fig. 5.6.18 Coining

Wire drawing

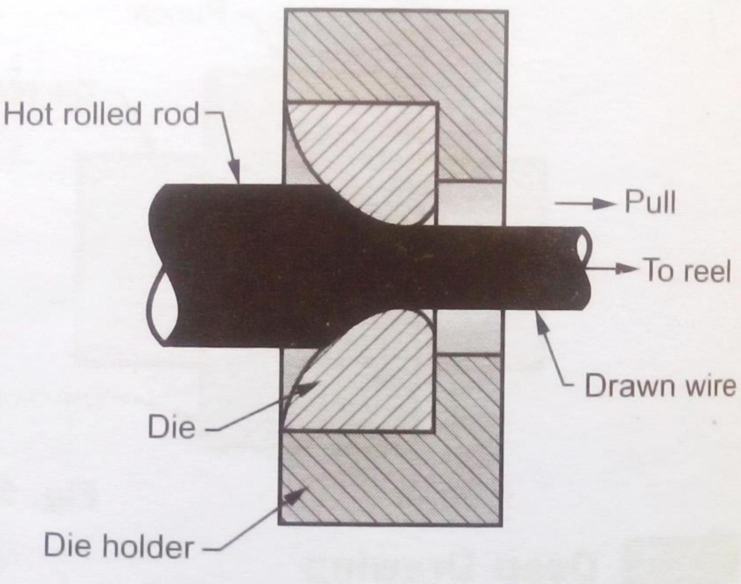


Fig. 5.6.20 Wire drawing

Deep drawing

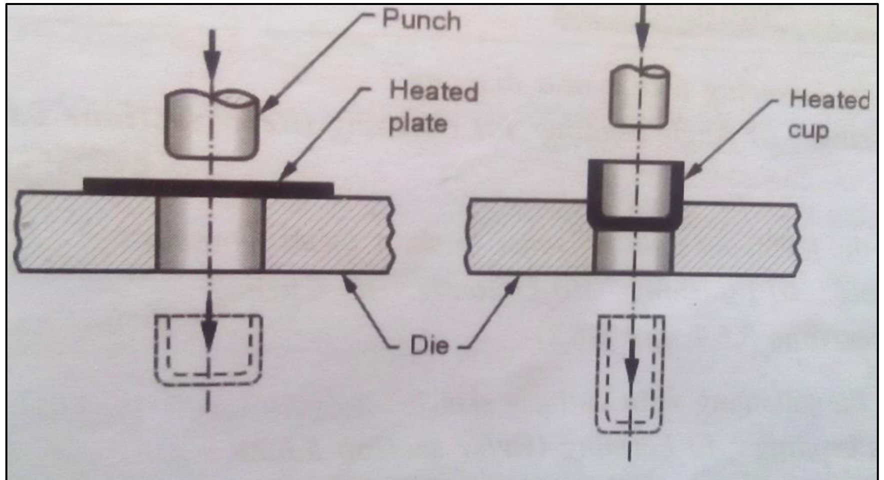


Fig. 5.6.19 Deep drawing

Metal joining processes

- These processes are used to join two or more metal parts.
- These processes are applied in general fabrication work for steam or water-tight joints.
- Temporary or permanent type of fastening is also enabled by these processes.
- The commonly used joining processes are
  - Welding
  - Soldering
  - Brazing
  - Adhesive bonding

Welding process

- It is joining process used for various metals and their alloys.
- In these processes, two or more pieces of metals are joined by application of either heat or pressure or both.
- In plastic/pressure welding, the metal pieces to be joined are heated to a plastic state and then forced together by external pressure.
- In fusion/non-pressure welding, the metal pieces to be joined are heated to molten state and allowed to solidify.

Advantages and disadvantages of welding

Advantages

- A large number of metals or alloys, both similar and dissimilar can be joined by welding.
- It can be mechanized.
- Strength of welded joint is more.
- It provides leak-proof joint.
- Welding equipments are not very costly.

Disadvantages

- It gives harmful radiations, fumes and spatter.
- Welding results in residual stresses and distortion of the workpiece.
- Heat generated in welding process produces metallurgical changes hence, the structure of welded joint is different than that of parent metal.

Applications of welding process

- Aircraft construction (welding of engine parts, turbine frames, ducts, etc.)
- Rail-road equipments (Air receiver, engine, front and rear hoods, etc.)
- Pipings and pipelines (open pipe joints, oil and gas pipelines, etc.)
- Pressure vessels and tanks
- Buildings and bridges (column base plates, erection of structures, etc.)
- Automobile parts (trucks, buses, cars, bike parts, etc.)
- Machine parts (frames, beds, tools, dies, etc.)

Arc welding process

- It is a fusion welding process in which welding heat is obtained from an electric arc between an electrode and the workpiece.

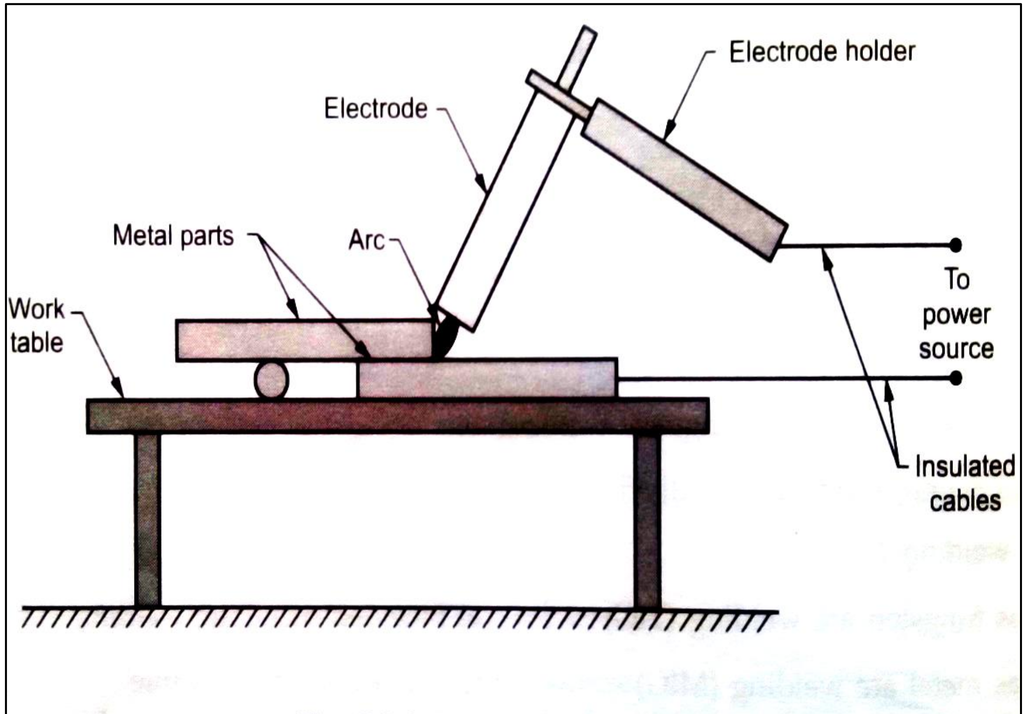


Fig. 5.9.1 Arc welding principle

- The temperature produced at the centre of an arc is 6000 to 7000^{0}C.
- In this, the base metal is melted by the temperature of the arc, forming a pool of molten metal.
- Either A. C. or D. C. supply is used.
- The electrodes used in the process are of two types i.e. bare and coated electrodes.
- The length of electrodes varies from 250 mm to 450 mm whereas, diameter varies from 1.6-9 mm.

Shielded metal arc welding (SMAW)

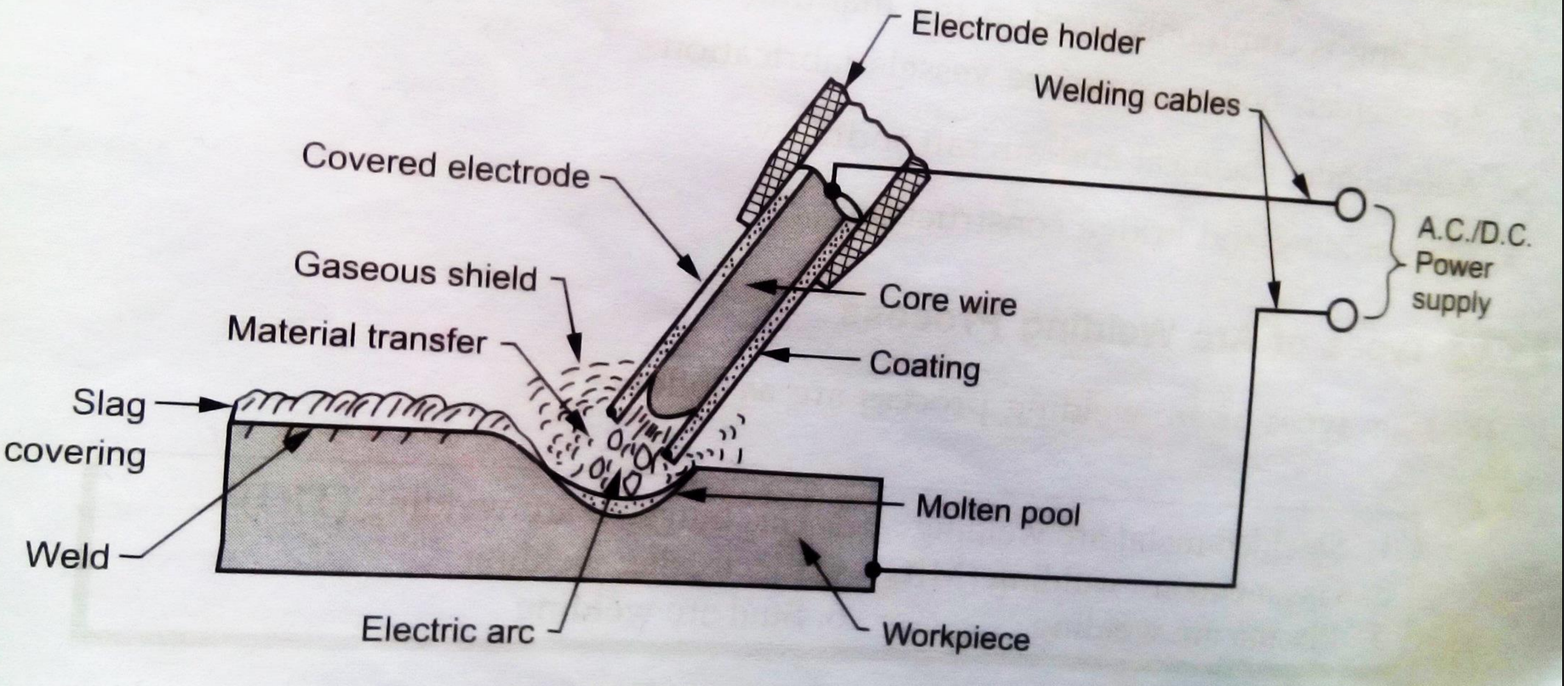
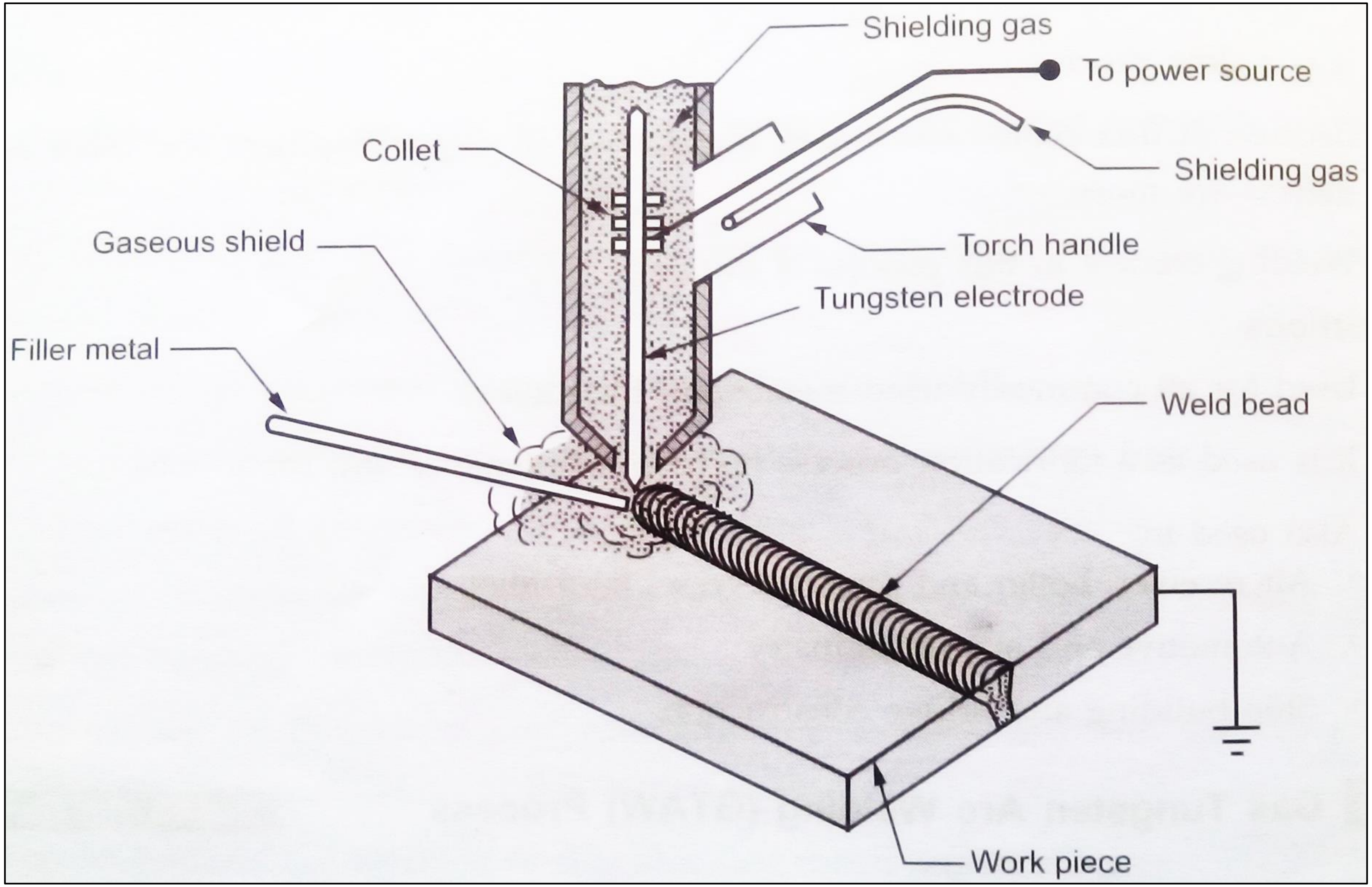


Fig. 5.9.2 Shielded metal arc welding (SMAW)

Tungsten Inert Gas (TIG) Welding



Soldering

- It is a process in which two or more metal items are joined together by melting and flowing a filler metal into the joint.
- The filler metal used in the process is called as solder which have relatively low melting point.
- In this process, the parts to be joined are heated which causes solder to melt and drawn into the joint by capillary action.
- In this process, base metals are not melted like welding.

- Solder material is mixture of lead and tin.

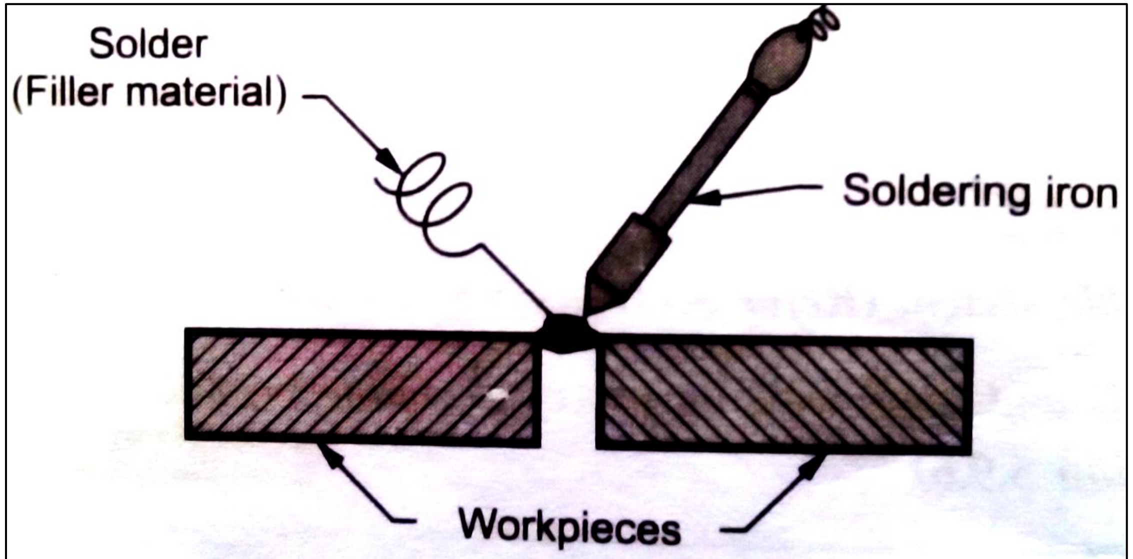


Fig. 5.10.2 Soldering process

Advantages and disadvantages- soldering

Advantages

- Variety of dissimilar metals can be joined.
- It is simple and low cost method.
- Workpieces of different thickness can also be joined.
- It is low temperature process hence, there is no change in properties of metals.

Disadvantages

- Soldered joints are not stronger.
- Soldered joint has limited service at elevated temperatures.
- Corrosion resistance of soldered joint is less.

Applications

- In assembly of electronic components
- Joints in sheet metal objects like food cans, roof flashing, iron, etc.
- Joints in wires
- Assembly of jewellery components

Brazing

- It is the metal joining process in which a filler metal is heated and distributed between two or more close fitting parts by capillary action.
- In brazing, metallic parts are joined by a non-ferrous filler metal or alloy.
- It is similar to soldering, except the temperature used to melt the filler metal is above 450^0C.
- The filler metals used in the process are copper and silver based alloys.

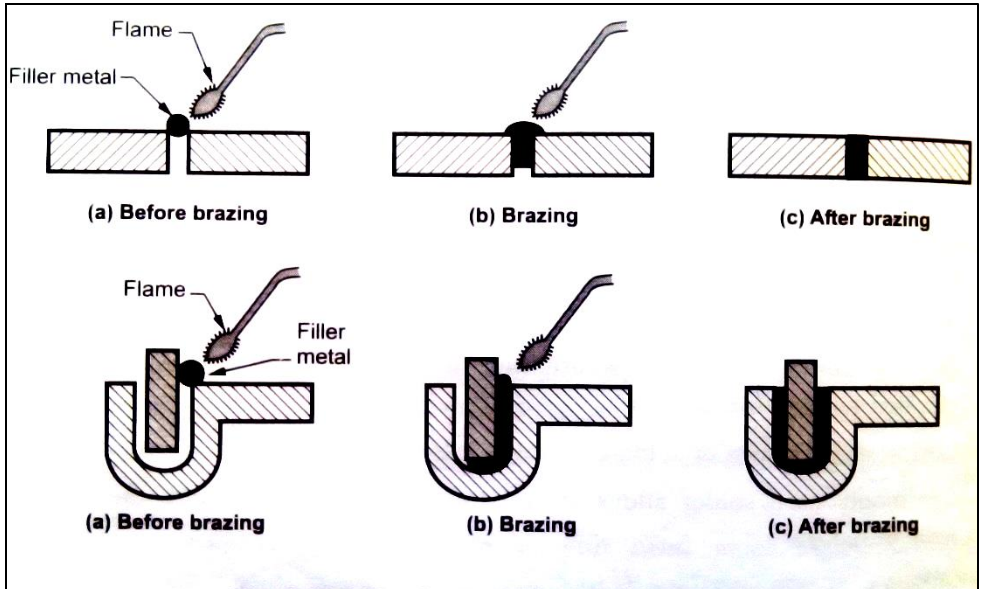


Fig. 5.11.1 Brazing of different components

Advantages, disadvantages of Brazing

Advantages

- Dissimilar metals and non-metals can be brazed.
- Due to uniform heating of parts, it produces less thermal distortion than the welding process.
- Complicated components can be brazed at low cost.
- It produces clean joint.

Disadvantages

- Strength of brazed joints is less as compared to welded joints.
- It can be damaged under high service temperatures.
- Filler metals used in the process are costly.

Applications

- Brazing can join non-metals to metals, porous metal components, dissimilar metals
- Joining of electrical equipments, pipes, heat exchangers, etc.
- Joining of carbide tool tips, steam turbine blades, etc.

Soldering and brazing-comparison

Sr. No.	Parameter	Soldering	Brazing
1.	Filler metal	Lead and tin	Alloys of copper, silver and nickel.
2.	Temperature	Filler material has MP below 427^0C.	Filler material has MP above 427^0C.
3.	Strength of joint	Weak	Strong
4.	Application	Used for carbon, low alloy steel, cast iron, stainless steel, Cu and alloys, Al and alloys.	Used for cast iron, steels, Cu and alloys, Al and alloys, Mg and alloys, etc.
5.	Corrosion resistance	Less	More
6.	Joint profile	Small gap between the joints	Smooth joint

Advanced manufacturing trends

Industry 4.0

Industry 4.0 comprises many things, but is generally considered to involve the use of **big data and automation** to create efficiencies in processes. A full implementation of Industry 4.0 equipment and practices is a huge capital commitment, but these technologies will slowly make their way into more and more facilities, forcing others to follow in order to remain competitive.

More helping hands from robots

Robots in the manufacturing setting are nothing new – but as they become smarter, safer and more mobile, the industry will see their use grow. Inventory, assembly and machining become increasingly efficient as robots are able to do more and provide greater benefit to their human co-workers.

Wearable tech

Following the shift to handhelds, the next step in on-demand data and information will be wearable devices. Smart watches, headsets with heads-up displays and other wearables will provide critical data more quickly and unobtrusively than ever.

- **VR and AR**
  Virtual reality and augmented reality are finally beginning to realize the promise they have advertised for years. These technologies will impact areas like training and maintenance in various ways, including:
- "**Hands-on" training** — Training and testing can be carried out in a VR environment, creating a much safer and lower-risk process.
- **Remote maintenance** — Much like arthroscopic surgery done remotely via camera, augmented reality will allow for maintenance technicians to carry out procedures from a remote location, making great strides toward closing the skills gap and improving efficiency.
- **Greater control over processes** — Both VR and AR can yield greater efficiency, improved accuracy and more targeted, predictive maintenance by providing more visibility and insight into processes as they occur.