MANUFACTURING PROCESSES

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Manufacturing processes

- Manufacturing is the application of mechanical/chemical/electrical energy to alter the geometry, properties and appearance of a given starting material to make parts/products.
- Classification of Manufacturing Processes
- Casting Processes
- Molten metal like cast iron, copper etc is poured into the mould of desired shape and allowed to solidify.
- Die casting
- Centrifugal casting
- Permanent mould casting
- Forming processes
- A deformation process, a metal in hot/cold condition is deformed into desired shape.
  - **Rolling**
  - **Forging**
  - **Extrusion**
  - **Wire drawing**
  - **Bending**
  - **Shearing**

Manufacturing processes contd…

- Machining Processes
- Material removed by means of a cutting tool to give the desired shape and size to the component.
  - **Turning**
  - **Drilling**
  - **Milling**
  - **Grinding**
  - **Shaping**
- Joining Processes
- Used for joining different machine components made up of same/different materials
  - **Welding**
  - **Soldering**
  - **Brazing**

General Purpose Machine Tools

General classification of machine tools

- **Conventional or traditional machine tools** like Lathes, Milling machines, etc. are used more widely for faster material removal in order to produce desired shape and size of the workpiece.
- **Non-conventional or non-traditional machine tools:** like EDM, ECM, USM, etc. which remove material from exotic materials slowly by electro-physical, electro-chemical processes.
- **Modern numerical and computer controlled machine tools:** Like CNC lathe, CNC milling

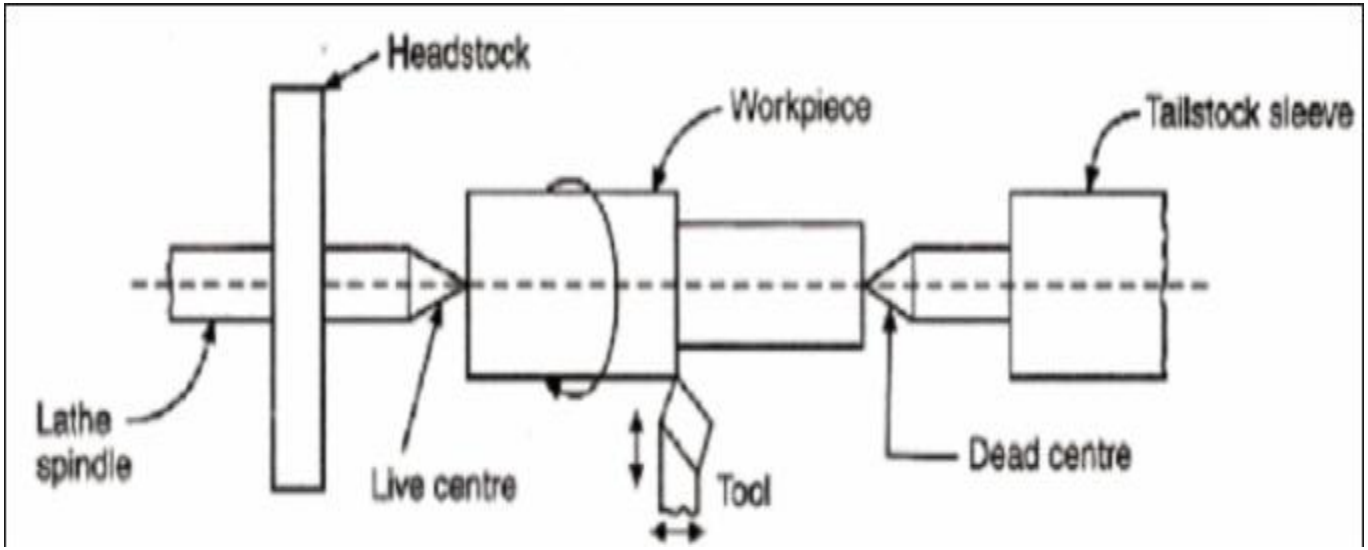
General Purpose Machine Tools

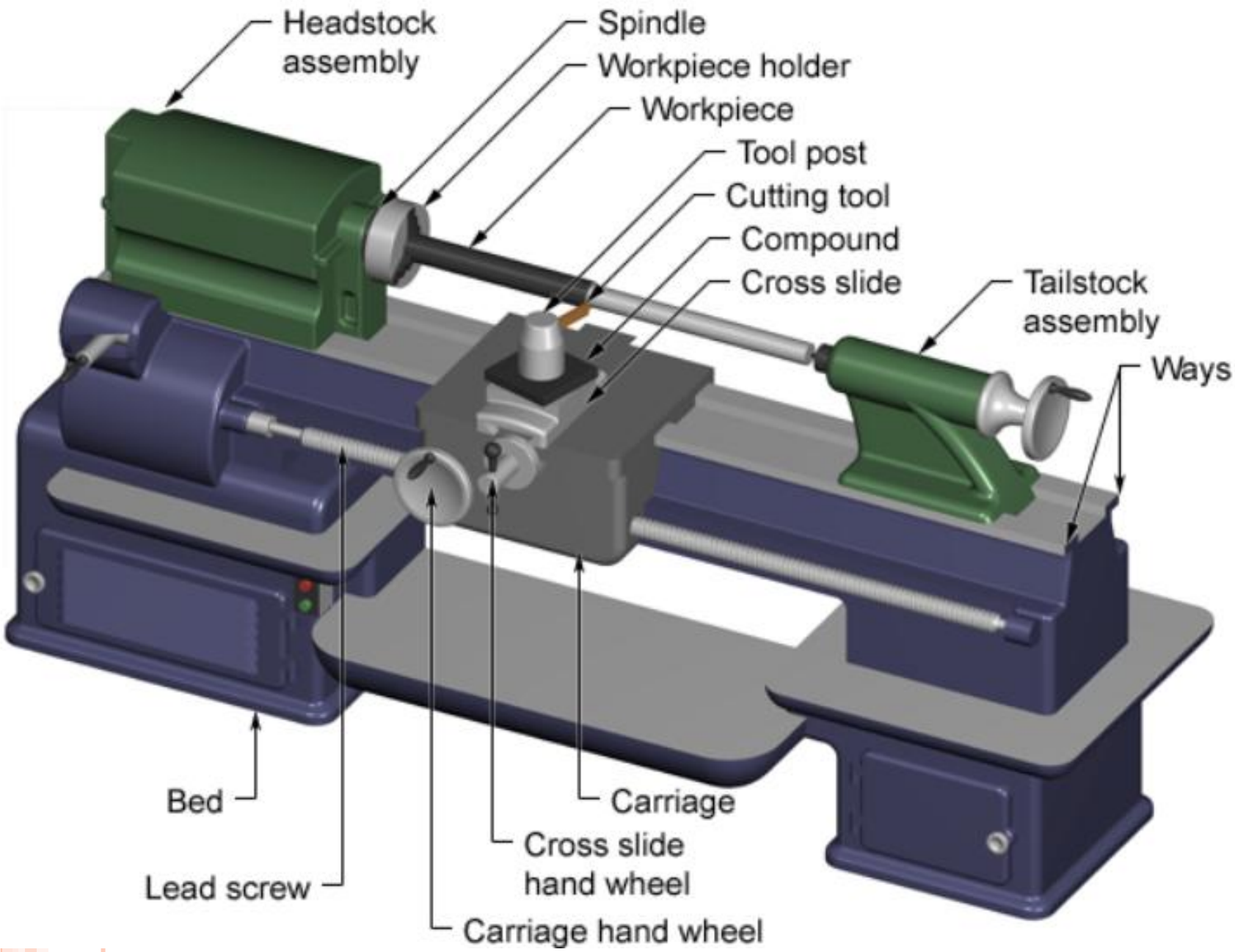
The basic machine tools which are commonly used for general purposes are:

1. Lathes
2. Drilling machines
3. Shaping machines
4. Planning machines
5. Slotting machines
6. Milling machines
7. Boring machines
8. Hobbing machines
9. Gear shaping machines
10. Grinding machine

WORKING PRINCIPLE OF CENTRE LATHE

- **Lathe is a machine, which removes the metal from a work piece in the form of chips to produce the required shape &size**
- **The work is held firmly and rotated about its axis.**
- **Single point cutting tool is advanced along the line of cut to produce the desired shape on the work.**
- **The tool may move parallel/normal/at an angle to the axis of rotation.**




Headstock assembly
Spindle
Workpiece holder
Workpiece
Tool post
Cutting tool
Compound
Cross slide
Tailstock assembly
Ways
Bed
Lead screw
Carriage hand wheel
Cross slide hand wheel
Carriage

Parts of a centre lathe

- BED
  - Base/foundation of the Lathe
  - Heavy rigid casting made in one piece
  - Holds/supports all parts like head stock, tail stock and carriage
  - Top of bed has guide ways for carriage and tail stock.
- HEAD STOCK
  - Hollow in section and fixed to the left end of the bed
  - Consists of spindle and driving arrangements
  - Lathe receives power from the head stock
  - Spindle used to attach various workholding devices like chuck, live centre

Parts of a centre lathe contd…

- TAIL STOCK
  - Fitted on the Lathe bed opposite to the head stock ie on the right side
  - To hold a centre (called dead centre) when turning between centres ie. acts as a support at the end of the long work pieces
  - Also used for supporting and feeding drills, reamers etc.
- CARRIAGE
  - It is fit in Lathe bed guideways
  - Can move along the guideways
  - Movement provided through a gear meshing in a rack fastened to Bed

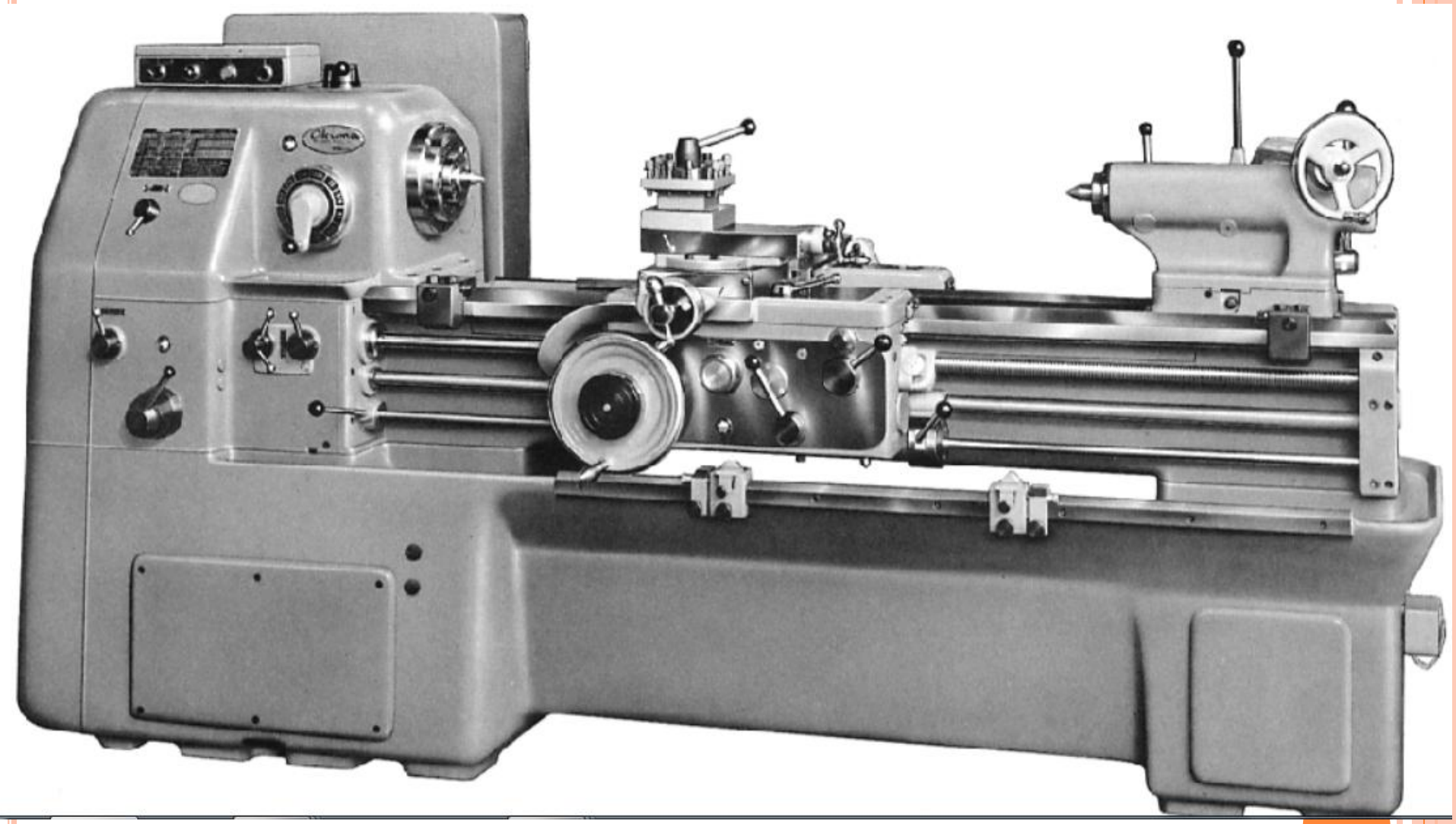
Parts of a centre lathe contd…

- Carriage supports cross slide, compound slide and tool post
- The driving mechanism is fitted in front of the carriage, called apron
- Carriage provided with some form of locking device to lock it to the bed
- Carriage can be moved to provided feed parallel to the work ie. Longitudinal feed
- Cross slide moved manually to provide cross movement for the tool
- Compound slide can be swiveled to an angel to provide angular feed of tool

Parts of a centre lathe contd…

- FEED MECHANISM
  - Employed to impart various feeds to the tool
  - Feed mechanism consists of Fead gear box, Feed rod and Lead screw
  - Feed gear box consists of number of different size gears to change the rate of feed etc
  - Feed rod is a long shaft extending from feed box. It is used to move the carriage, cross slide
  - Lead screw is a long threaded shaft brought into operation only for thread cutting operation. At all other times it remains disengaged from the gear box

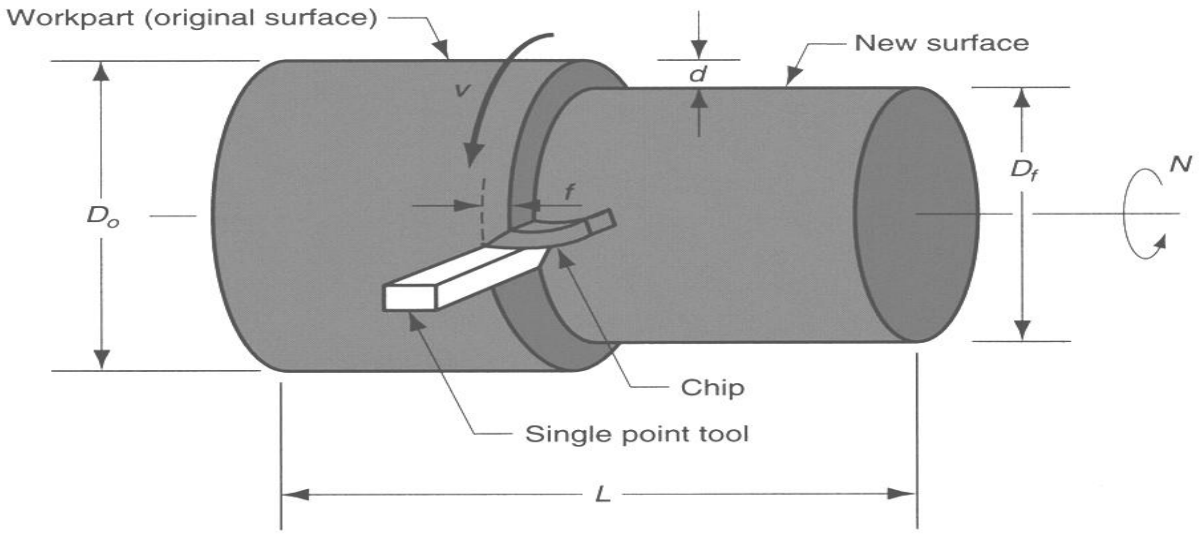
LATHE



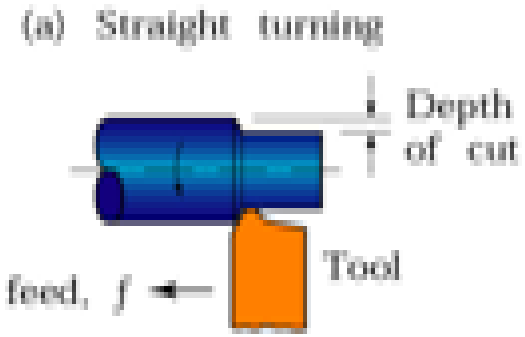
Lathe operations

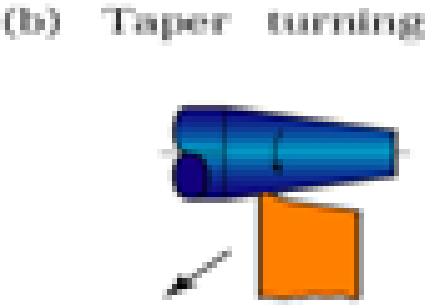
- **Turning:** to produce cylindrical surface
- **Facing**: to produce a flat surface at the end of the part or for making face grooves.
- **Boring:** to enlarge a hole or cylindrical cavity made by a previous process or to produce circular internal grooves.
- **Drilling:** to produce a hole by fixing a drill in the tailstock
- **Threading:** to produce external or internal threads
- **Knurling:** to produce a regularly shaped roughness on cylindrical surfaces

Lathe operations
Turning



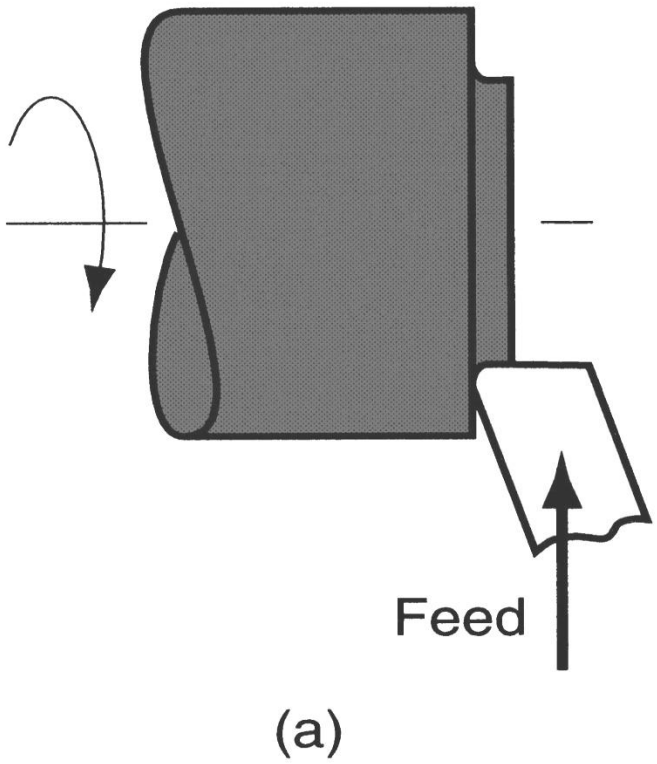
Turning means to remove extra material from the workpiece to produce a cylindrical/conical surface





FACING

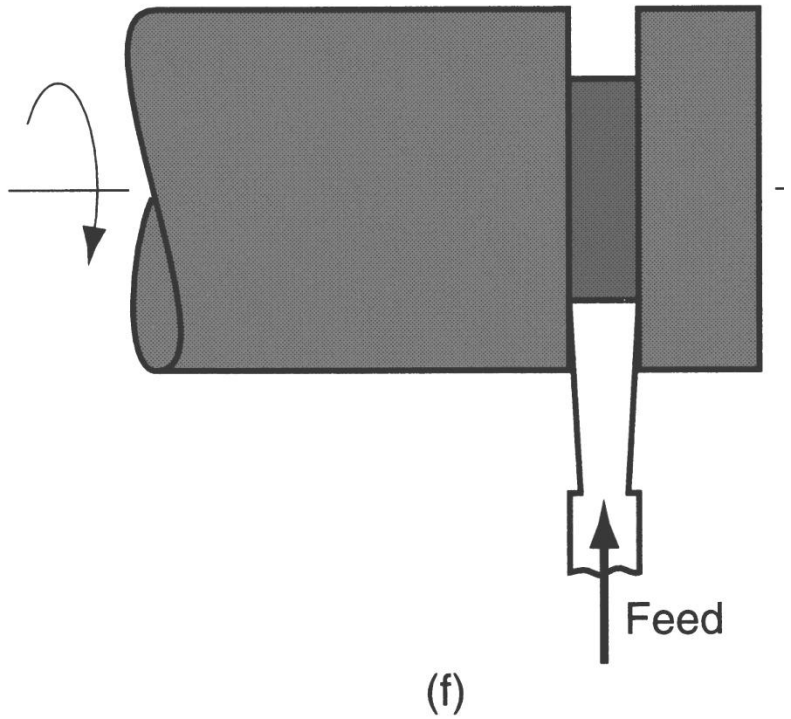
- Machining the ends of a workpiece to produce flat surface.
- Also used to cut the work to the required length
- Tool fed perpendicular to the axis of rotation of the workpiece
- A properly ground facing tool is mounted in the tool holder on the tool post.



(a)

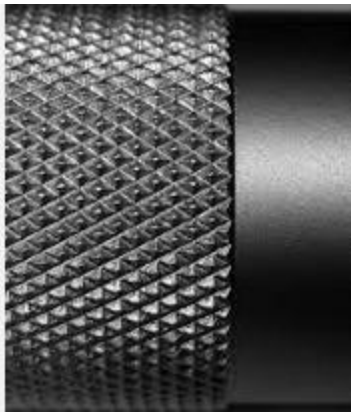
Cont rolle d

Parting (Cutoff) / Grooving



- Reducing the diameter of the work piece over a very narrow surface
- Grooving tool of required shape is fed straight into the work

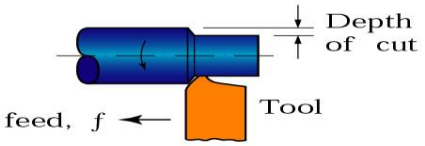
KNURLING



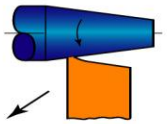
- Knurling forms raised diamond shaped or straight line projections on a work piece.
- It is used on some types of screws, tools and machine handles to provide a non slip gripping surface or simply to improve appearance.

Lathe operations

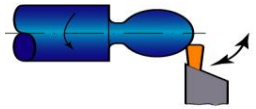
(a) Straight turning



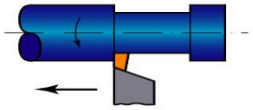
(b) Taper turning



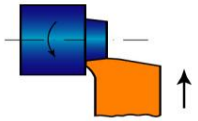
(c) Profiling



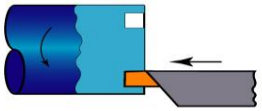
(d) Turning and external grooving



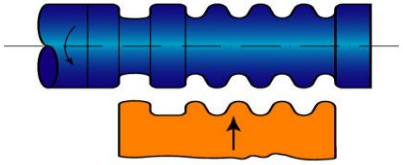
(e) Facing



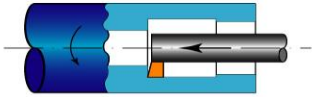
(f) Face grooving



(g) Cutting with a form tool

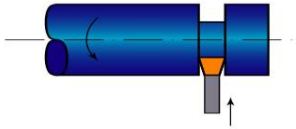


(h) Boring and internal grooving

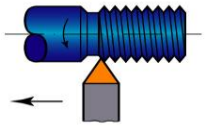


(i) Drilling

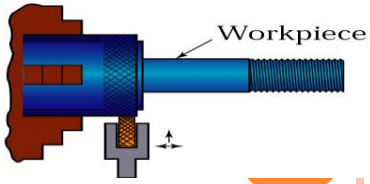
(j) Cutting off



(k) Threading



(l) Knurling



Drilling machine

- Drilling is the operation of producing a cylindrical hole.
- The hole is generated by the rotating edge of a cutting tool known as the drill.
- Sensitive drilling machine
- It is a high speed machine used for drilling small holes upto 15 mm diameter. Workpiece firmly clamped on the worktable.
- Principal of operation:
- Workpiece is stationary. The multipoint cutting tool (drill) is fitted into the spindle.
- The rotating drill made up of harder material than that of the workpiece is fed against the stationery work piece by hand feed or power feed. Material removed in the form of chips producing cylindrical holes.

Sensitive drilling machine

- Parts and working

Base

- Made up of cast iron and is bolted to the floor
- Has slotted grooves for securing the work holding device
- Is quite heavy and provides stability to the machine and a rigid support to the column.

Column

- Cylindrical post, supports the table, spindle head, the motor and the drilling mechanism.
- Their position is adjustable on the column

Table

- Table attached to the column
- Its position is adjustable vertically along the column or radially about the column
- Table may be circular or rectangular in shape and is provided with slots for securing workpiece or vice on it

Sensitive drilling machine

Spindle Head

- Spindle head contains mechanism to hold the cutting tool to revolve it and advance it into the work

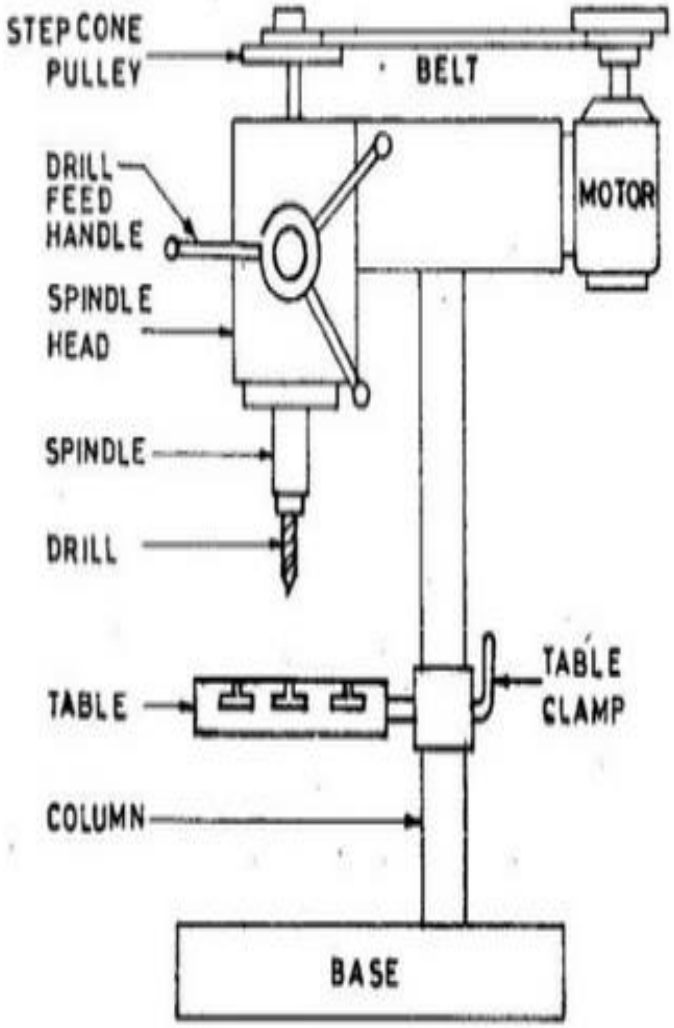
Driving mechanism

- Electric motor provides the power to the spindle head through a gear box
- Usually 3 to 10 speeds are provided range being from 50 to 2000 rpm

(1) Sensitive Drilling Machine

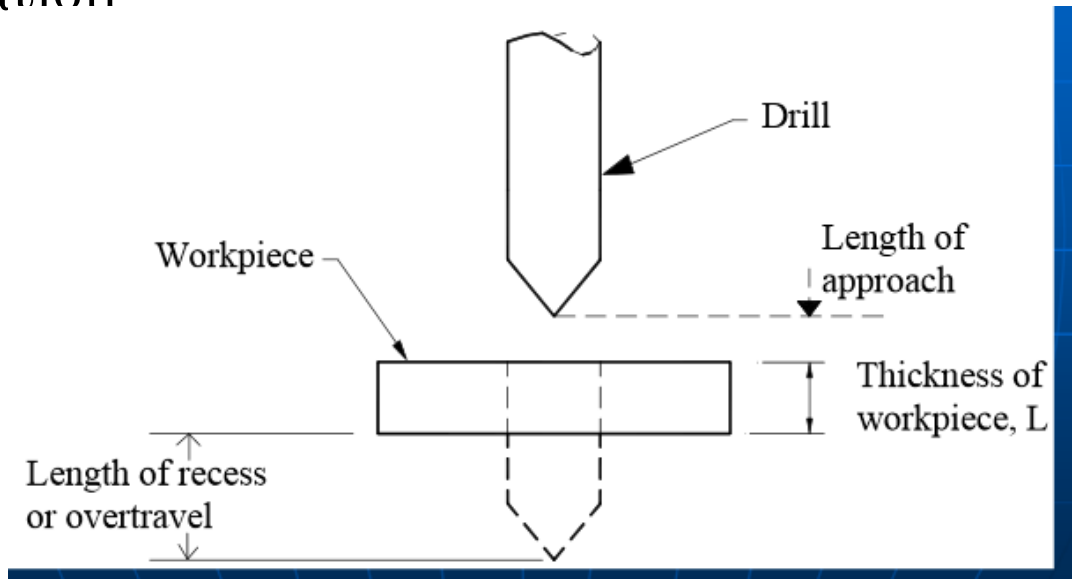
Drill holes from 1.5 to 15mm

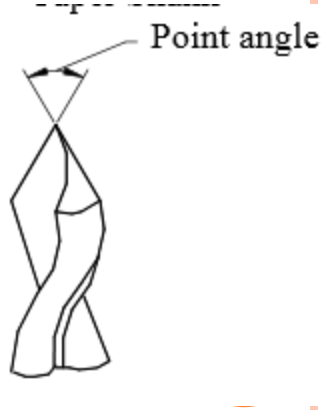
Operator senses the cutting action so sensitive drilling machine



Drilling machine operations

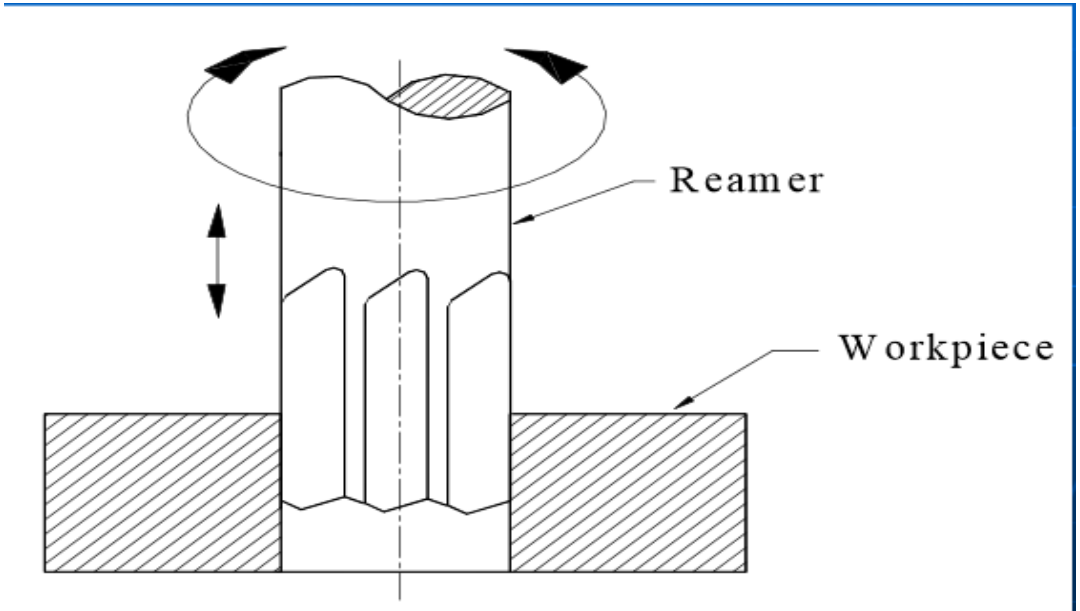
- Drilling
- Operation of producing cylindrical hole by removing metal by the rotating edge of a cutting tool called drill
- Before drilling, centre of the hole located by drawing two lines at right angles to each other
- An indentation produced at the centre by the centre punch
- Hole generated is rough. It may need some finishing operation





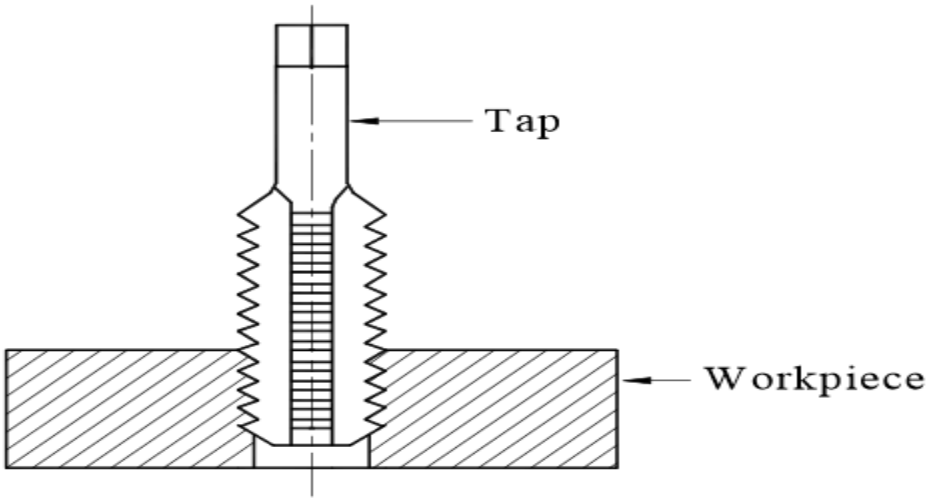
Drilling machine operations contd…

- Reaming
- An accurate way of sizing and finishing an already drilled hole
- To perform the reaming operation the original hole is drilled slightly undersize.
- It is a slow process as compared to drilling and automatic feed may be employed
- Tool used is called a Reamer, having multiple cutting edges
- Reamer can not originate a hole. It follows the path of already drilled hole
- Material removed is around 0.375 mm



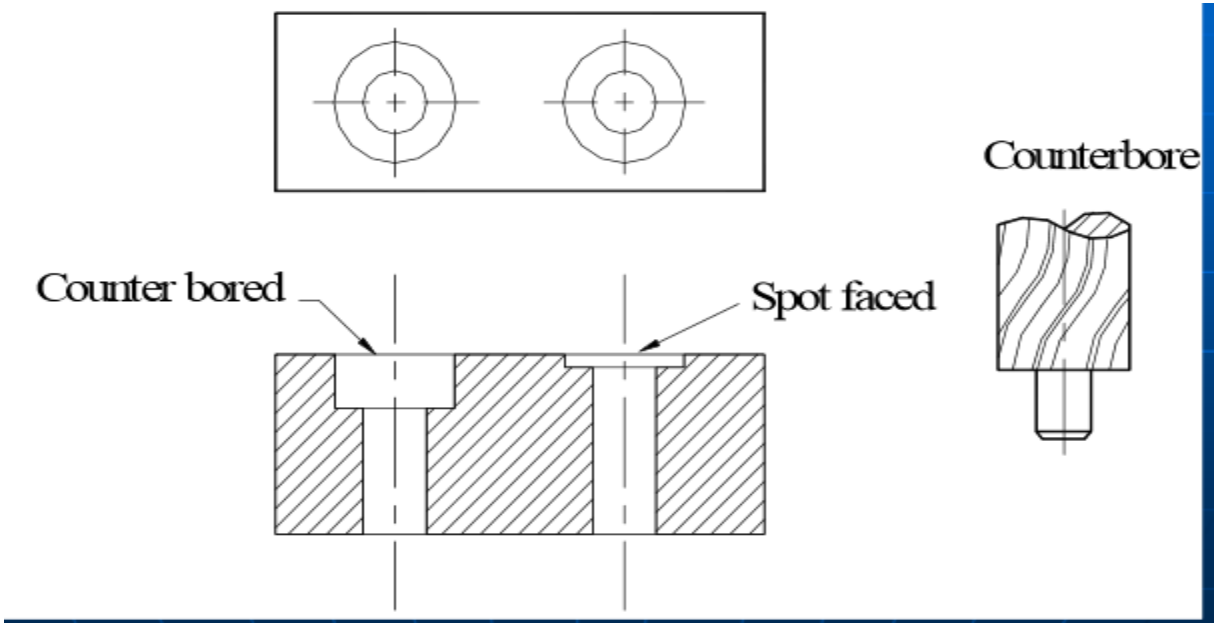
Drilling machine operations contd…

- Tapping
- Operation of cutting internal threads
- Tool used is called Tap
- A Tap may be considered as a bolt with accurate threads cut on it
- The threads act as cutting edges
- When Tap screwed into the hole it removes metal and cuts internal threads



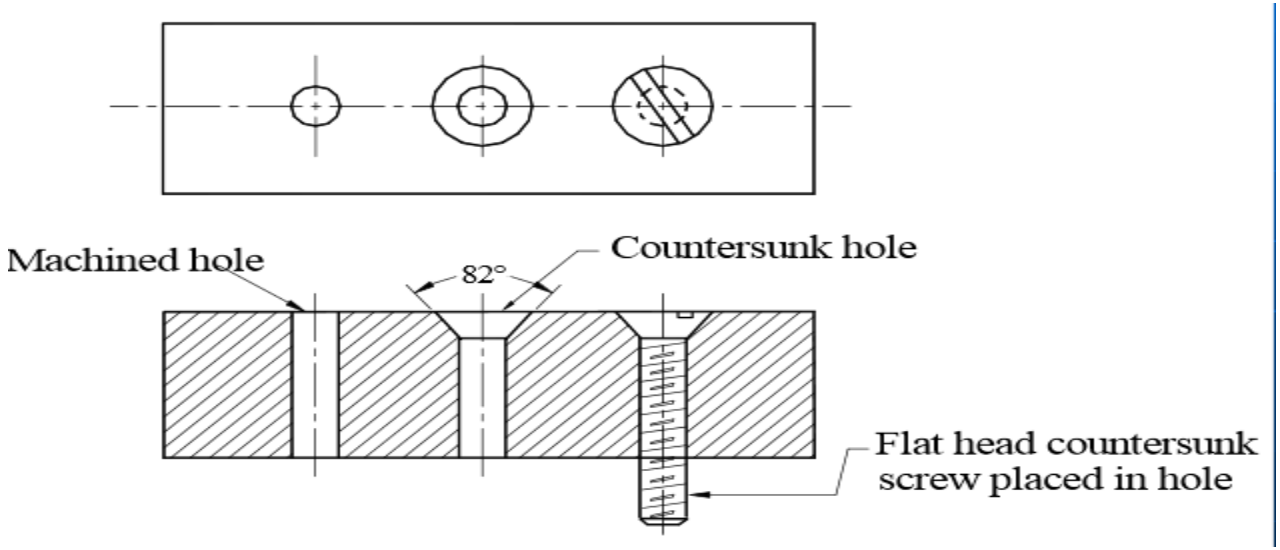
Drilling machine operations contd…

- Counter boring
- Operation of enlarging the end of a hole cylindrically
- This is required in some cases to accommodate the heads of bolts, studs and pins
- Tool is called a Counterbore
- Spot facing is done to provide seating for Washer



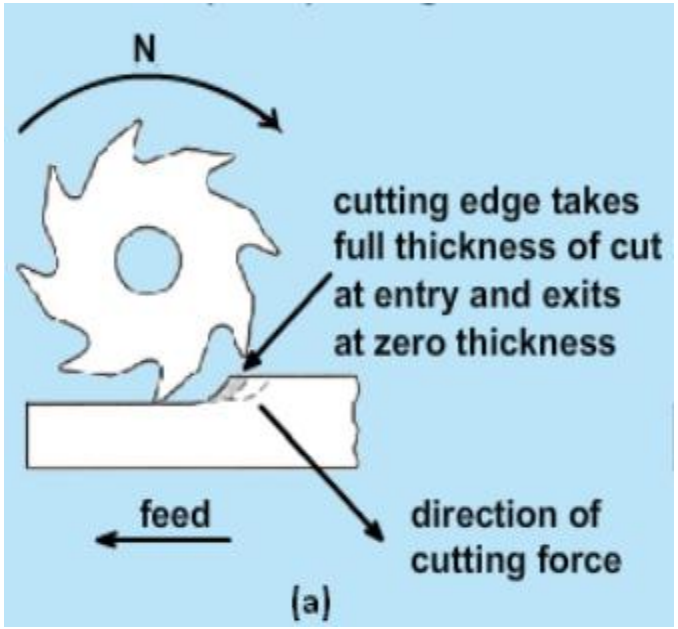
Drilling machine operations contd…

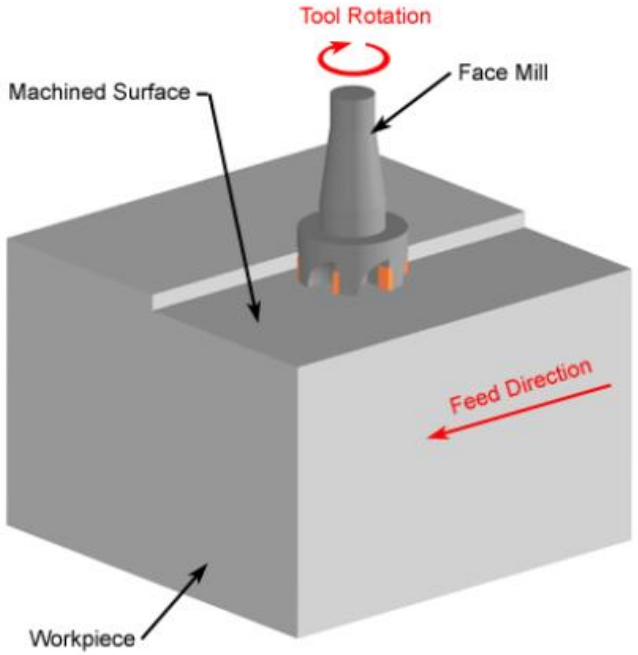
- Counter sinking
- Operation of making a cone shaped enlargement of the end of a hole to provide a recess for head of a screw or countersunk rivet fitted into the hole.
- The tool is called a countersink



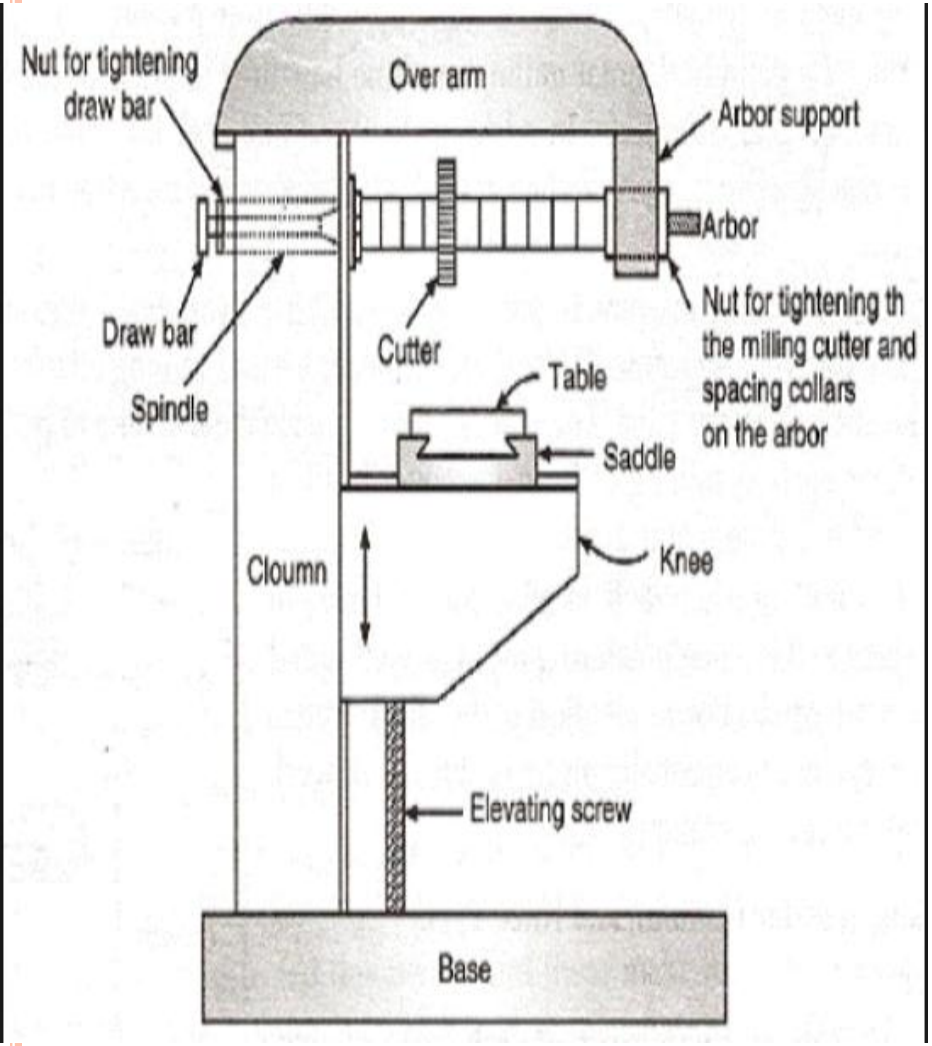
Milling machine

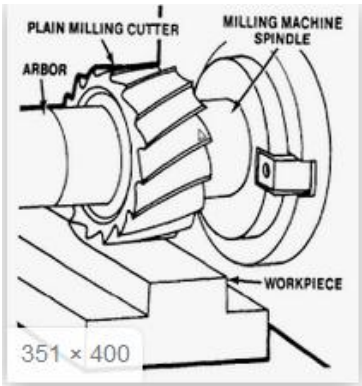
- Used to produce components having flat as well as curved shapes. The intricate shapes that can't be produced by other machines, can be produced.
- Cutting tool fits on the spindle and work piece attached to the table directly or in a holding device clamped to the table
- The undesirable material removed from work piece by feeding it past a rotating multipoint milling cutter.





Plain milling machine





Parts of Plain milling machine

- Base
- Iron casting, serves as foundation and base for all other parts
- On its one end, it carries the column
- Column
- Main supporting frame mounted vertically on the base
- Column is box shaped and houses all driving mechanisms for the spindle and the table feed
- The front vertical face of the column is accurately machined and is provided with guideways for supporting the knee
- Top of column holds an overarm that extends outward at the front of the machine

Parts of Plain milling machine contd…

- Knee
- Rigid iron casting that slides up and down on the vertical ways of the column
- Knee houses the feed mechanism of the table and its controls
- Top face of knee forms a slideway for the saddle to provide cross feed of the table
- Table
- Table rests on ways in the saddle
- Top of the table has T slots for clamping the work

Parts of Plain milling machine contd…

- Overhanging arm
- Mounted on top of the column, serves as a bearing support for the other end of the arbor
- The arm is adjustable so that the bearing support may be provided nearest to the support
- Spindle
- Located in the upper part of the arm
- Receives power from the motor through gears and transmits to the arbor
- Spindle is provided with provision for a cutting tool.
- Accuracy of cutting depends on the accuracy, strength and rigidity of the spindle
- Arbor
- An extension of the machine spindle on which cutters are securely mounted and rotated

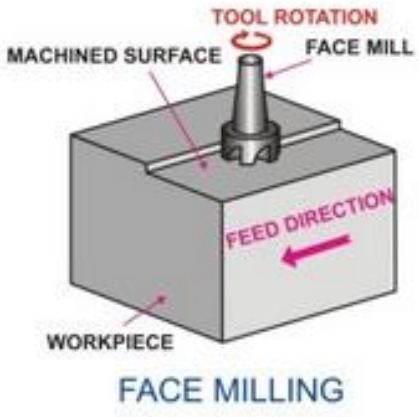
Milling operations

Plain milling: Most common type of milling machine operations. Performed to produce a plain, flat, horizontal surface parallel to the axis of rotation of a plain milling cutter.

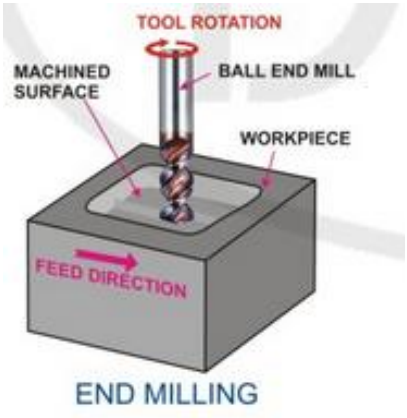
- Side milling: Cutter machines the side face of the workpiece.
- Slot milling: Width of the cutter is less than the workpiece width creating slot in the workpiece.

Face milling

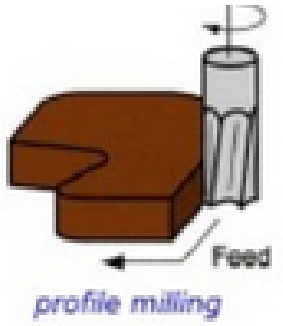
- Performed by a face milling cutter rotated about an axis perpendicular to the work surface.
- End milling: cutter diamter is less than the work width, so a slot is cut into the part.
- Profile milling: Outer periphery of a flat part is cut



FACE MILLING



END MILLING



Casting process

- Casting is the process of pouring the molten metal in a mould(or cavity) and allowing it to solidify to make the required component.
- Advantages of Casting process
  - Components of complicated shapes can be casted easily and in less time
  - Molten metal flows into any small section in the mold cavity and so intricate internal or external features can be made
  - The cast components may not require further finishing operation hence reducing the overall production time
- Application
- Typical applications of sand casting process are cylinder block, piston, piston rings, machine tool bed, wheel etc.

Casting process contd…

- The whole process of casting may be classified into five stages

1. Pattern making
2. Moulding and core making
3. Melting and casting
4. Fettling
5. Testing and inspection

Moulding tools and equipments:

Classified into three groups namely hand tools, flasks and mechanical tools

Casting process contd…

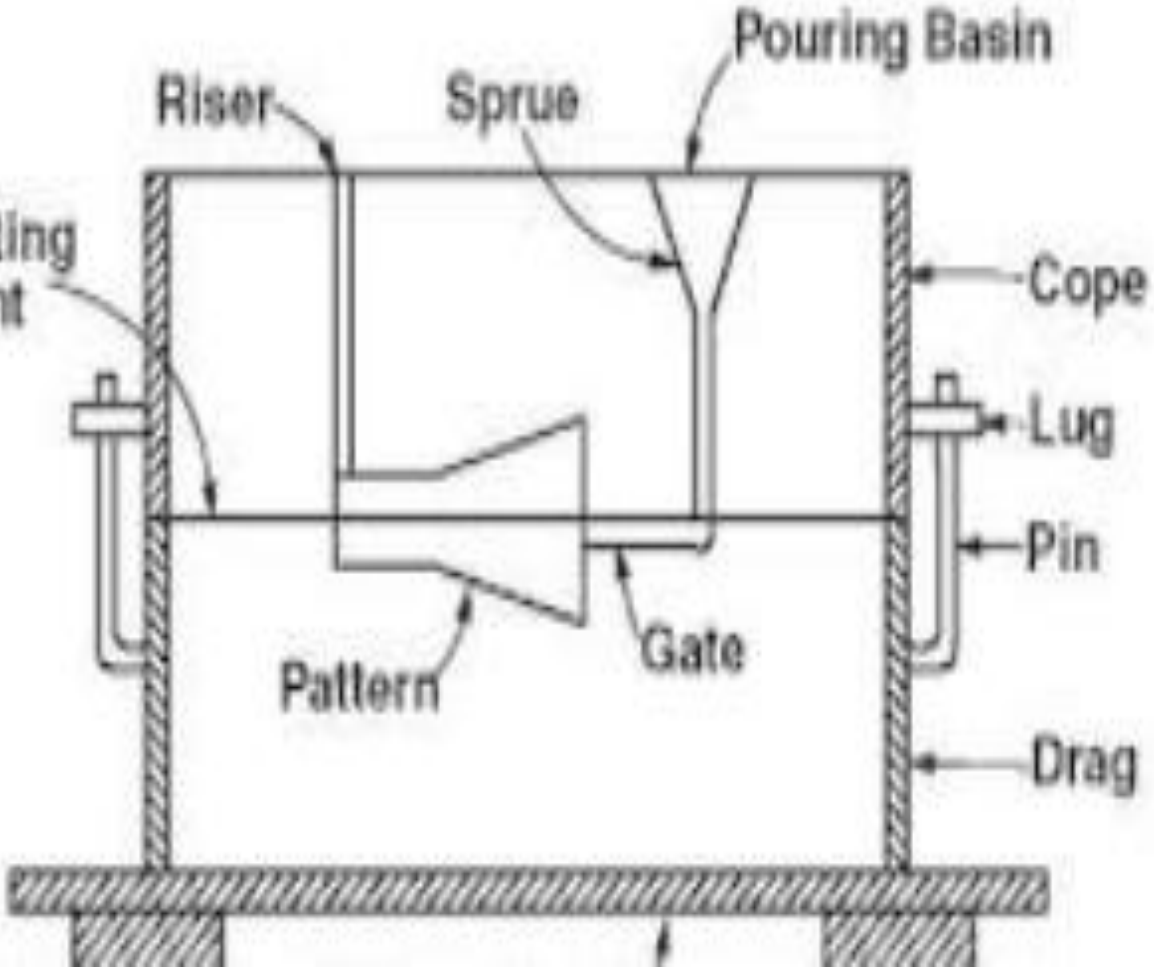
- Various Hand tools are shovel, Rammer, Slick, Lifter, Strike-off bar, bellow, Gate cutter, Mallet, Clamps etc.
- Moulding board is a smooth wooden board on which the flask and patterns are placed
- Sand moulds are prepared in boxes called flasks(wooden or metallic). It gives necessary rigidity and strength to the sand in the moulding. Top part is called cope and bottom one drag.
- Sand moulding procedure:
  - Pattern with necessary allowance is kept over a moulding board
  - Drag placed on moulding board

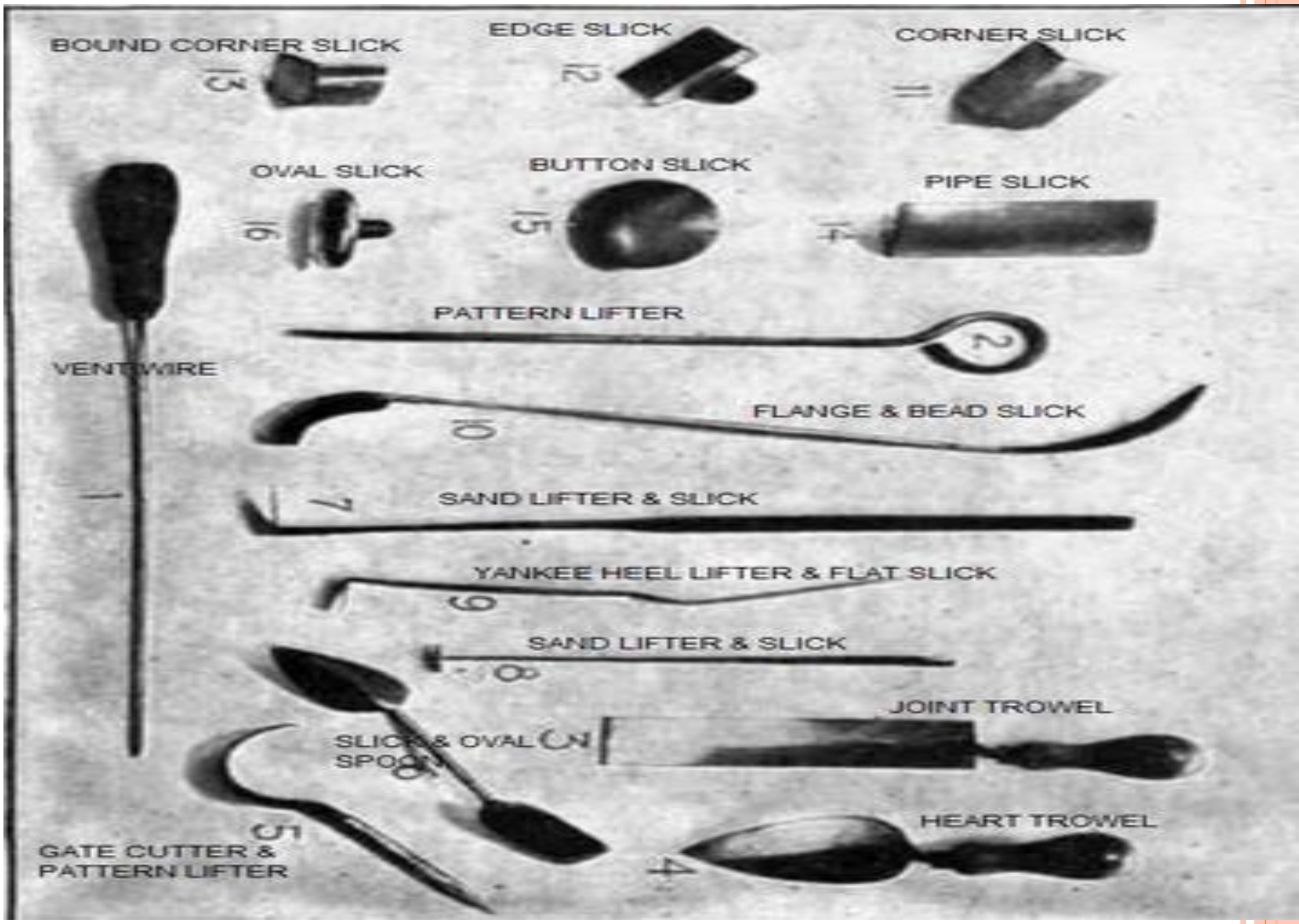
Casting process contd…

- Conditioned moulding sand poured over the pattern in the drag
- Sand is rammed to get perfect packing
- Drag is leveled off with a strike rod
- Vent holes are made with vent holes to let out the escape gases
- Little sand sprinkled over the mould and bottom board placed over the drag
- Drag turned over. The moulding board taken off.
- Parting sand sprinkled over and cope placed over the drag such that pins fit in proper position and cope and drag interlocked
- A sprue pin kept vertically and taken out later to leave a passage for the molten metal to be poured through

Casting process contd…

- Cope filled with moulding sand, rammed and properly packed and vent holes made
- Sprue pin withdrawn first.
- Cope lifted off carefully. Pattern removed carefully
- A gate is cut connecting the bottom of the sprue opening to the cavity for molten metal to flow to the cavity
- The cope put over drag again to get the two halves of the mould together.
- Metal is poured to get the casting


Pouring Basin
Riser
Sprue
Parting
Joint
Cope
Lug
Pin
Gate
Pattern
Drag

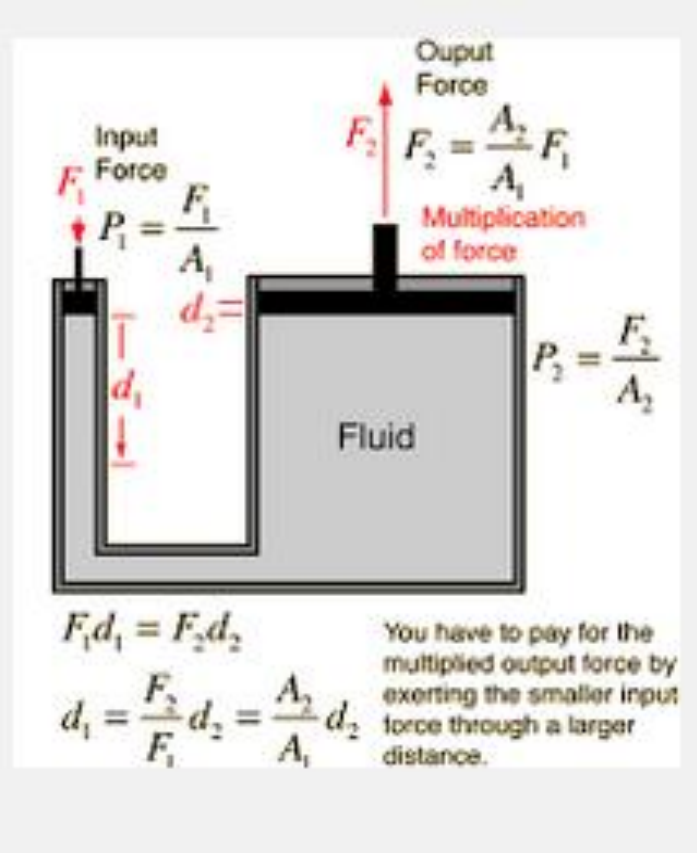

BOUND CORNER SLICK
13
EDGE SLICK
12
CORNER SLICK
11
OVAL SLICK
9
BUTTON SLICK
15
PIPE SLICK
14
PATTERN LIFTER
2
VENT WIRE
1
FLANGE & BEAD SLICK
10
SAND LIFTER & SLICK
7
YANKEE HEEL LIFTER & FLAT SLICK
5
SAND LIFTER & SLICK
8
JOINT TROWEL
SLICK & OVAL SPOON
6
GATE CUTTER & PATTERN LIFTER
HEART TROWEL
4

Forging process

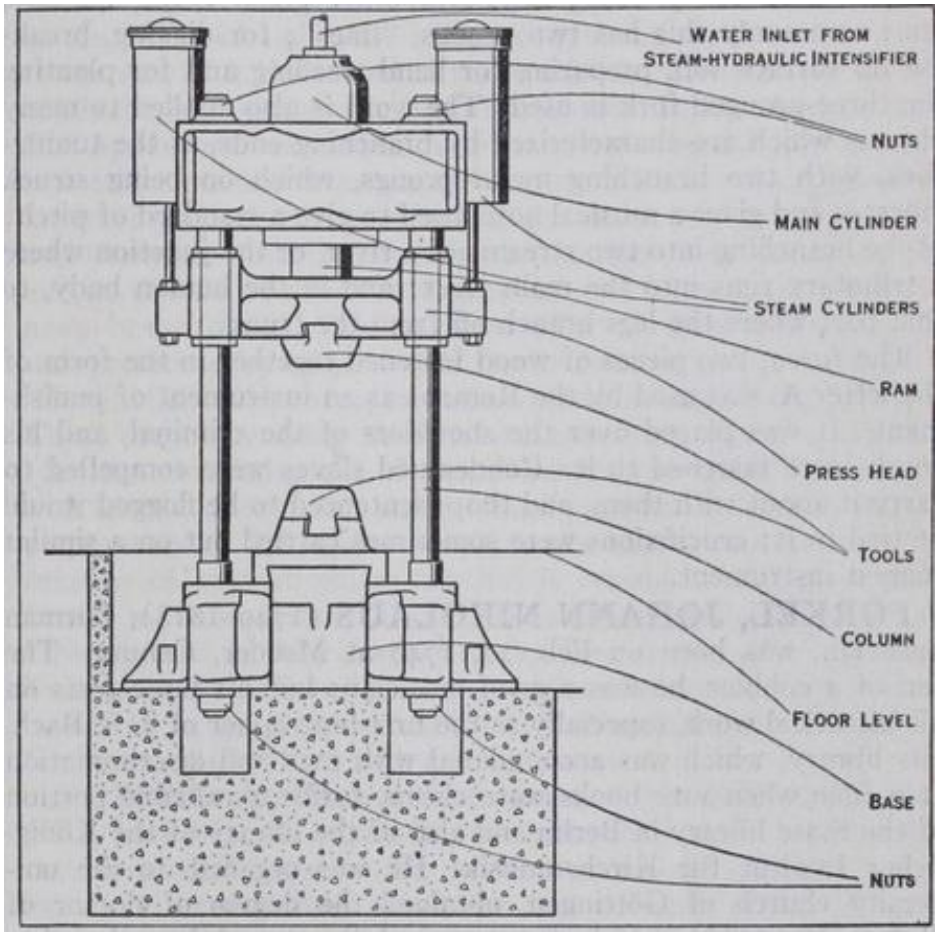
- Is a deformation process in which the work is compressed between two dies using either impact or gradual pressure to form a part.
- A forging machine applying impact load- forging hammer
- A forging machine applying gradual load- Forging press
- Small parts are forged with pneumatic power hammers, very large parts are forged in hydraulic presses
- Hand forging
- Power forging

FORGING PROCESS CONTD…

- Press Forging: Steady high pressure is applied on hot metal workpiece, slow squeezing instead of giving heavy blows, more accurate.
- In a hydraulic press, Ram is raised or lowered by large pistons driven by high pressure oil. Press action is slow in comparison to hammer but reduction in the size of heavy parts is comparatively rapid.
- In hammer forging, the blow works the metal only in the surface layers of the workpiece so deformation does not penetrate into the volume of the metal. While in case of a press, the pressure is applied gradually and it penetrates deep into the metal



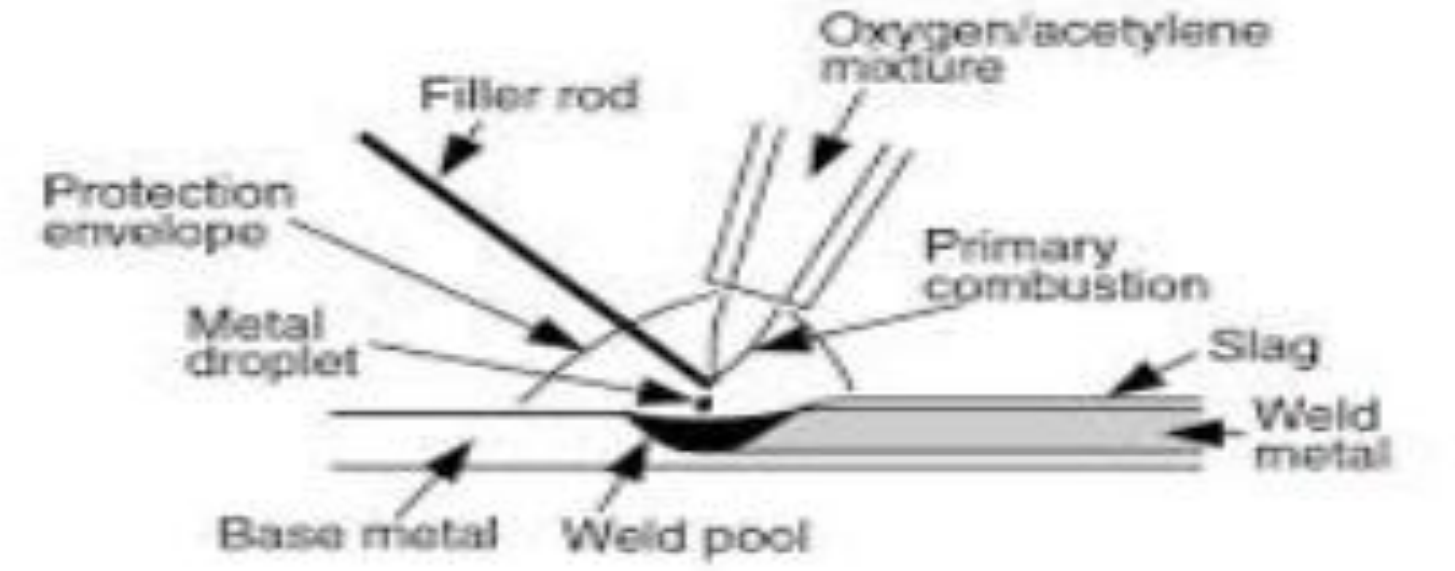
Forging process contd…



JOINING PROCESSES

- Metal fabrication involves joining of two metals together depending on the material to be joined and degree of permanency required.
- Welding is a process of joining two (or more) metal pieces by application of heat with or without application of pressure and addition of filler material.
- Welding is extensively used in the fabrication work.
- Application of Welding: fabrication of bridges, electric towers, manufacturing of automobile bodies, building of ships and air crafts, manufacturing of boilers, storage tanks, pipelines etc.
- In pressure welding, the parts to be joined are heated upto the plastic state and fused together by applying external pressure like forge welding, resistance welding etc
- In fusion welding, the joint of the two parts is heated to the molten state and allowed to solidify like gas welding, electric arc welding etc

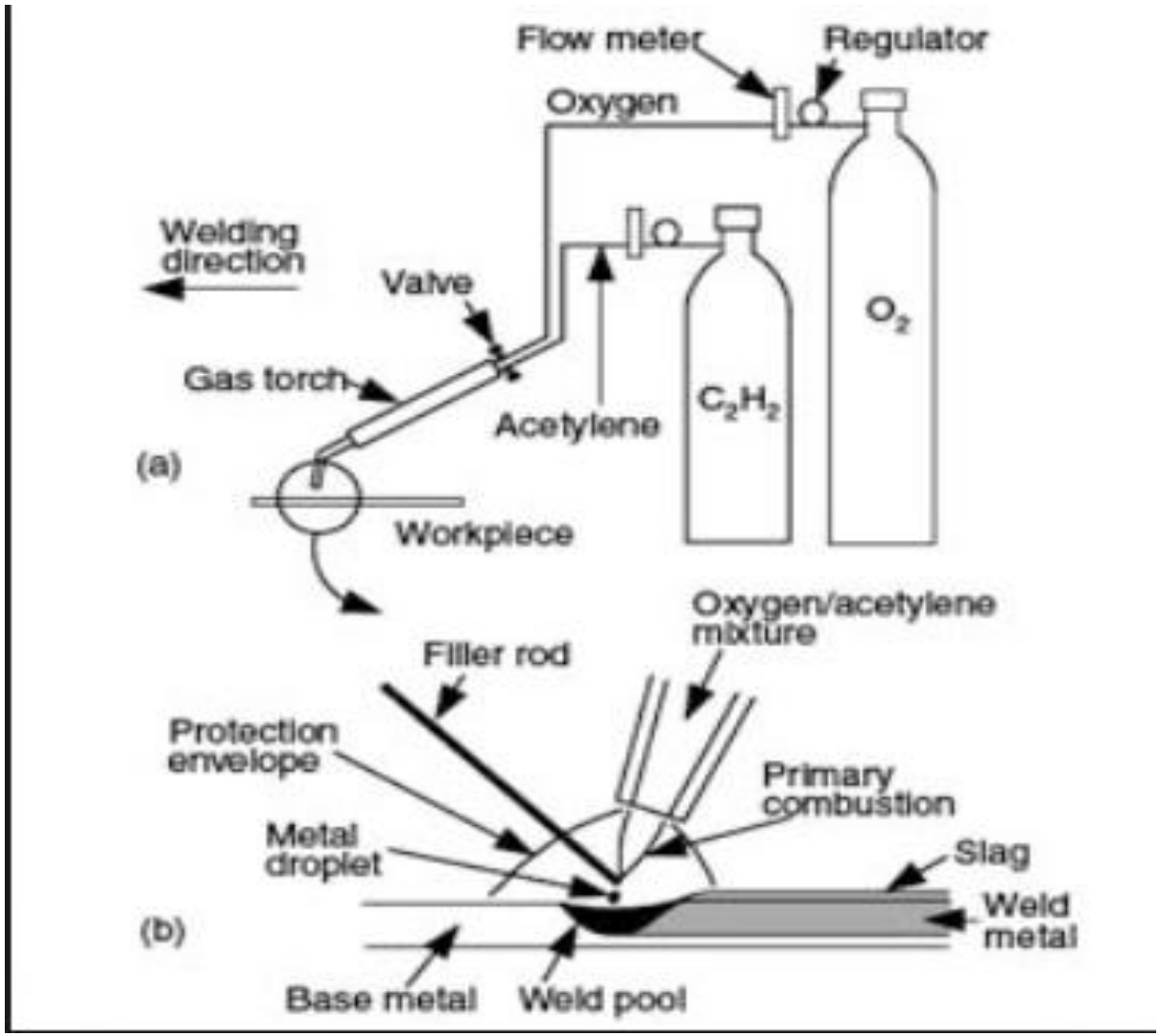
Oxy acetylene gas welding



- Melting the edges to be joined by gas flame allowing the molten metal to flow together hence forming a continuous joint upon cooling
- Suitable for joining two plates of 2 to 50 mm thickness.

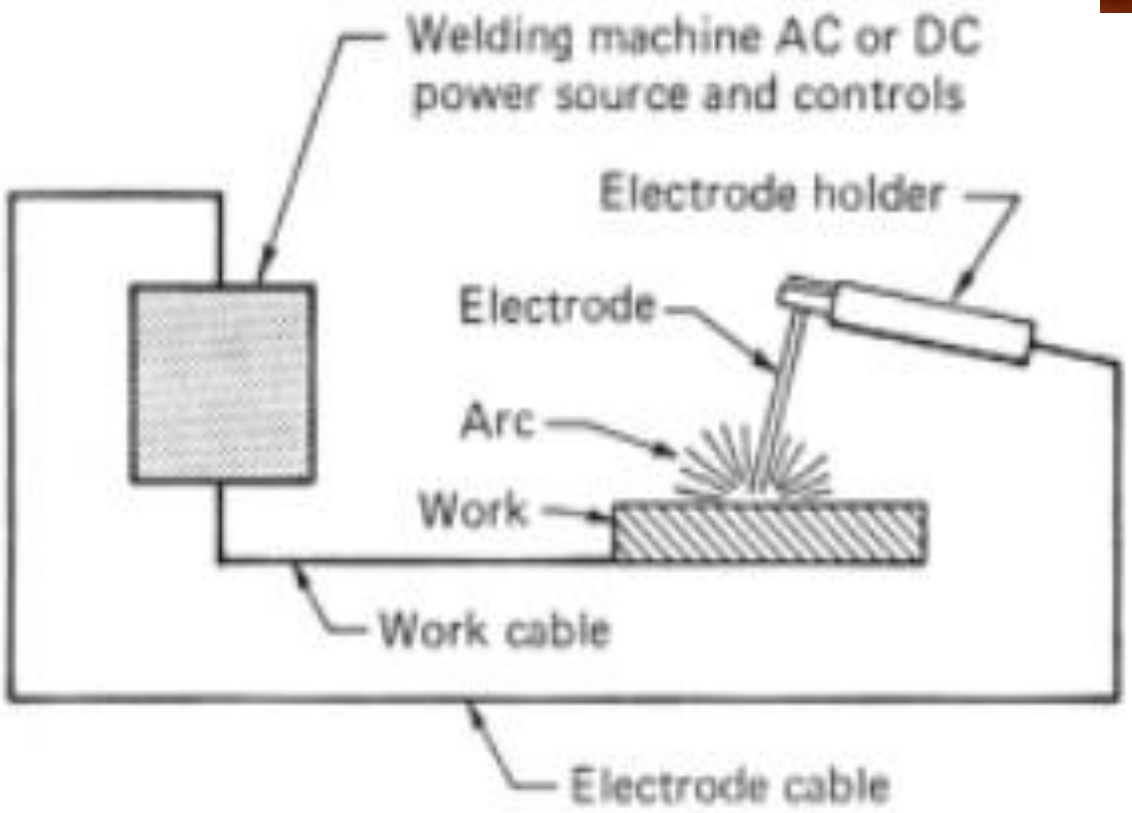
Oxy acetylene gas welding contd…

- >15 mm thick plates, filler metal added to the weld in the form of weld rod
- To remove impurites and oxides present on the surface, a flux is added.
- Various gas mixtures like oxygen and acetylene, oxygen and hydrogen etc are used
- The max temperature in oxy acetylene flame is about 3200 deg C.
- Welding equipment:
- Welding torch
- Welding tip
- Pressure regulator
- Hose and hose fittings
- Goggles, gloves and spark lighter
- Gas cylinders



Correct and safe oxygas welding station

Arc welding


Welding machine AC or DC
power source and controls
Electrode holder
Electrode
Arc
Work
Work cable
Electrode cable

Arc welding contd…

- Principle of arc welding:
- When two conductors of an electric circuit are touched together momentarily and then separated slightly, assuming there is sufficient voltage in the circuit to maintain the flow of current, an electric are is formed. Concentrated heat is produced through out the length of the arc of the order of 5000 to 6000 deg C.
- Filler metal provided in two ways: consumable electrodes, non consumable electrodes
- An arc welding equipment comprises ac/dc power supply, electrode, electrode holder, cables, safety devices etc

Soldering and brazing

- Soldering is a method of uniting two metal pieces using a fusible alloy/metal applied in the molten state.
- Soft soldering used in sheet metal work for joining parts not exposed to high temperature and excessive loads, also for joining wires and small parts. Also employed for joining wires and small parts. Solder used is lead and tin alloy (melting range 150 to 350 deg C)
- Hard soldering employs solders that are stronger. Solders like silver based alloys (melting range 600 to 900 deg C) are used.

SOLDERING AND BRAZING

- Brazing is a method of joining two similar or dissimilar metals using a special fusible alloy. It produces a clean and stronger joint than soldering. Main difference is the use of a harder filler material called spelter (copper based and silver based alloys)
- Material used in brazing are copper and silver based alloys
- Before brazing the parts/ surfaces to be brazed are cleaned removing oxides/grease etc.
- Strength of brazed joint is lesser than welded joint but relatively good.

S.No	Welding	Soldering	Brazing
1	Welding joints are strongest joints used to bear the load. Strength of the welded portion of joint is usually more than the strength of base metal.	Soldering joints are weakest joints out of three. Not meant to bear the load. Use to make electrical contacts generally.	Brazing joints are weaker than welding joints but stronger than soldering joints. This can be used to bear the load up to some extent.
2	Temperature required is 3800°C in welding joints.	Temperature requirement is up to 450°C in soldering joints.	Temperature may go to 600°C in brazing joints.
3	To join work pieces need to be heated till their melting point.	Heating of the work pieces is not required.	Work pieces are heated but below their melting point.
4	Mechanical properties of base metal may change at the joint due to heating and cooling.	No change in mechanical properties after joining.	May change in mechanical properties of joint but it is almost negligible.

5	Heat cost is involved and high skill level is required.	Cost involved and skill requirements are very low.	Cost involved and sill required are in between other two.
6	Heat treatment is generally required to eliminate undesirable effects of welding.	No heat treatment is required.	No heat treatment is required after brazing.
7	No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating of workpieces before soldering is good for making good quality joint.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature.