Systems In Mechanical Engineering

UNIT 5

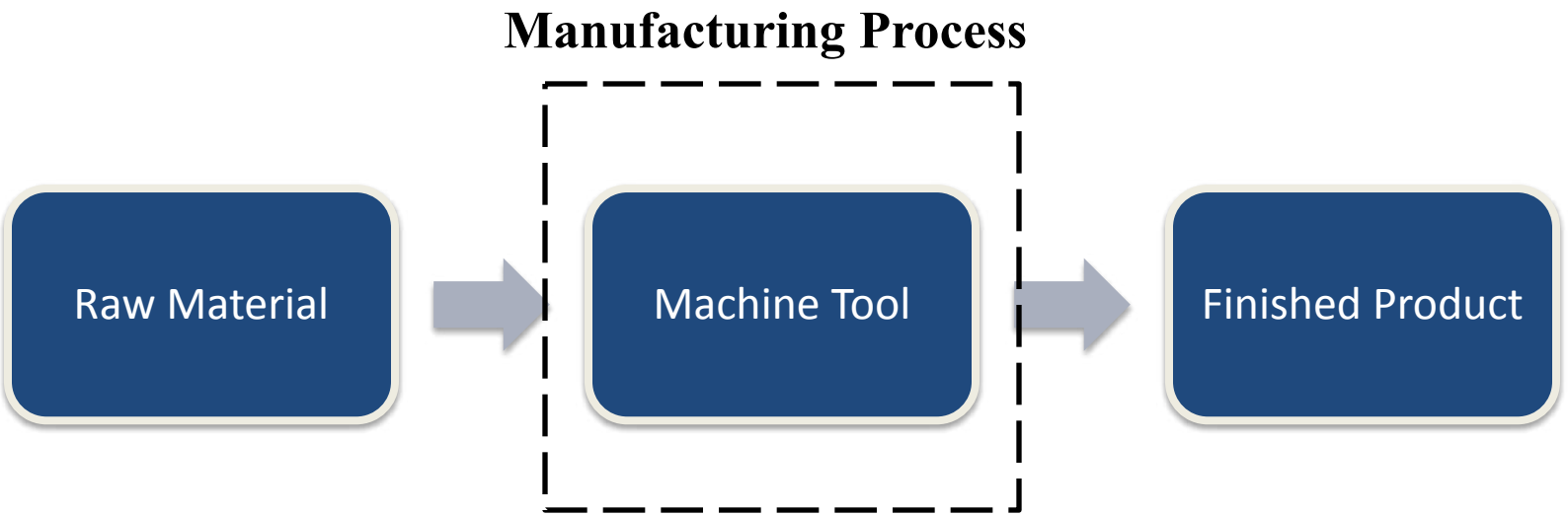
Manufacturing Processes

Casting

Mr. Girish G Khope

Manufacturing Process

It involves transforming a raw material from it's original state to a finished state by changing it's shape or the properties of the material in a series of steps.



- Turning
- Facing
- Drilling
- Milling
- Shaping
- Reaming

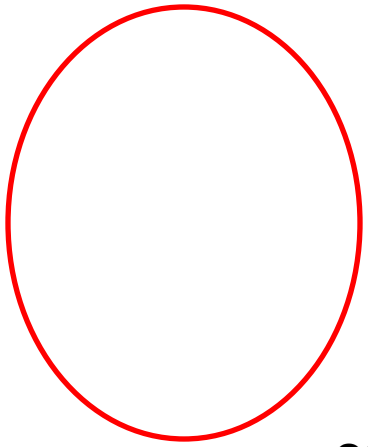
- Joining Processes
- Welding
- Soldering
- Brazing
- Screwing
- Riveting
- Adhesive Bonding

- Surface Finishing Processes
- Honing
- Lapping
- Buffing

Metal Casting

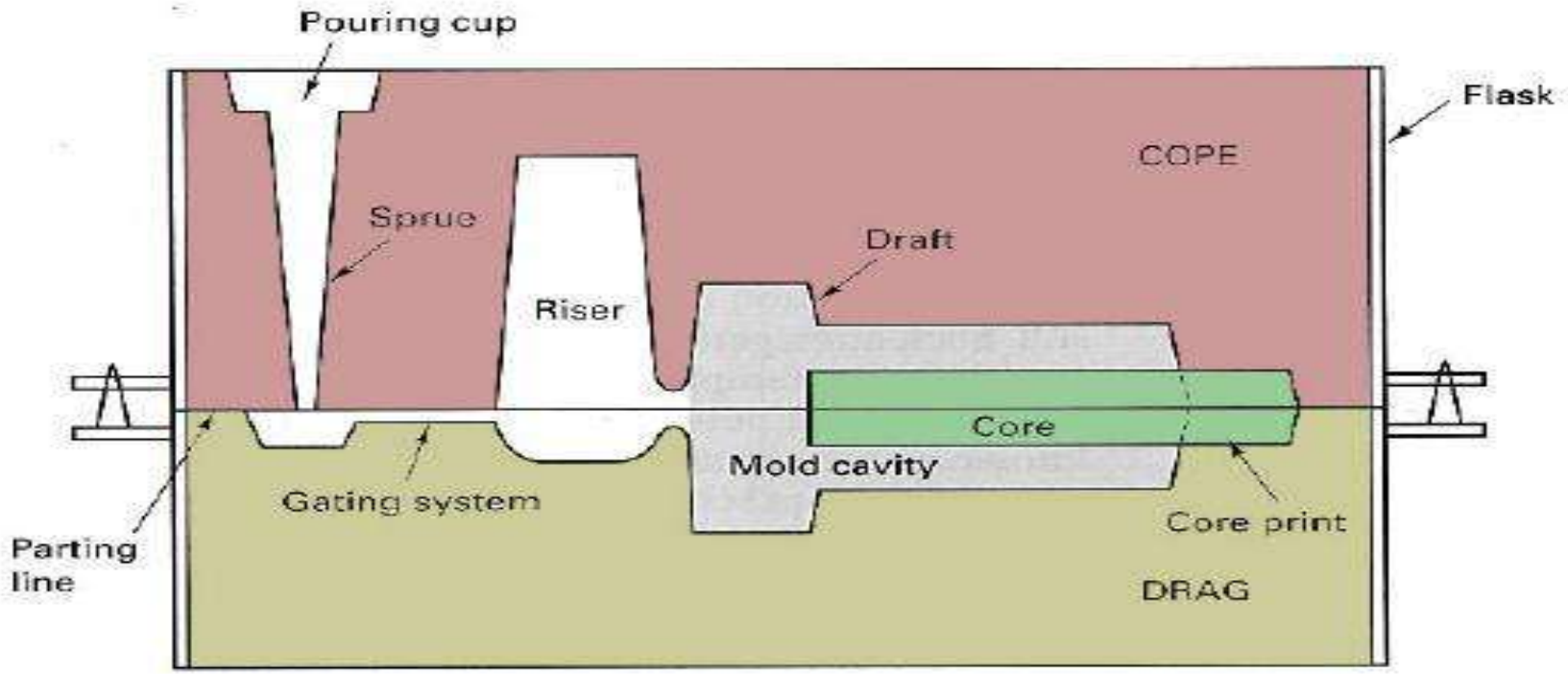
- Casting: It is a manufacturing process in which part of desired shape is obtained by pouring molten metal into cavity of required shape

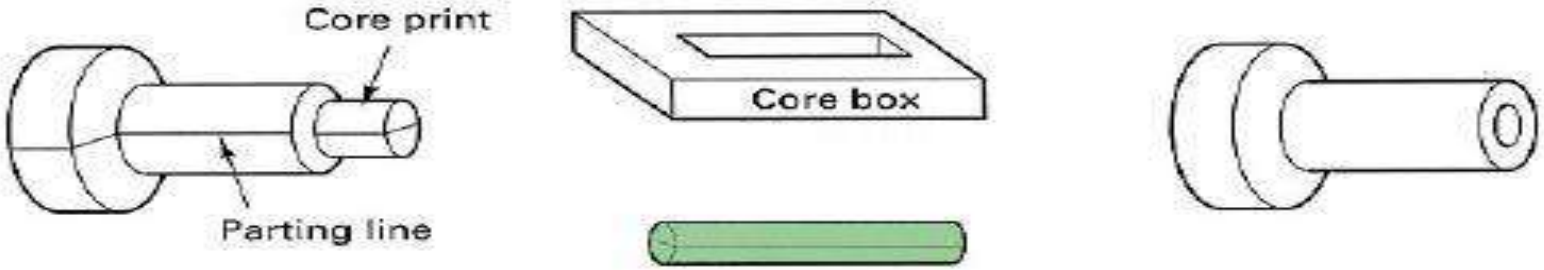
- It is one of the oldest manufacturing process (around 6000 year old, Egyptians were first to use castings)



- **Castings**
  - **Sand Casting**
  - **Die Casting**
  - **Investment casting**
  - **Centrifugal casting**
  - **Slush Casting**

Metal Casting: Sand Casting



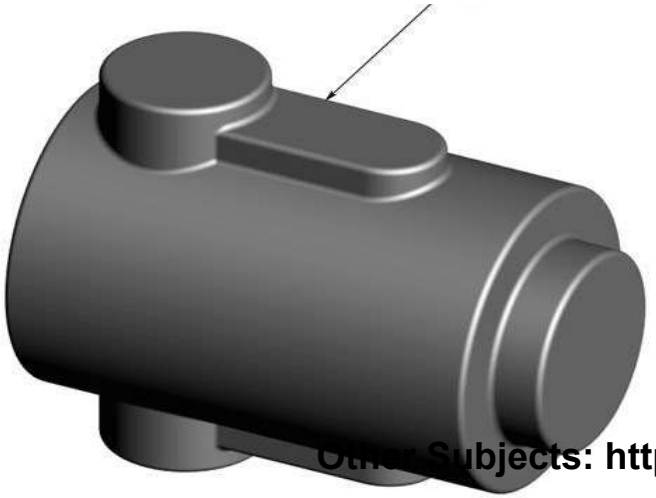


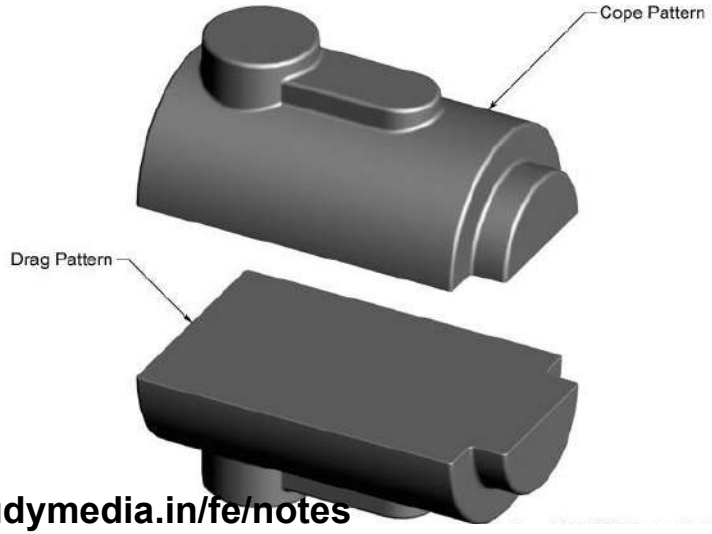
Pattern + Core = Casting

Metal Casting: Sand Casting

- Steps in Sand Casting:

1. Pattern Making:
   - Pattern is replica of the part to be casted.
   - Initially pattern has to be made using different manufacturing process other than casting.
   - Draft/Taper is provided on pattern for its easy removal from sand mould
   - Commonly used materials for pattern making are- Wood, Plastic and metal

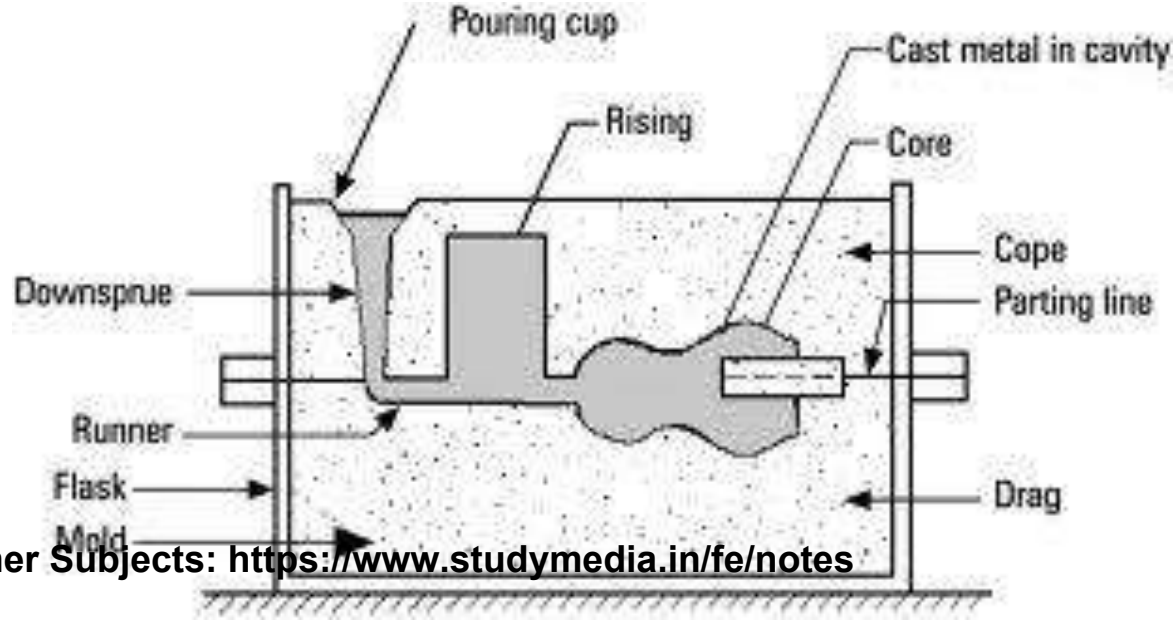




Metal Casting: Sand Casting

- Steps in Sand Casting:

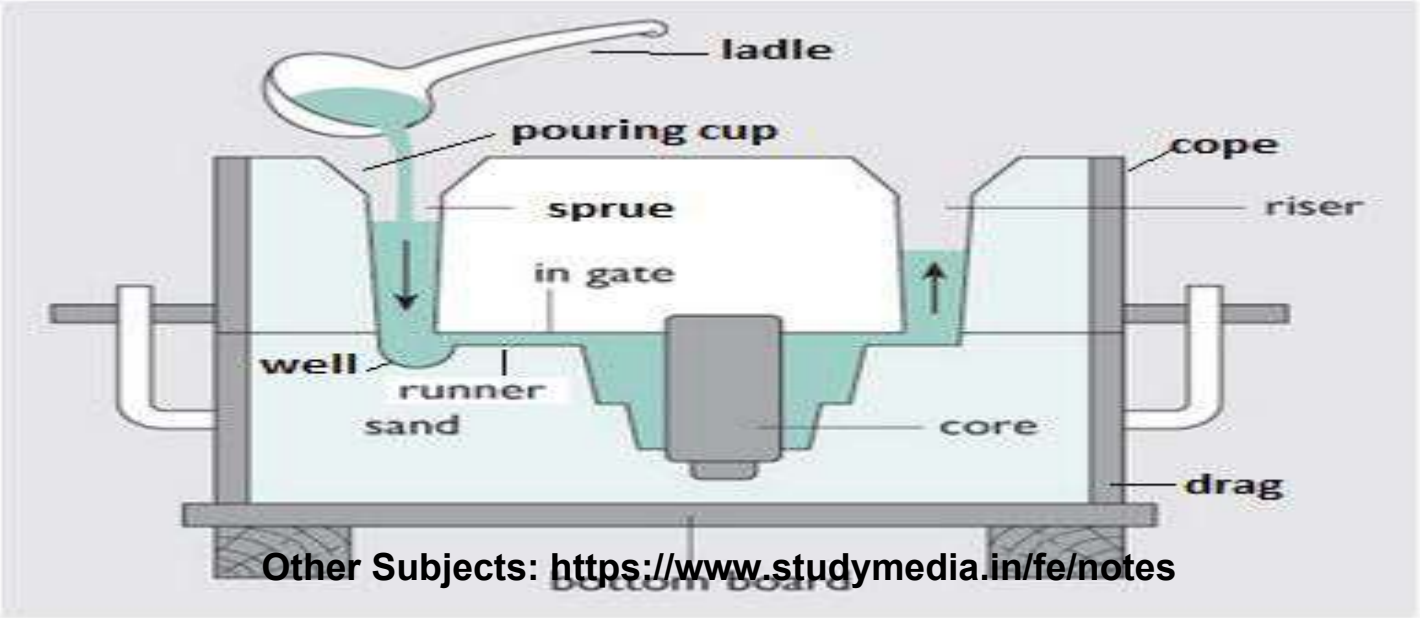
2. Mould Making:
   - Mould is a container made from green sand and which has cavity in which molten metal can poured.
   - Mould box has two halves, the upper halve is called cope and lower halve is called drag
   - Arrangement for metal pouring has to be made inside the mould



Metal Casting: Sand Casting

- <u>Steps in Sand Casting</u>:

3. Core Making:
   - Core is a device used in sand casting to produce hollow castings
   - Generally core is made from same material as that of the mould i.e. sand
   - Supporting elements called chaplets are used to support core



Metal Casting: Sand Casting

- <u>Steps in Sand Casting</u>:

4. Metal Melting and Pouring:
   - The raw material is melted using furnace. Furnace may be operated on electricity or fuel
   - The molten metal is poured into mould using ladle
   - Pouring basin, sprue, runner, gate are used to guide molten metal into the cavity

Metal Casting: Sand Casting

- Steps in Sand Casting:

5. Solidification
   - Metal is allowed to cool to room temperature
   - During solidification the metal shrinks and the extra metal required compensate this shrinkage is obtained from the riser

6. Finishing
   - Undesired part which corresponds to gating system and riser has to be cut from main casting
   - The casted surface generally is rough and some finishing operation like grinding, machining, polishing are required

7. Inspection
   - Before dispatching the casted part has to be checked for desired dimensions. The part which doesn't meet expected dimensions has to be scraped
   - Castings are also checked for various undesirable defects

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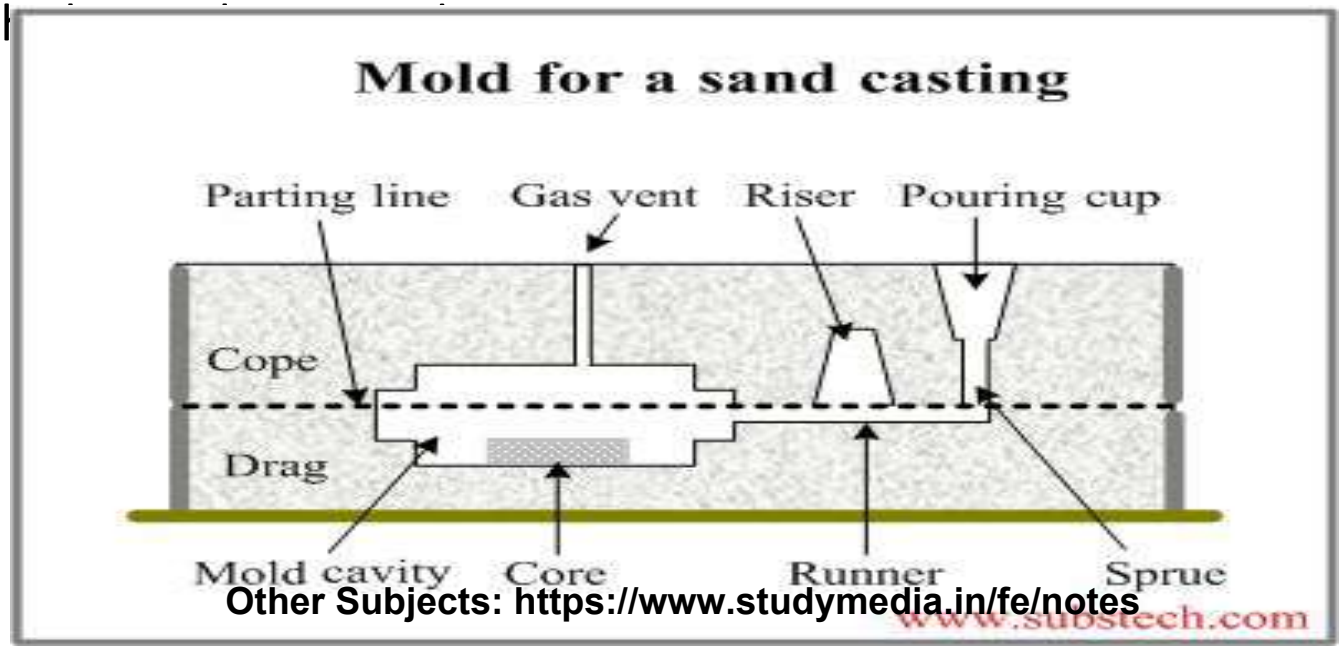
Metal Casting: Sand Casting

- Terminology in Sand Casting:

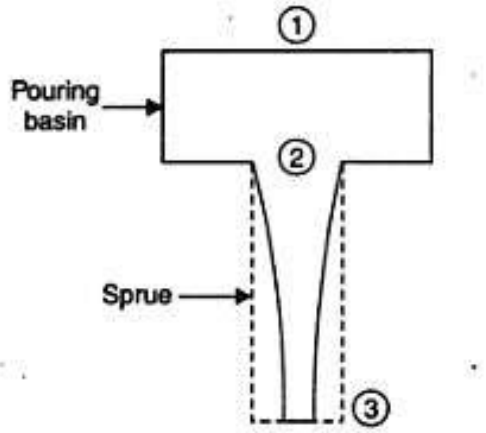
1. Mould Box:
   - It is metallic or wooden box in which sand mould is created.
   - Upper part of mould box is called cope and lower part is called drag
2. Pouring Basin/Cup:
   - It is a shallow part at the entry of gating system through wh
   -



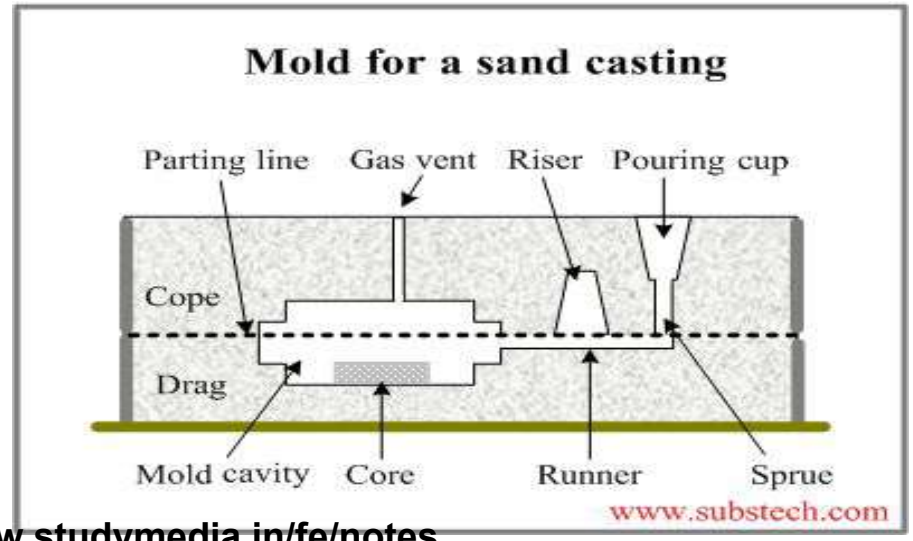
Metal Casting: Sand Casting

- Terminology in Sand Casting:

3. Sprue:



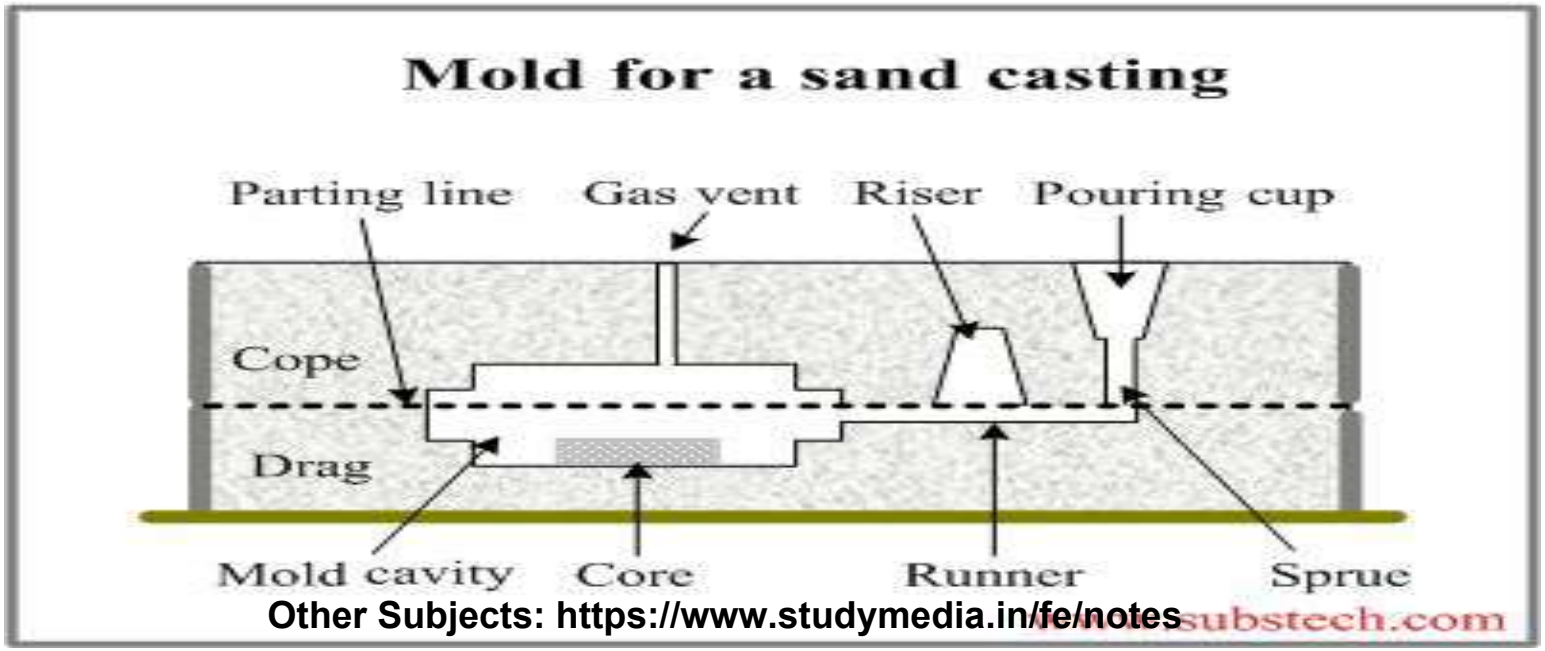
- A conical vertical portion immediately after pouring cup is called sprue
- Diameter of free falling liquid under gravity will be decreasing. If straight sprue is used, a vacuum will be created in between sprue wall and the metal stream.
- This vacuum will be responsible for suction of atmospheric gases which will create voids in casting



Metal Casting: Sand Casting

- Terminology in Sand Casting:

4. Runner:
   - The horizontal portion immediately after the sprue is called runner
5. Gate:
   - A narrow entry through which metal enters mould cavity is called gate

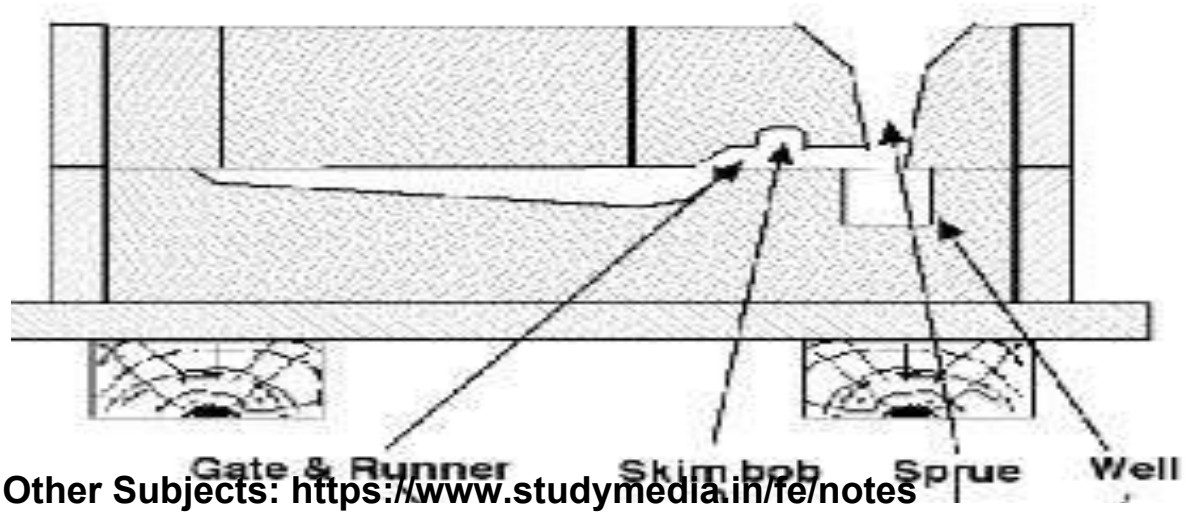


Metal Casting: Sand Casting

- Terminology in Sand Casting:

4. Skim Bob:
   - A small hollow spherical bulge above the top runner surface which is used to separate light floating impurities is called skim bob

5. Well:
   - A deep portion immediately below the sprue which acts as cushion to molten metal so that the sand is not washed off into the casting is called well

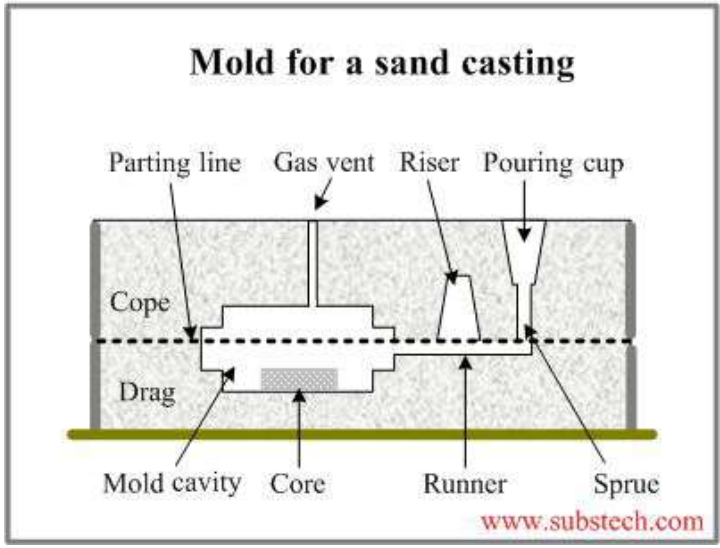


Metal Casting: Sand Casting

- Terminology in Sand Casting:

6. Riser:

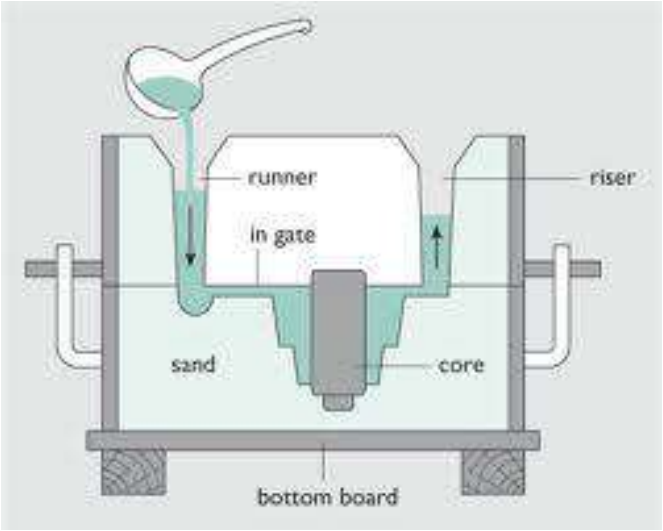
- It is a cavity cut into the sand mould which permits the molten metal to rise above the casting cavity



- Main function of riser is to supply molten metal during the shrinkage which happens during the solidification

- The riser shape has to be designed in such a way that its solidification time is more than that of the casting

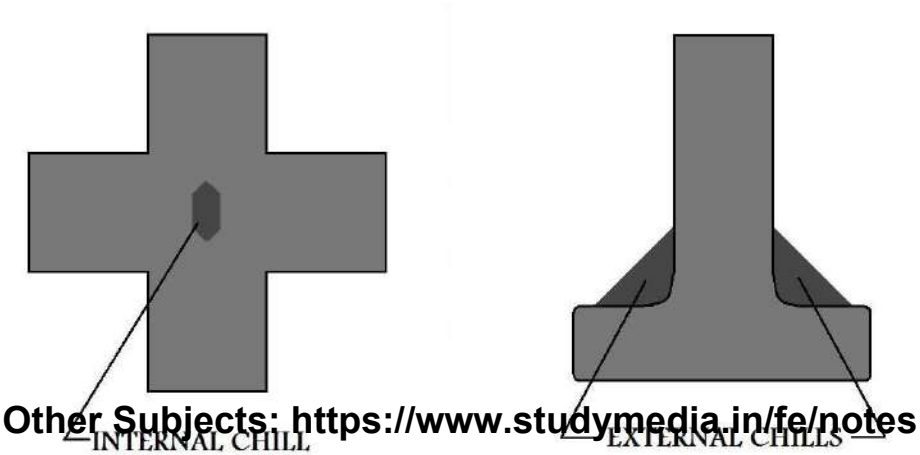
- Riser can be through or blind. Through riser also serves as an exit to the entrapped gases in mould cavity



Metal Casting: Sand Casting

- Terminology in Sand Casting:

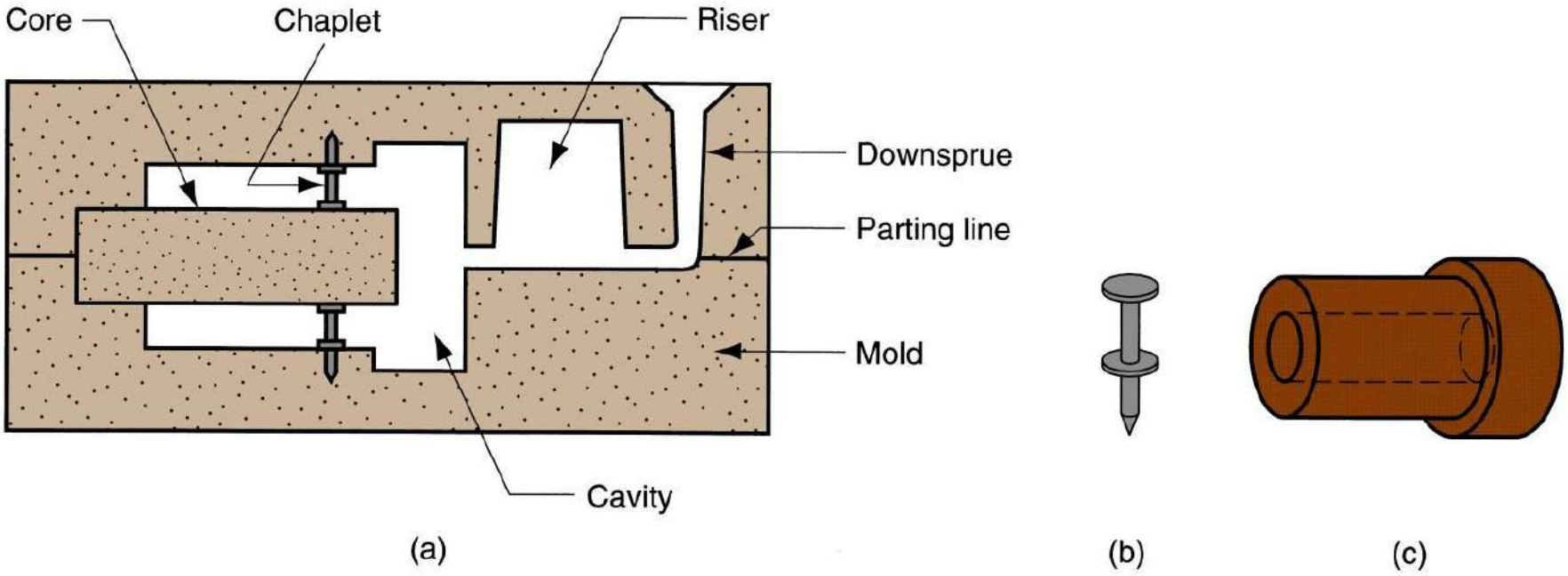
7. Chills:
   - Chills are the metallic element which are used to enhance solidification rate
   - As metals have higher thermal conductivity than sand, heat transfer rate will be higher in the vicinity of chills hence the molten metal solidifies faster there
   - Using chill we can control solidification direction as well as grain size (Faster cooling rate will result in finer grain size)
   - Chills can be internal as well as external. Internal chills have to be made from same material as that of casting



Metal Casting: Sand Casting

- Terminology in Sand Casting:

8. Chaplet:
   - It is a supporting element which used to hold core in correct position
   - Chaplet has to be made from same material as that of the casted part

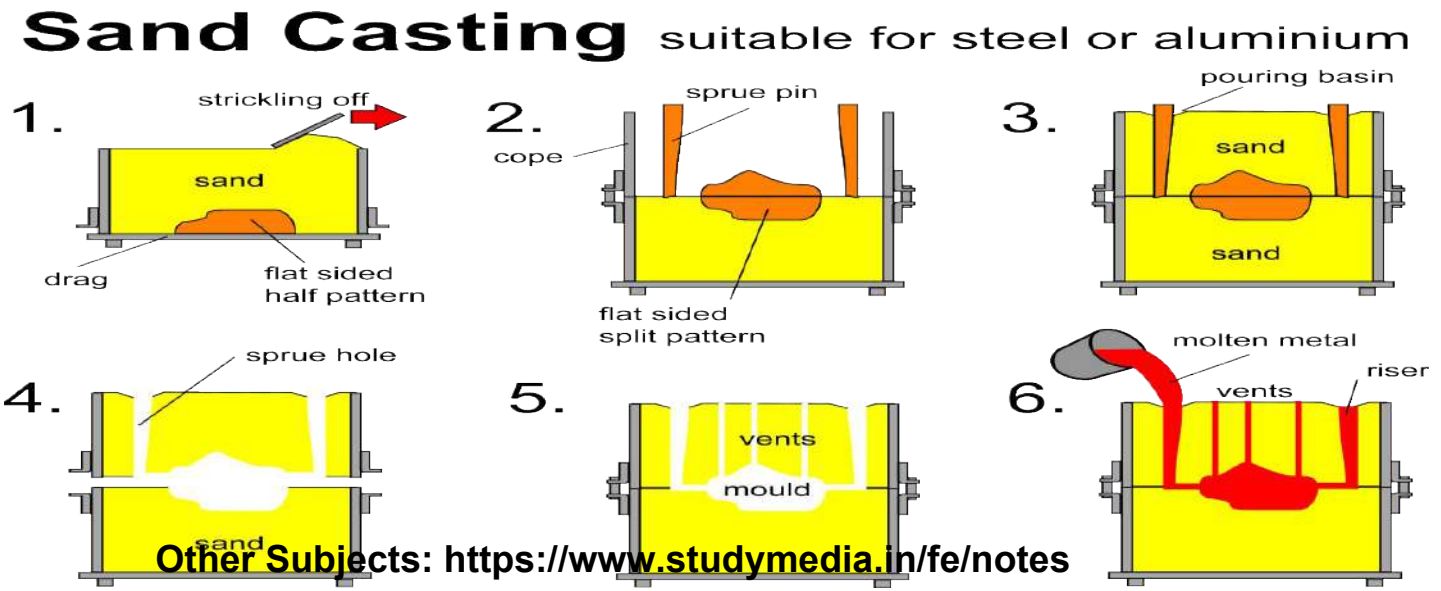


Metal Casting: Sand Casting

- Terminology in Sand Casting:

9. Machining Allowance:
   - Casted products require finishing operation because of poor surface finish. After finishing operation, size of the casted part reduces.
   - In order to compensate this reduction, size of 'casting pattern' is increased . This increase in size of pattern with respect base size is called machining allowance

10. Shrinkage Allowance:
   - When the casted product cools from its melting point to room temperature , size of component reduces. In order to compensate this reduction pattern of bigger size than product size are used.
   - The percentage increase in size of casted product at its melting point with respect its size at room temperature is called shrinkage allowance.



Metal Casting: Sand Casting

Advantages of Sand Casting:

- It is one of the cheapest manufacturing process. Operating as well as initial cost of equipment is much lower as compared to other manufacturing processes
- Casting can be used to create complicated shapes
- Casting can be used to manufacture components made from brittle as well as ductile material
- Casting can be used economically to create small as well as large components
- Casting is a primary manufacturing process. Raw material supplied to various other manufacturing process is obtained through the casting

Metal Casting: Sand Casting

Disadvantages of Sand Casting:

- Casting can not be used to create very thin components (thickness < 6mm)
- Casting contains various defects such cracks, voids, foreign particle inclusions which reduces strength of the component
- Casted components are brittle in nature as compared forged components
- Surface finish of sand casted component is poor
- Man power and space requirement is high
- Pollution during the casting process is high
- Risk of injury in metal handling is high

Metal Casting: Sand Casting

Applications of Sand Casting:

- Machine beds for various machines (Lathe, Drilling, Shaping, Milling)
- Automobile parts (Pistons, cylinder block, clutch and brake plates, Gearbox casing)
- Aircraft parts (Turbine and compressor blades, Engine casing)
- Casings used in various machines (Turbine, Generator, Compressors, Motors, Gear box, Pumps)
- Pulleys, Railway wagon wheels, Valves

Casting

Systems In Mechanical Engineering

Unit 5

SHEET METAL WORKING

Mr. Girish G Khope

SHEET METAL WORKING

Sheet metal working

is the process of manufacturing the components from the sheet metal of thickness ranging from 0.1 mm to about 8 mm.

It is carried out by a machine tool called press (Press working).

Sheet Metal Working

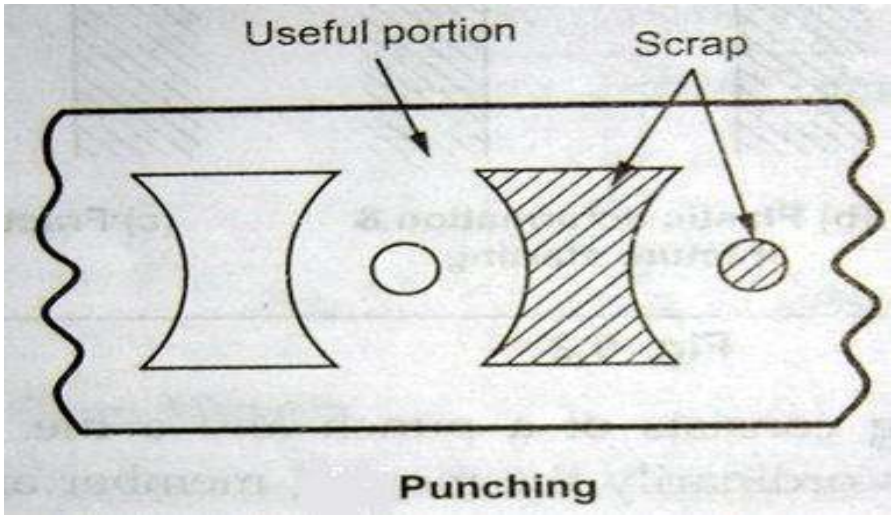
- **Sheet Metal Cutting (Shearing) Operations**
  - Piercing
  - Punching
  - Blanking
  - Perforating
  - Notching
  - Lancing
  - Slitting

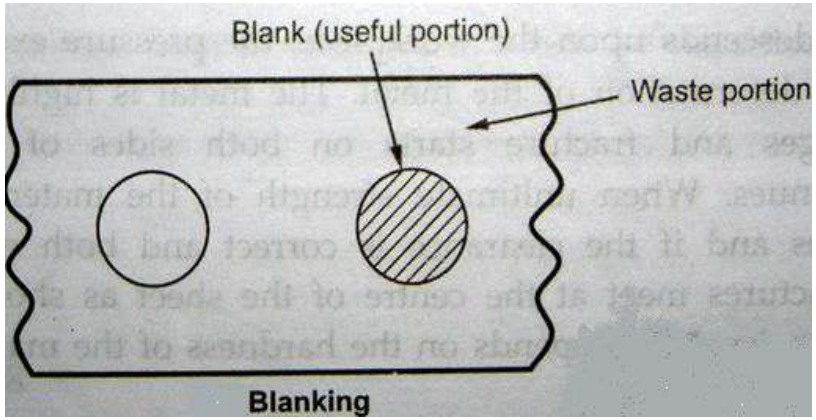
- **Sheet Metal Forming Operations**
  - **Bending**
  - **Drawing & Deep Drawing**
  - Embossing
  - Forming
  - Coining (Squeezing)

Metal Cutting (Shearing) Processes:

Piercing- Producing a hole of any desired shape in metal sheet.

Punching- Producing a circular hole in metal.





Blanking-

The metal punched out is the required component, called blank**.**

Difference between punching and blanking

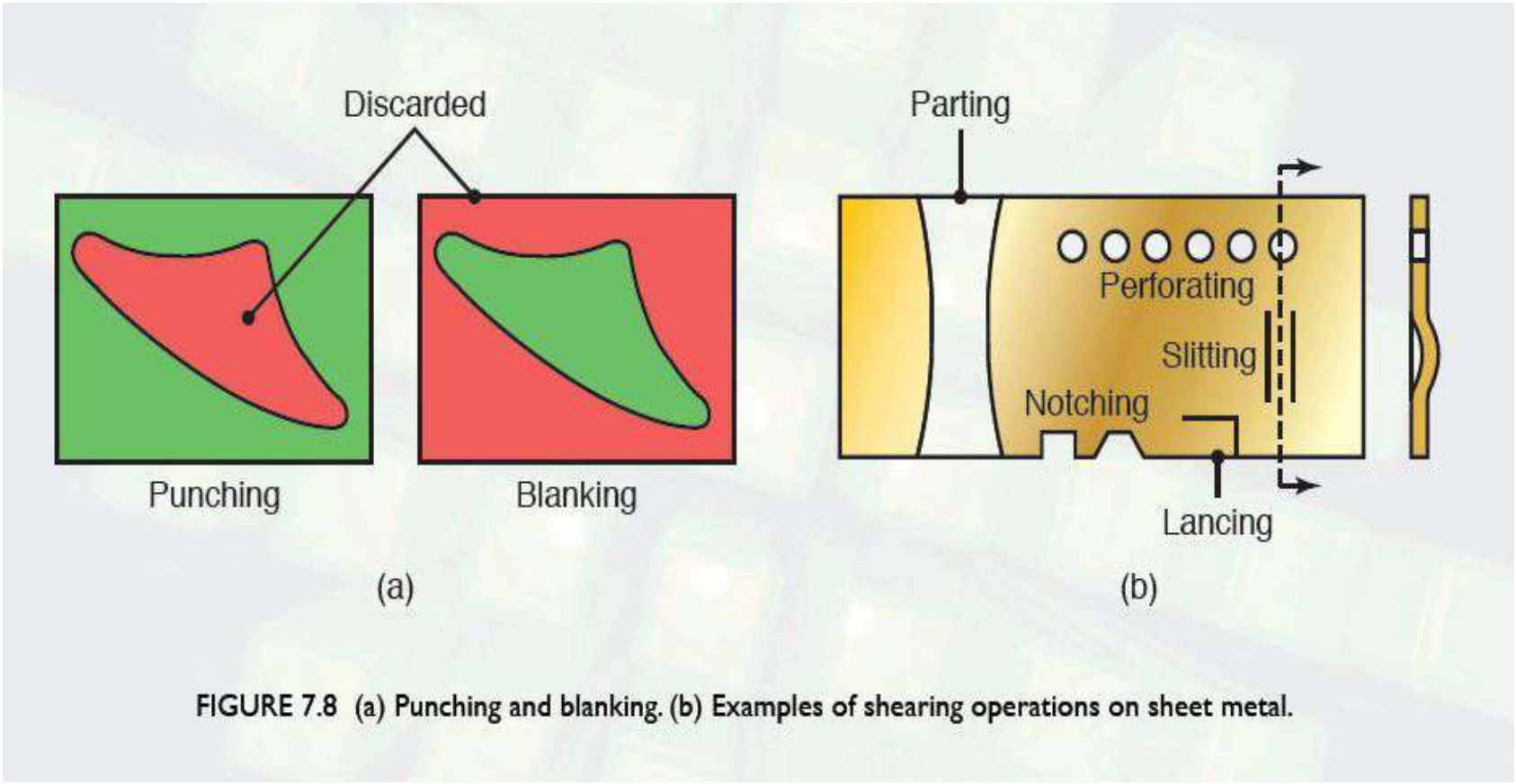
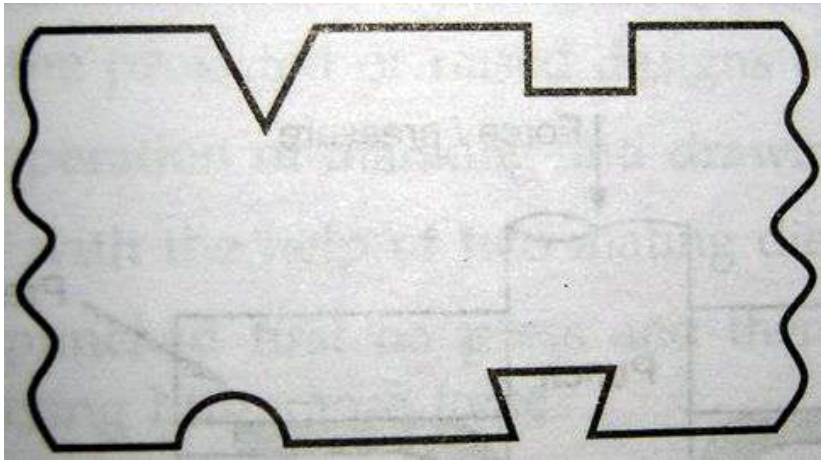
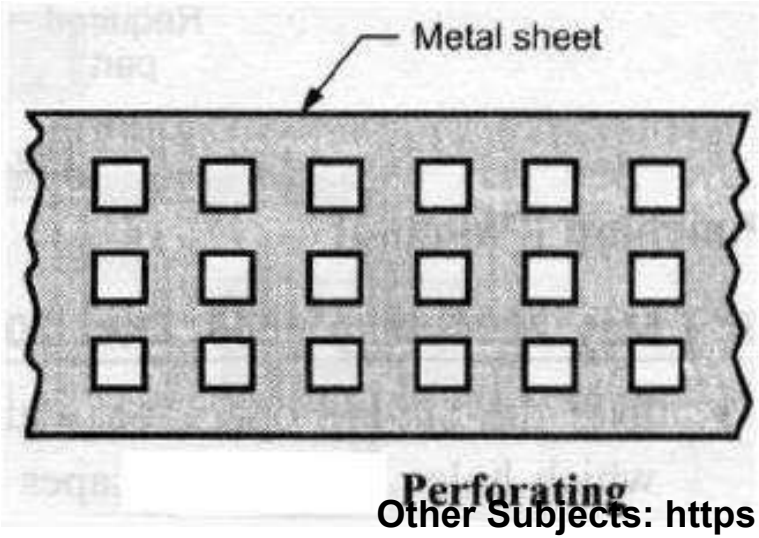


FIGURE 7.8 (a) Punching and blanking. (b) Examples of shearing operations on sheet metal.

Notching- **removal of a small part of a metal sheet of any desired shape.**

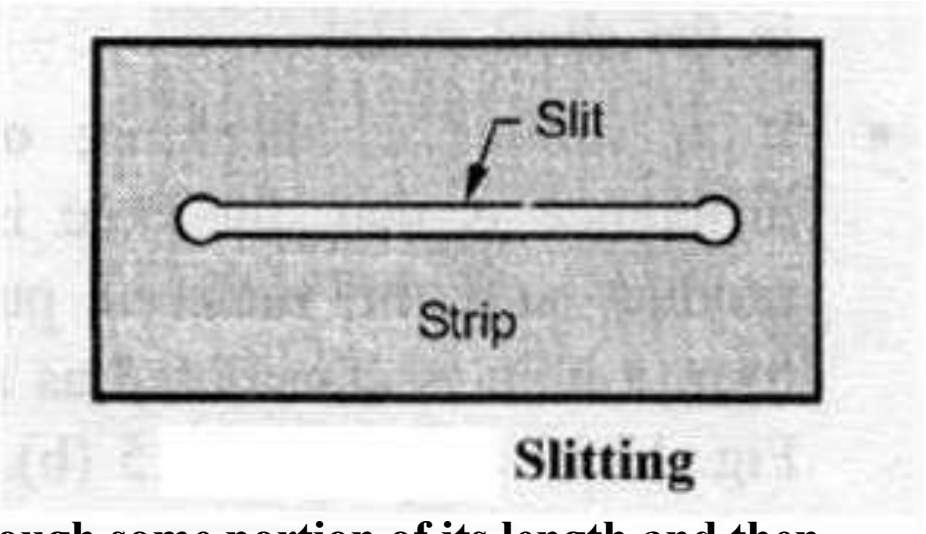


Perforating- **Producing no of evenly spaced holes in a metal sheet.**

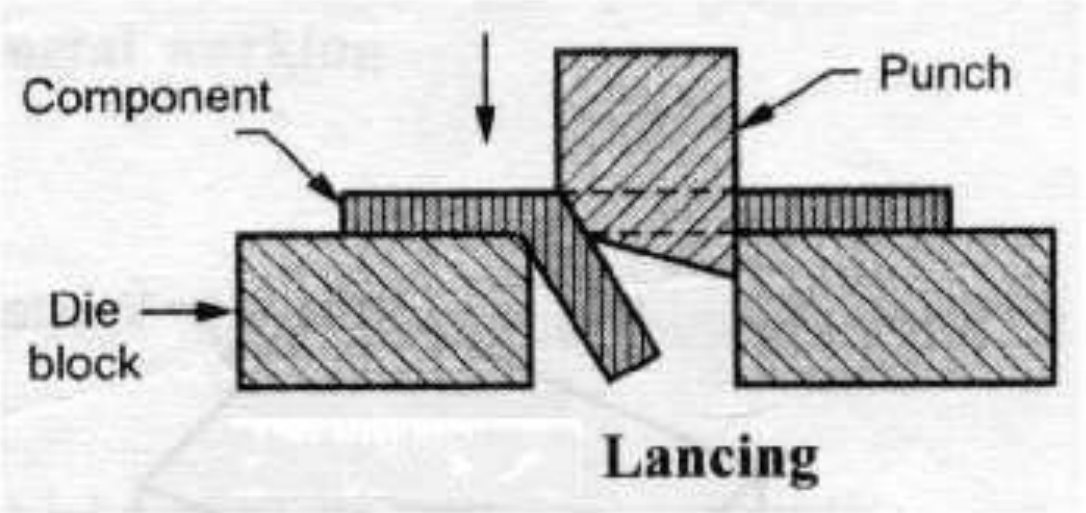


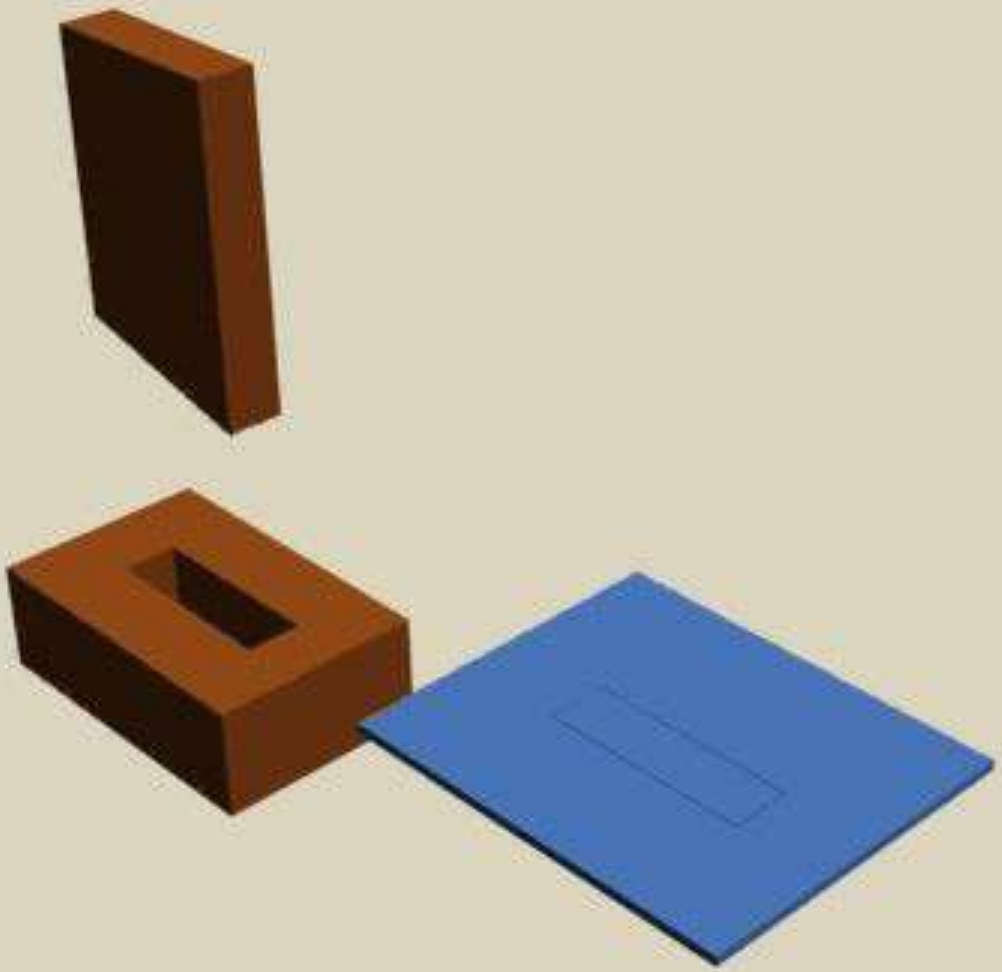
Perforating

Slitting- Cutting a metal sheet in a straight line along a length .



Lancing- Cutting a part of metal sheet through some portion of its length and then bending of cut portion .



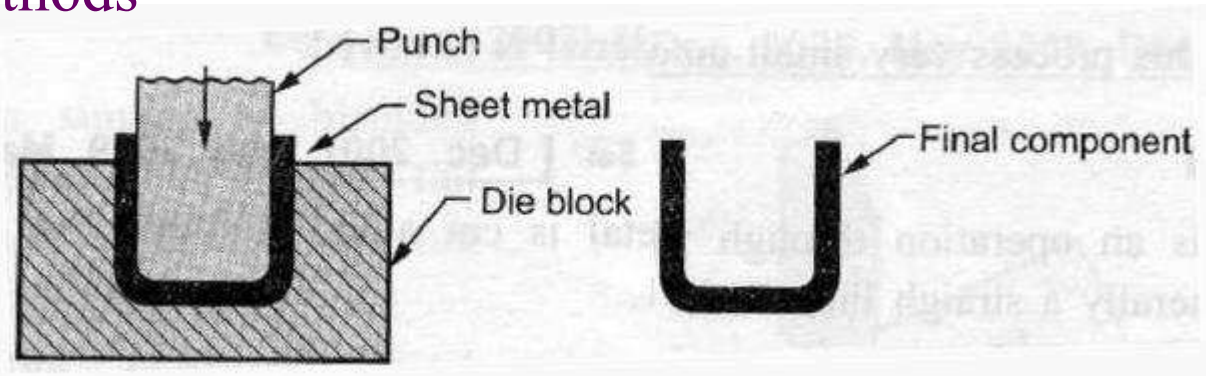


Metal Forming processes

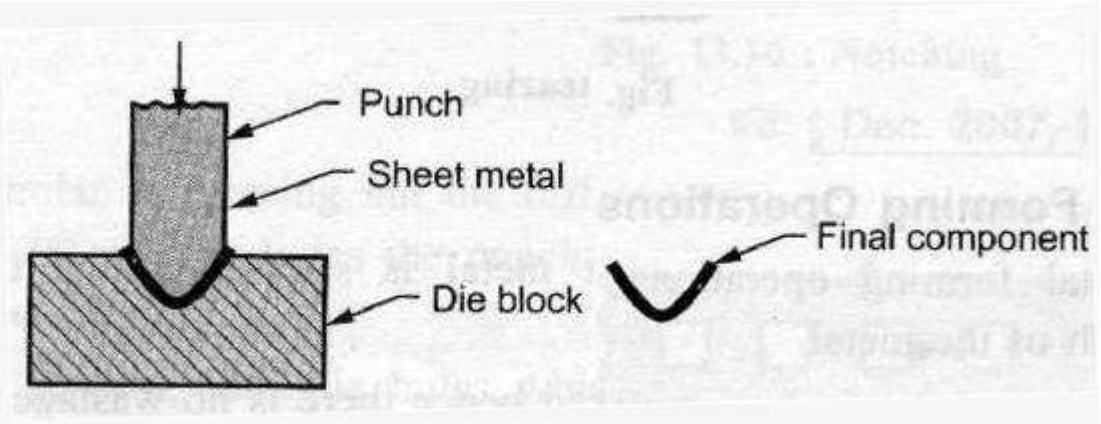
- It is a process in which flat plate metal sheet is converted into a desired shape without wasting the material.

  - **Drawing and deep drawing**
  - **Bending**
  - Forming
  - Coining
  - Embossing

Bending Methods-

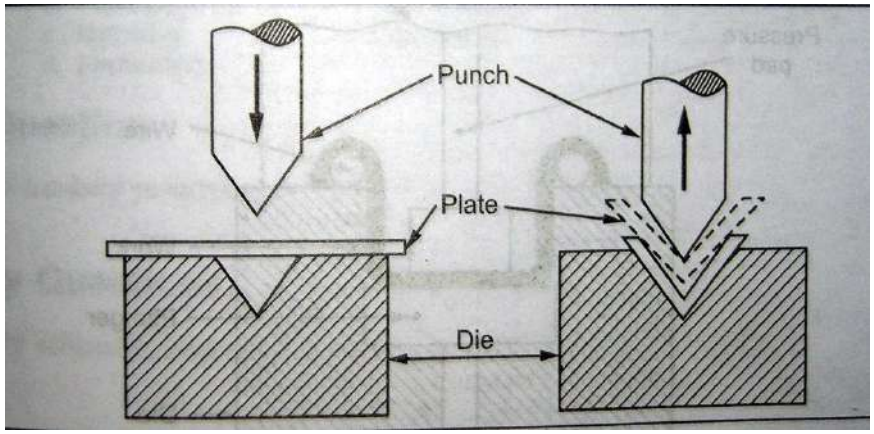


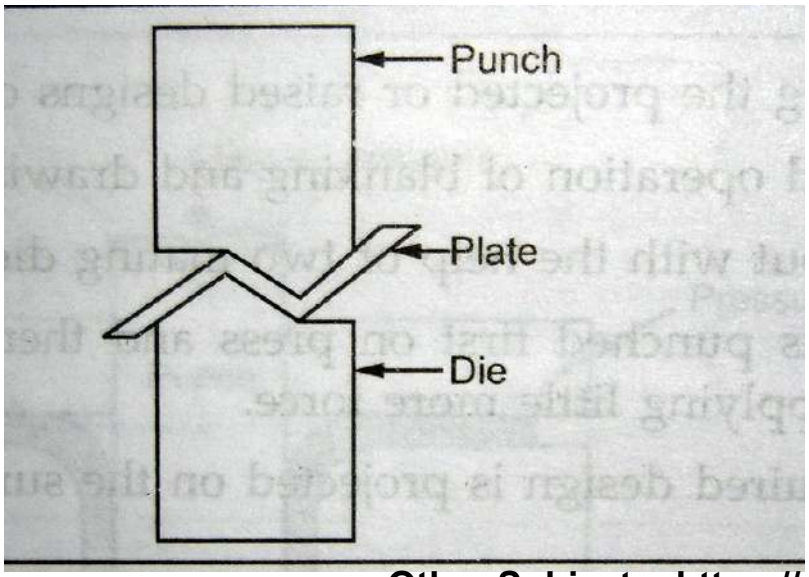
U Bending



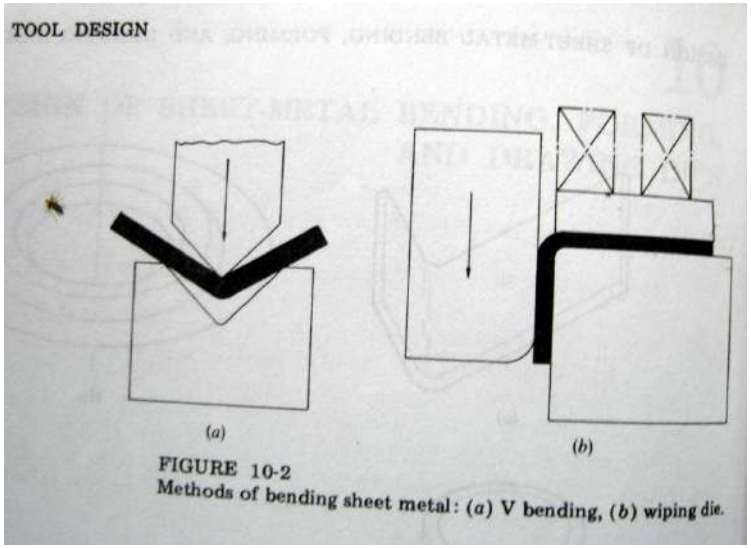
V Bending

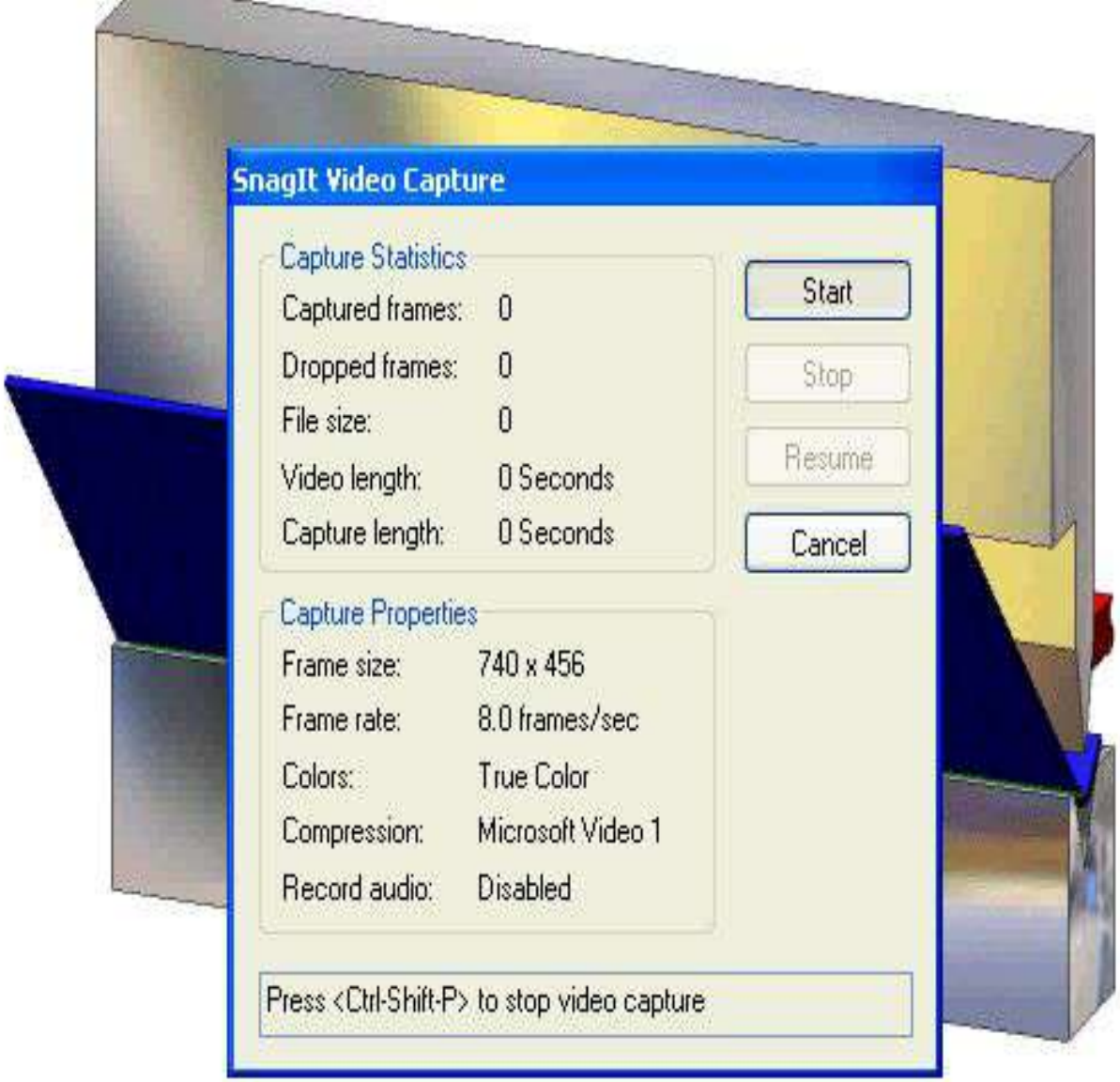
Angle Bending





Bending and wiping/ Edge bending





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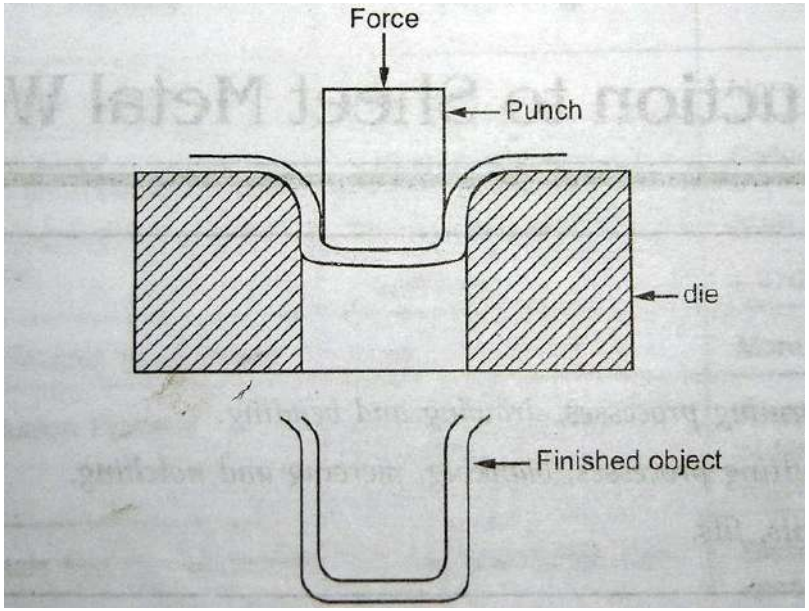
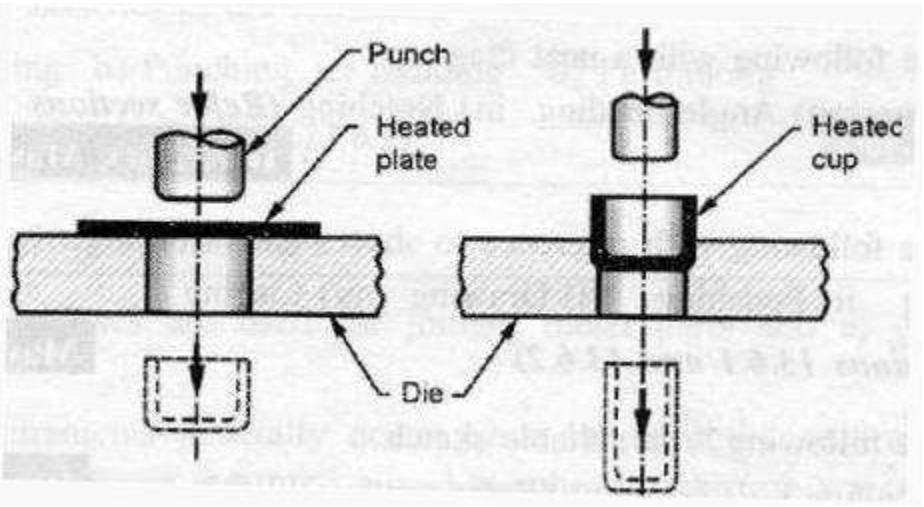
Drawing

process of forming a flat metal sheet into a three dimensional hollow shape.



Drawing



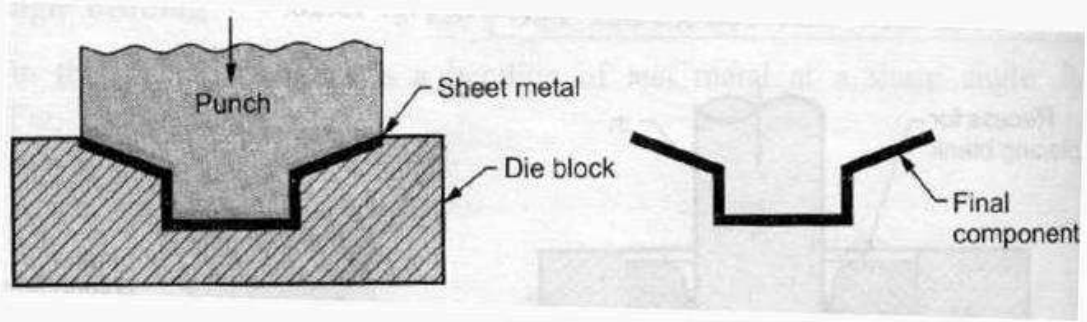
Deep Drawing

Deep drawing

If the depth of hollow cup exceeds the diameter of formed cup, the process is called Deep Drawing.

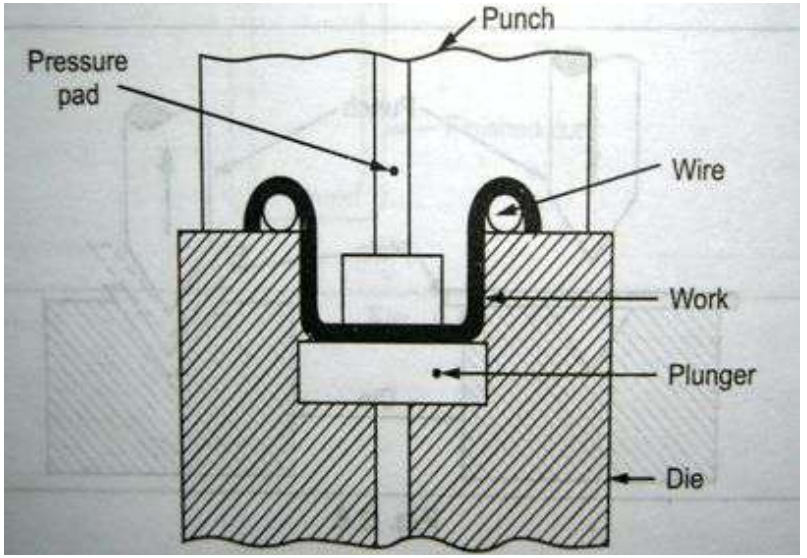
Forming-

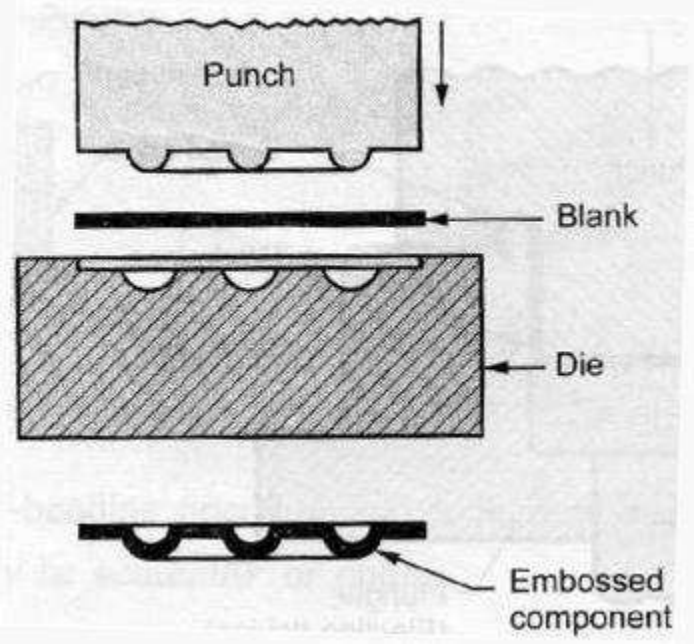
Process of flat metal sheet into a surface of a desired profile.



Curling

an edge of circular cross section is formed along a sheet or at the end of the tube.





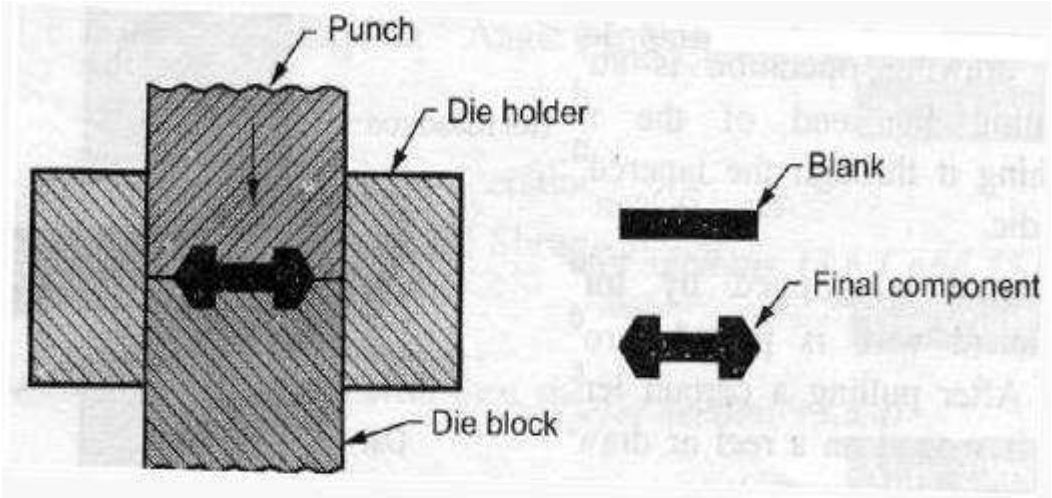
Embossing

Embossing

is the process of producing depressed or raised impression of letters figures or designs on metal sheet.

Coining

is the process of cold squeezing of metal sheet in which all the surface are confined within a set of dies.



Coining (Squeezing)

Advantages:

- Components produced are light in weight.
- Cheap
- Rate of production is high
- High dimensional accuracy
- Not required skilled man power

Limitations:

- Limitation of thickness of metal sheet
- Components have low strength.
- Vibrations are more during operations
- Noisy in operation.
- Dies are costly.

Applications:

- Automobile body parts (bike , car , buses etc), aircraft body parts.
- Steel furniture, Utensils
- Electronics appliances

Kitchen Tools

Machine Parts

Automobile bodies

Aircraft bodies

Sheet metal Working

Systems In Mechanical Engineering

UNIT 5

METAL FORMING PROCESS

Mr. Girish G Khope

- Metal forming process

  is the process in which the component of desired shape and size is obtained through the plastic deformation of the metal under the action of extremely applied force.

FORGING PROCESS

is a metal forming process in which metal is first heated and then plastically deformed to the desired shape and size by the application of compressive force using hand hammer, or a press.

Ductile materials are required. (ability of material to sustain plastic deformation without failure.)

- Alloy Steel, Low Carbon Steel, Medium Steel, Stainless steel
- Copper Alloys
- Aluminum Alloys etc.

Forging Process:

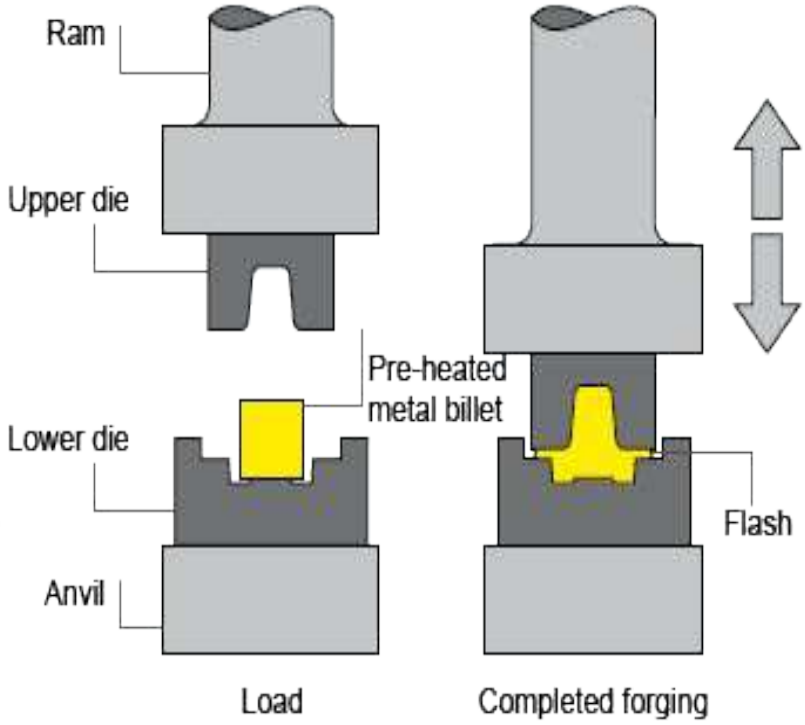
- Forging is the process of shaping heated metal by the application of sudden blows (hammer forging) or steady pressure (press forging) and makes use of the characteristic plasticity of the material.

- In forging process the material is heated to a temperature at which its elastic properties completely disappear. This temperature is known as forging temperature and it varies from material to material.

- Similar to casting the forging is also one of the oldest process of manufacturing metallic components. In ancient days the forging was in use for making the implements of war such as: swords, knives, arrows, protective armour, helmets etc.

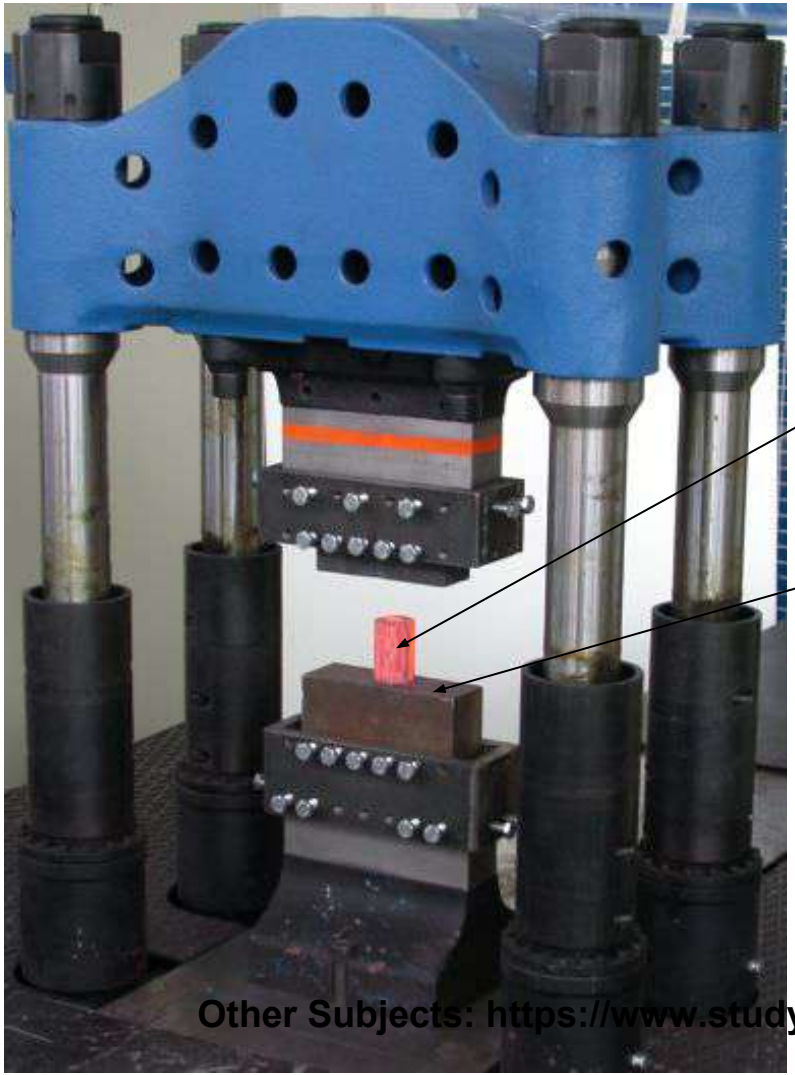
Working principle:

- In forging process, the material (billet) is deformed into the desired shape between two parts called dies.
- The shape of the dies matches with desired shape of the forged component.
- The forging press shown in figure consists of a lower die fixed to the frame (Anvil) while upper die is connected to the ram.
- The hot material is kept on the lower die.
- In mechanical press the ram is driven by the crank shaft through the connecting rod where as in hydraulic press the ram is driven by the hydraulic cylinder.
- During the downward stroke of the ram, the upper die exerts sudden compressive force on the hot material.
- Due to this sudden compressive force the hot material is converted into the desired shape.



Forging

[Heated] metal is beaten with a heavy hammer to give it the required shape



Hot forging,

open-die

Classification

Based on types of dies used, forging process are classified as:

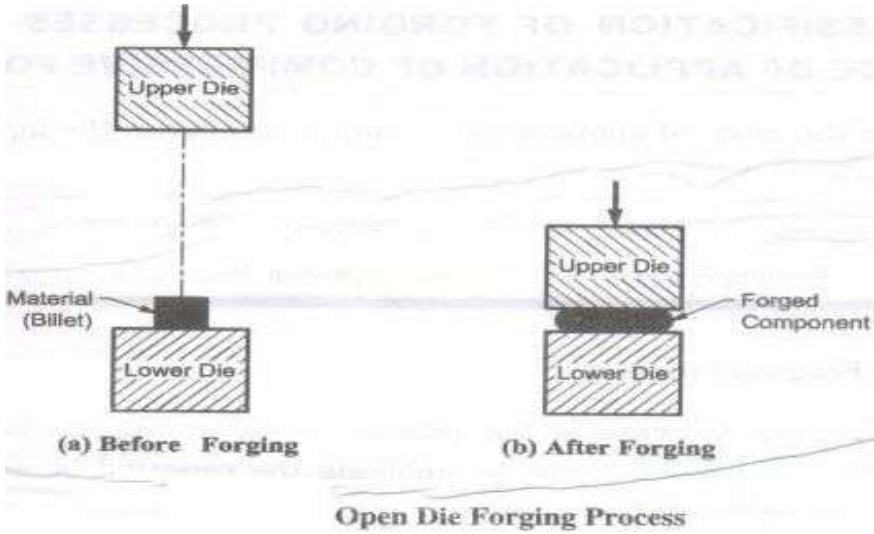
1. Open die forging
2. Closed die forging

Open Die Forging process:

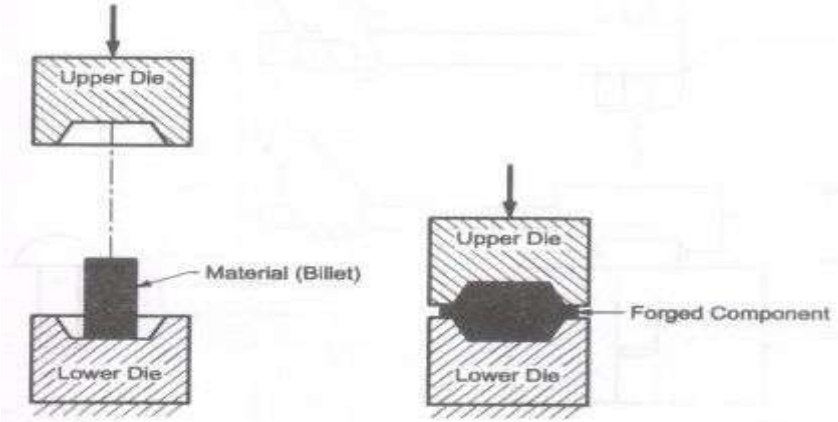
- In open die forging, the material or work piece is deformed between two flat dies or dies of very simple shape.

Closed Die Forging process:

- In closed die forging, the material or work piece is deformed between two dies which have the impression of the desired shape.
- when the two cavities are closed, the cavity formed is of the desired final shape.



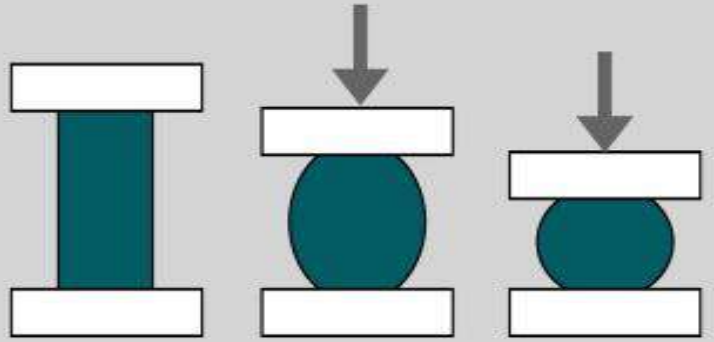
Open Die Forging Process



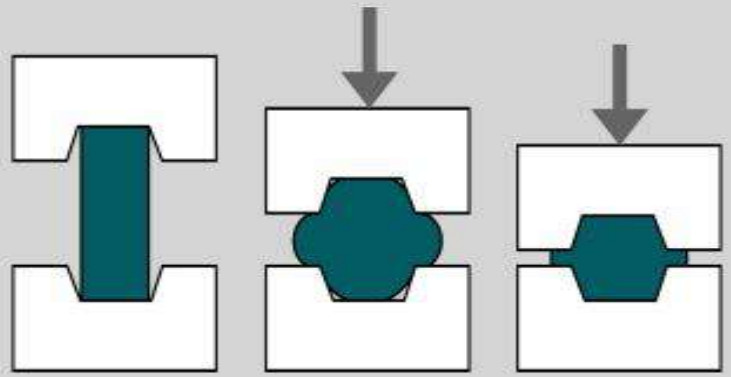
Closed Die Forging Process

Open and Closed Die Forging Processes

(1) OPEN-DIE FORGING



(2) CLOSED-DIE FORGING

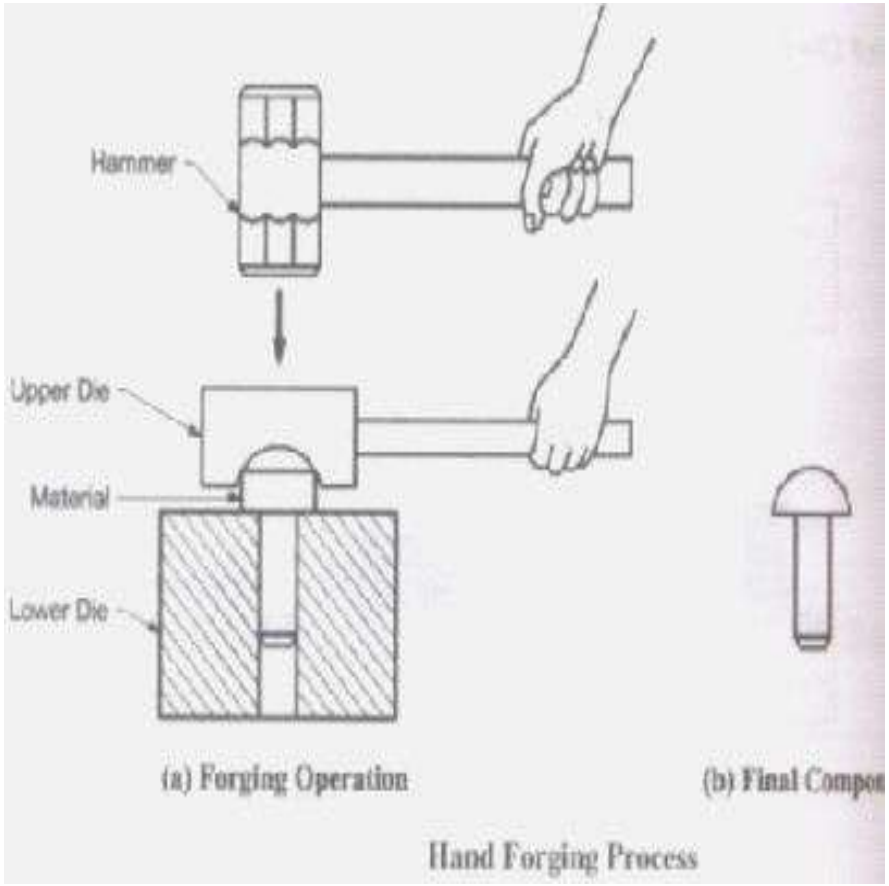


steelavailable.com

Original Source: Suranaree University of Technology

Based on mode of application of compressive force, forging processes are classified as:

1. Hand forging
2. Drop forging
3. Press forging
4. Upset or machining forging



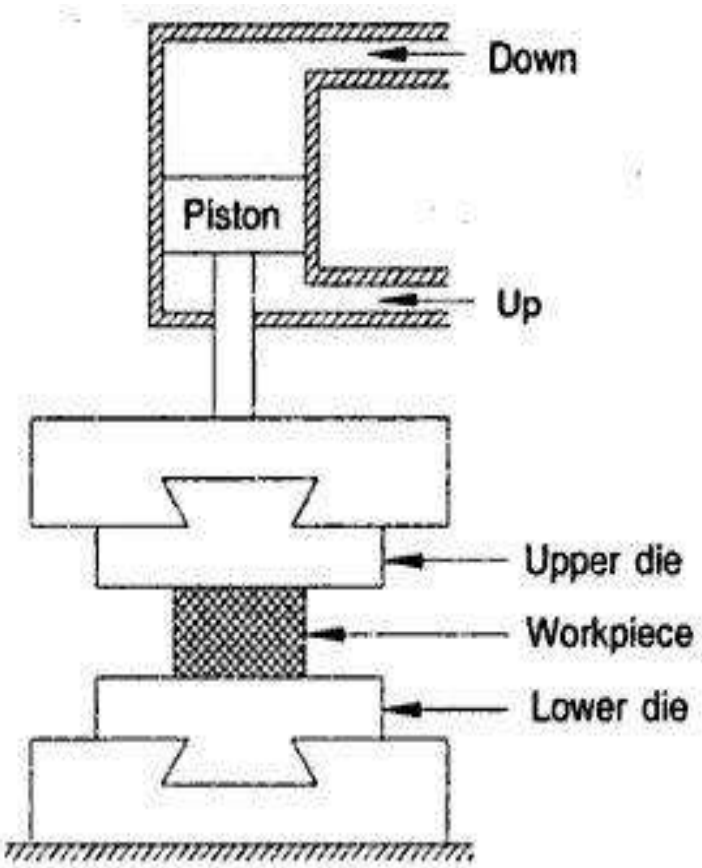
Hand Forging Process

Hand forging:

- It is the process of deforming the hot material or work piece into desired shape by applying repeated blows of hand held hammer.
- In case of hand forging, hammering is done by hand; whereas forging by m/c involves the use of dies and it is mostly used in mass production.

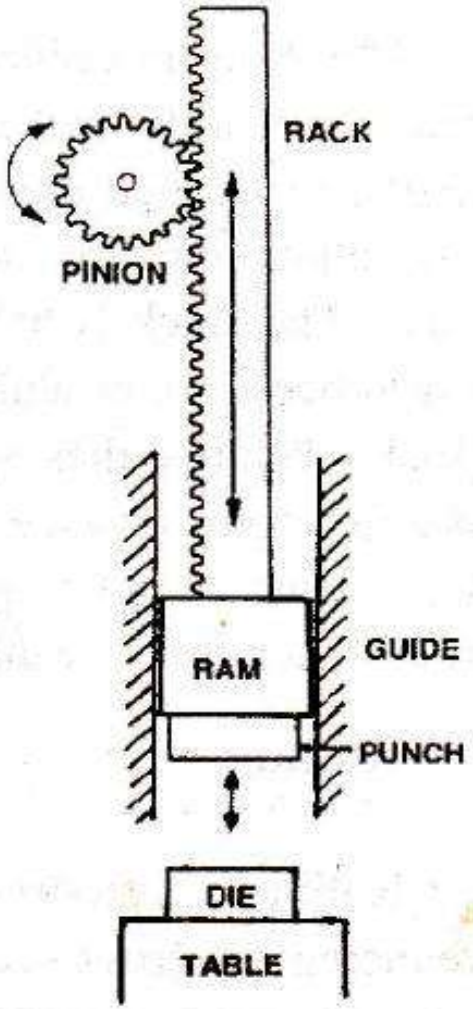
Drop forging:

- It is the process of deforming the hot material or work piece into a desired shape by raising the die with the help of arrangement like pneumatic cylinder and allowing it to fall so as to impart the blow or impact on the material.
- In this process the lower die is fixed to the frame while the upper die is attached to the ram which reciprocates in a guide.
- The ram is connected to the piston through the piston rod.
- It is important to note that the purpose of pneumatic cylinder is mainly to lift the ram and upper die unit to the required height. The pneumatic cylinder does not control but assist the fall of ram and upper die unit.



press forging:

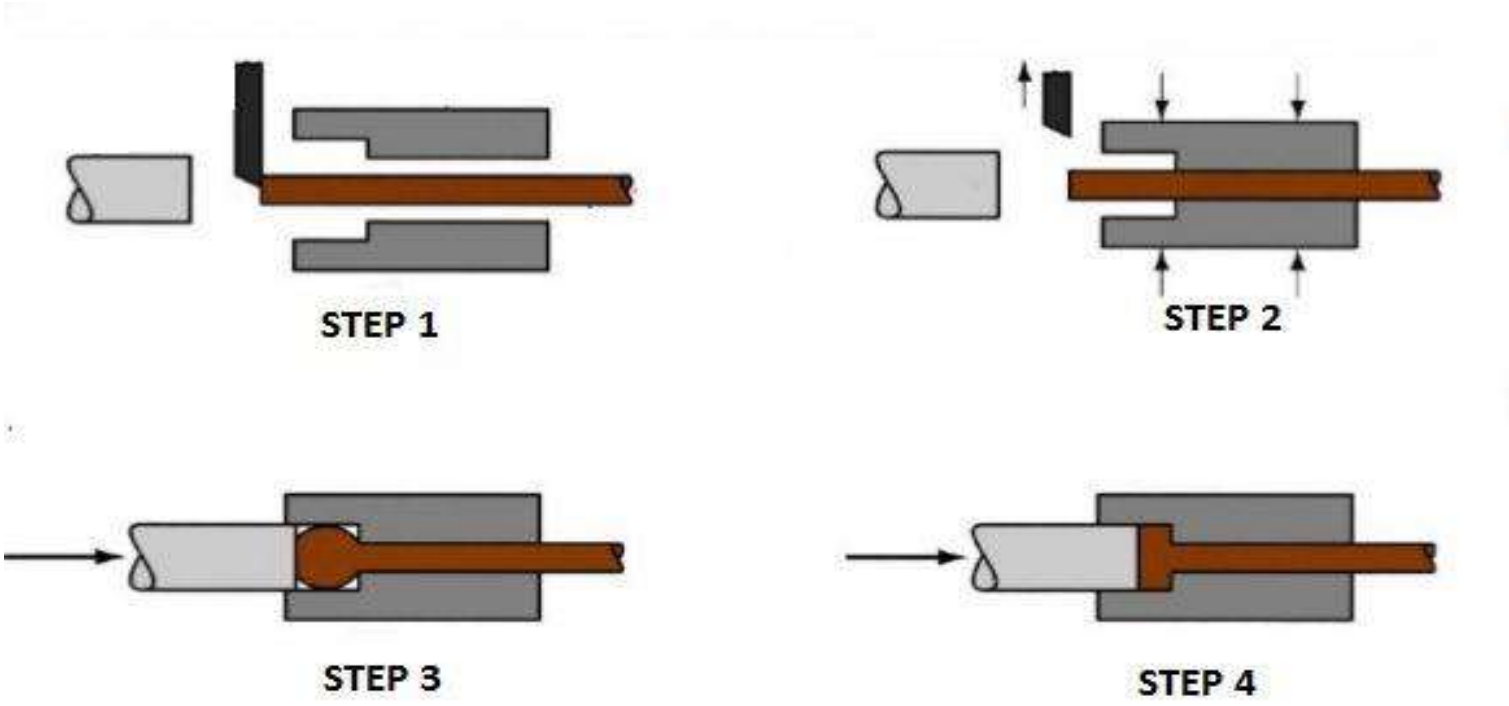
- It is the process of deforming the hot material or work piece into a desired shape by slow squeezing action.
- The gradual motion of the upper die transfers the compressive force uniformly and gradually to the hot material so as to deform it to the desired shape.
- Unlike hand forging and drop forging processes, in press forging process there is no blow or impact.



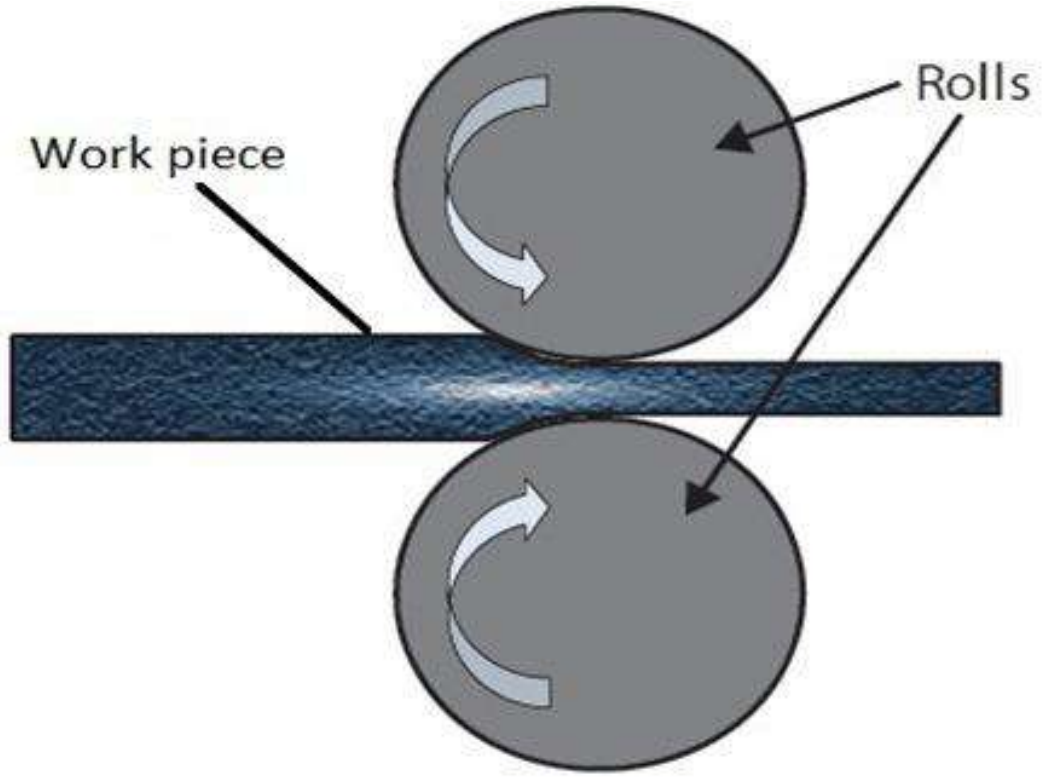
Press Forging

Machine or Upset forging

– The cross section of the hot material or workpiece is increased locally with a corresponding reduction in it's length by slow squeezing action.



- **Roll Forging-**
  - long cylindrical products- axle, leaf spring, tapered levers.



ROLL FORGING

Mechanical working of metals

- Mechanical working of metals is simply plastic deformation of metal performed to change the dimension, properties and surface condition with the help of mechanical pressure.

- Depending upon the temperature and strain rate, mechanical working may be either Hot working or Cold working.

- Process of formation of new grains is called as recrystallisation and the corresponding temperature is the recrystallisation temperature.

- Recrystallisation temperature is the point which differentiates hot working and cold working.

- Mechanical working of metals above the recrystallisation temperature, but below the melting or burning point is known as hot working, whereas below the recrystallisation temperature is known as cold working.

Hot Forging(Isothermal Forging)

- Hot Forging is accomplished at a temperature above the recrystallisation temperature but below the melting or burning point of the metal, because above the melting point, the metal will burn and become unsuitable for use.

- Material is heated extremely at high temp.
  - (For Steel-up to 1200 ^{0}c, Al Alloys- 525 ^{0}c)

- Every metal has a characteristic hot working temperature range over which hot working may be performed.

- The changes in structure from hot working improves mechanical properties such as ductility, toughness, resistance to shock and vibration, % elongation, % reduction in area, etc.

Cold Forging

- The working of metals at temperatures below their recrystallisation temperature is called as cold working.
- Most of the cold working processes are performed at room temperatures.
- Unlike hot working, it distorts the grain structure and does not provide an appreciable reduction in size.
- Cold working requires much higher pressure than hot working.
- If the material is more ductile, it can be more cold worked.
- Residual stresses are setup during the process, hence to neutralize these stresses a suitable heat treatment is required.

Difference between Cold &Hot Working Forging

Parameters	Hot Working Forging	Cold Working Forging
Definition	It is Defined as the deformation of the material into predetermined shape carried out at a temperature above its recrystallation temperature.	It is Defined as the deformation of the material into predetermined shape carried out at a temperature below its recrystallation temperature.
Force & Energy required	Low	High

Parameters	Hot Working Forging	Cold Working Forging
Dimensional accuracy	Poor (due to thermal contraction during cooling)	Good
Machine requirement	Light	Heavier and Powerful
Ductility of component	Increases	Decreases
Type of materials	Need not be soft	Soft like Aluminum
Strain Hardening effect	Absent	Present

Materials used for forging:

- Must be ductile material.
- Examples: low and medium carbon steels, alloy steels, stainless steels, copper alloys, aluminum alloys etc

Advantages:

- Forging process gives high dimensional accuracy and good surface finish.
- As the forging process gives high dimensional accuracy it reduces the material removal during machining and finishing operations.
- This process reduces the grain size, which results in improving the strength and toughness of the forged components.
- It produces components without shrinkage cavities, blow holes and machining scratches which increases the endurance strength of the parts.
- Forged components offer better resistance to shock and vibrations.
- Welding of forged parts is easier.

Limitations:

- Brittle like cast iron can not be forged.
- Difficult to produce complex components with intricate shapes by forging process.
- Normal forged components cost more than cast components.
- The cost of forged dies is high.
- Forging process is mostly suitable for large parts.
- More noise and vibrations are produced during the process.

Applications of Forging process:

1. Car axles, crankshafts, connecting rods, leaf springs, crane hooks, jet engine turbine dies and blades.

2. Levers, flanges, propellers, hollow bodies, railway wheel disks, tank bottoms.

3. Aircraft and rocket parts, knife blades, bolts, nuts, washers, collars, gear blanks, etc.

Applications of Forging process:

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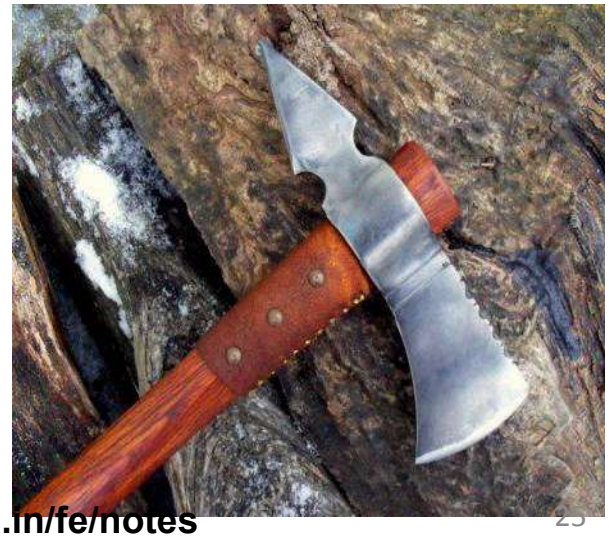


Systems In Mechanical Engineering

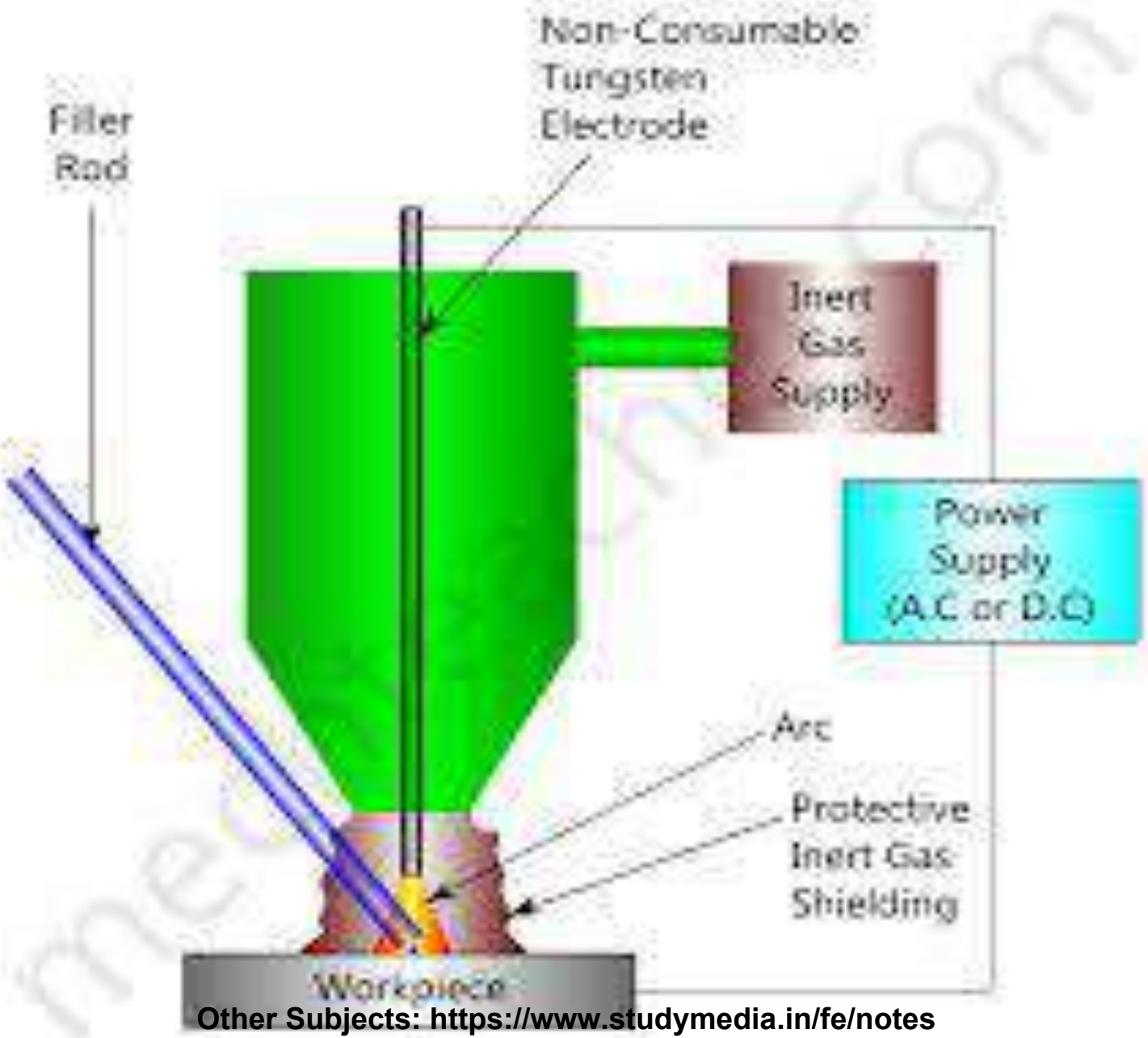
UNIT 5

METAL JOINING PROCESSES

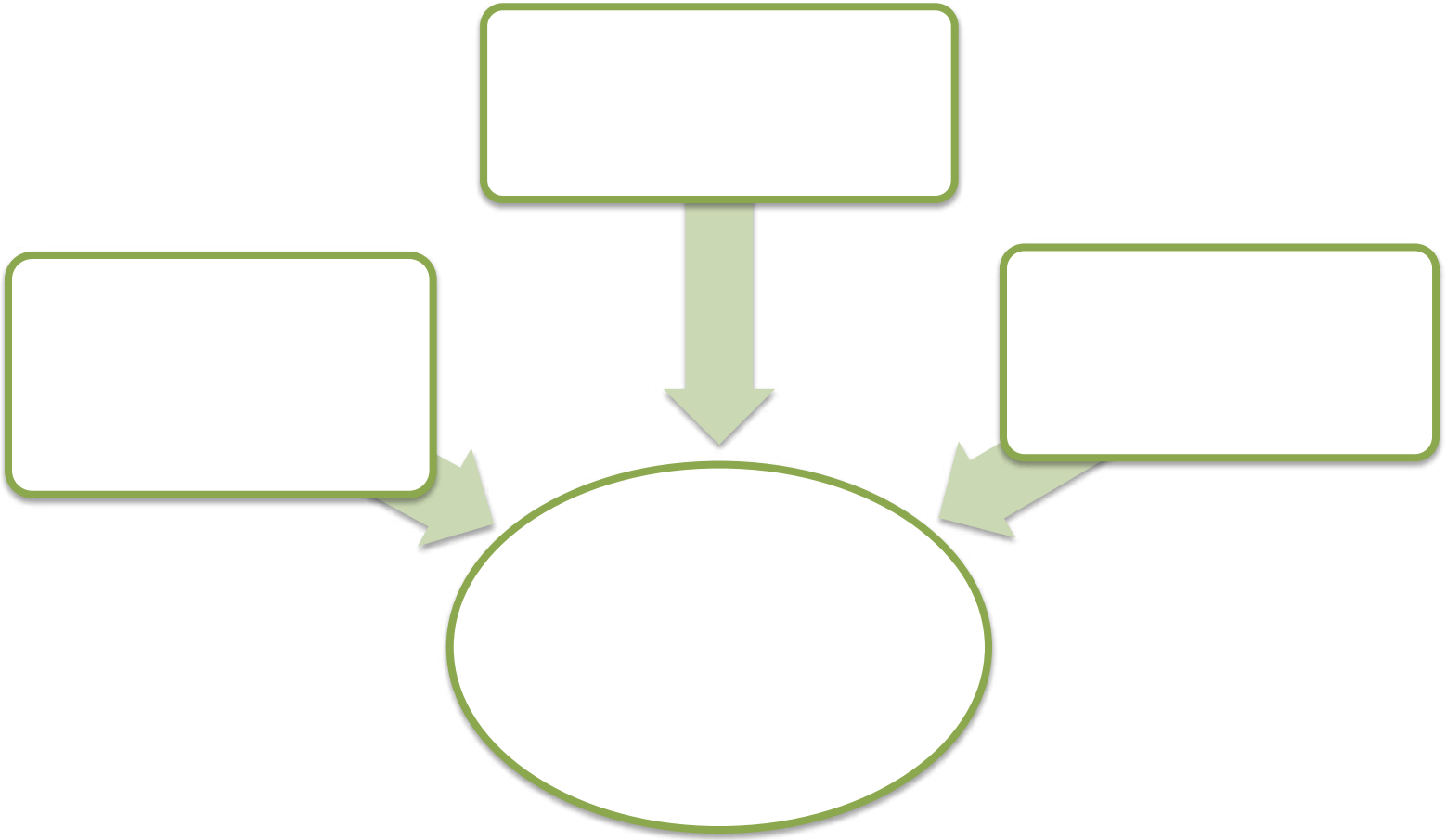
Mr. Girish G Khope

Welding

- **Welding** is the process of joining two plastic or metal parts by melting them, with or without using a further molten material.
- Welding is a process of joining two metal pieces by the application of heat.
- *The heat produced by an arc is used in **welding** to melt metal rods, which solidify to provide a strong joint between two metal surfaces.*
- *Special helmets must be worn when doing **welding** to protect the eyes*
- Welding is the least expensive process and widely used now a days in fabrication.
- Welding joints different metals with the help of a number of processes in which heat is supplied either electrically or by mean of a gas torch.
- Different welding processes are used in the manufacturing of Auto mobiles bodies, structural work, tanks, and general machine repair work.

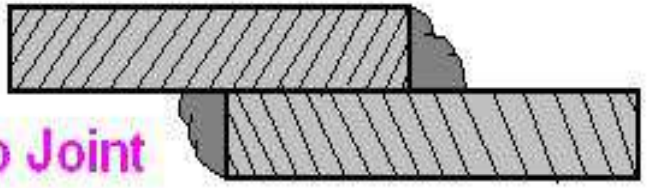


Welding

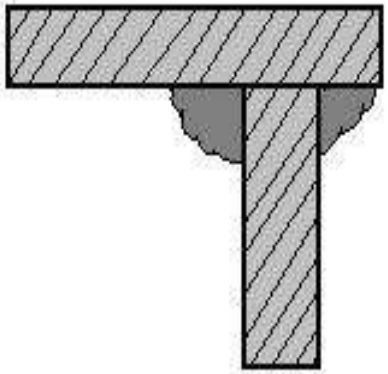


Welding Joints

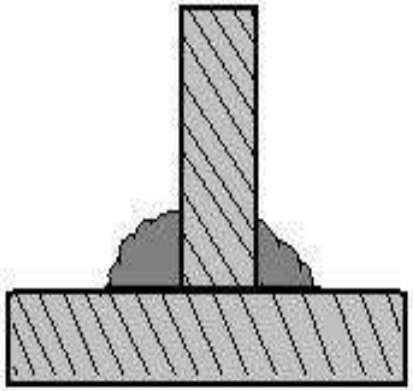
Butt Joint



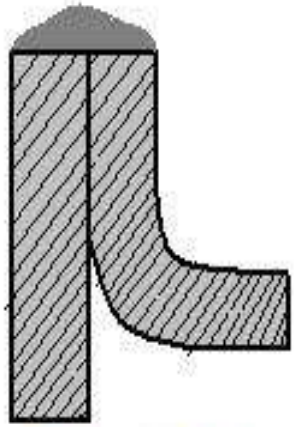
Lap Joint



Corner Joint



Tee Joint



Edge Joint

TYPES OF WELDING

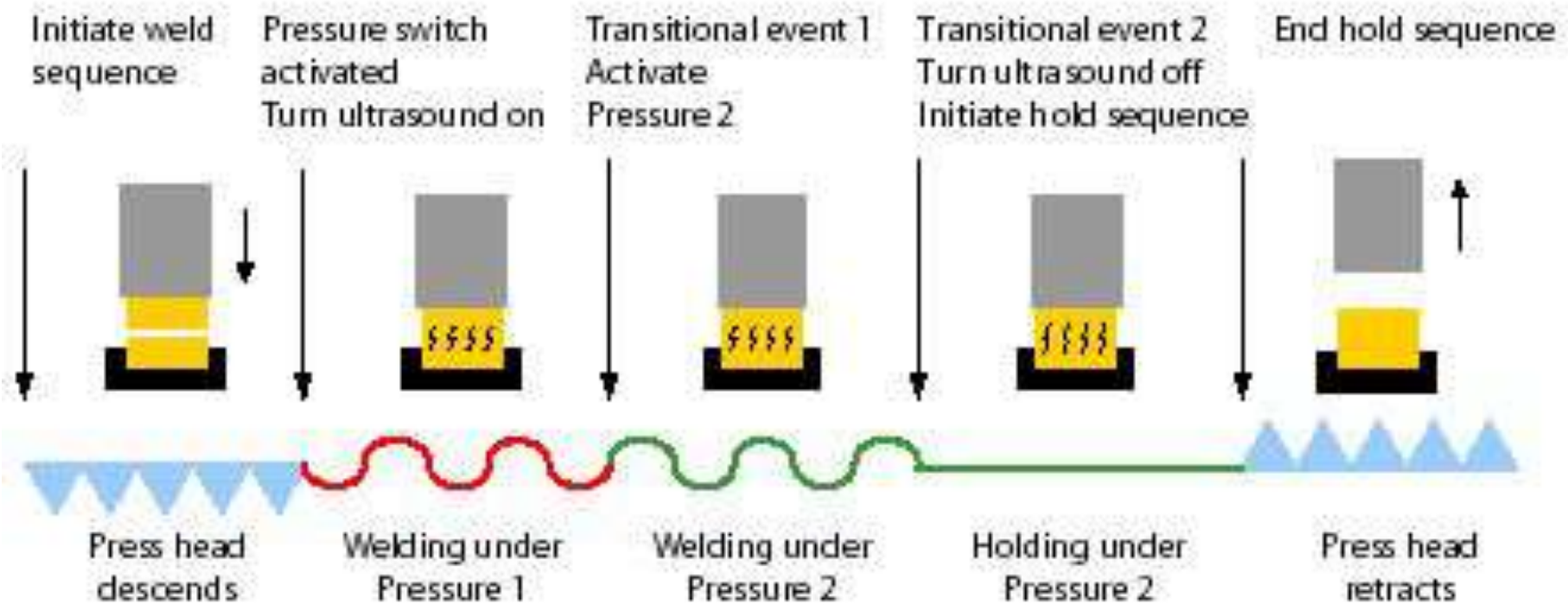
Pressure Welding (Plastic Welding):-

- **Pressure welding** is a process in which external **pressure** is applied to produce welded joints either at temperatures below the melting point, which is solid state **welding**, or at a temperature above the melting point, which is fusion state **welding**.

- In this process, metal pieces to be welded are heated to a temp. so as to make them plastic and then forced together by external pressure.

- This process does not require additional metal for completing the weld.

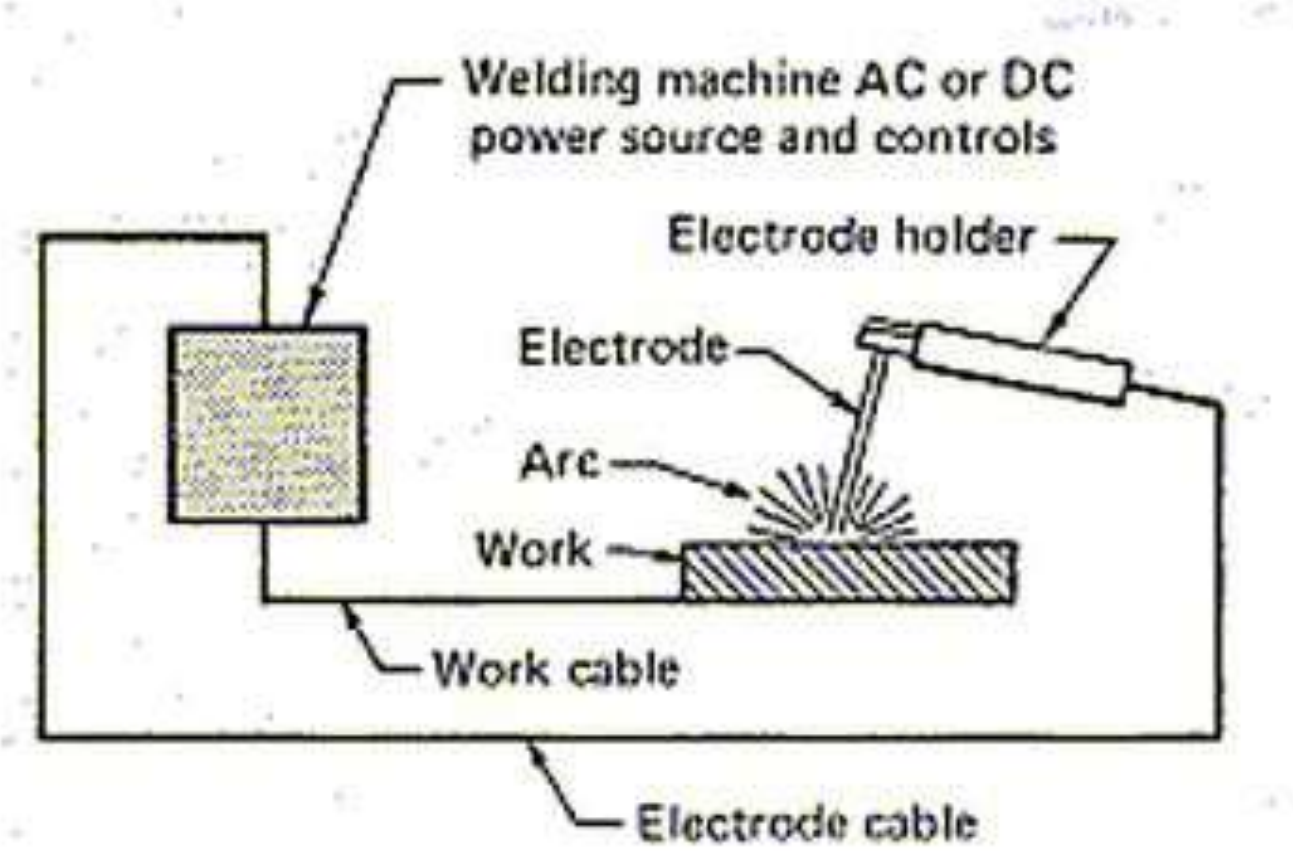
Pressure Welding (Plastic Welding):-



Fusion Welding (Non-Pressure Welding):-

- In this process, metal pieces to be welded are heated to molten (fusion) state & allowed to solidify.
- No pressure is required in this process.
- Additional metal is generally supplied by filler rod (welding rod) to complete the joint.
- The material at the joint is heated to a molten state and allowed to solidify
- (Ex) Gas welding, Arc welding

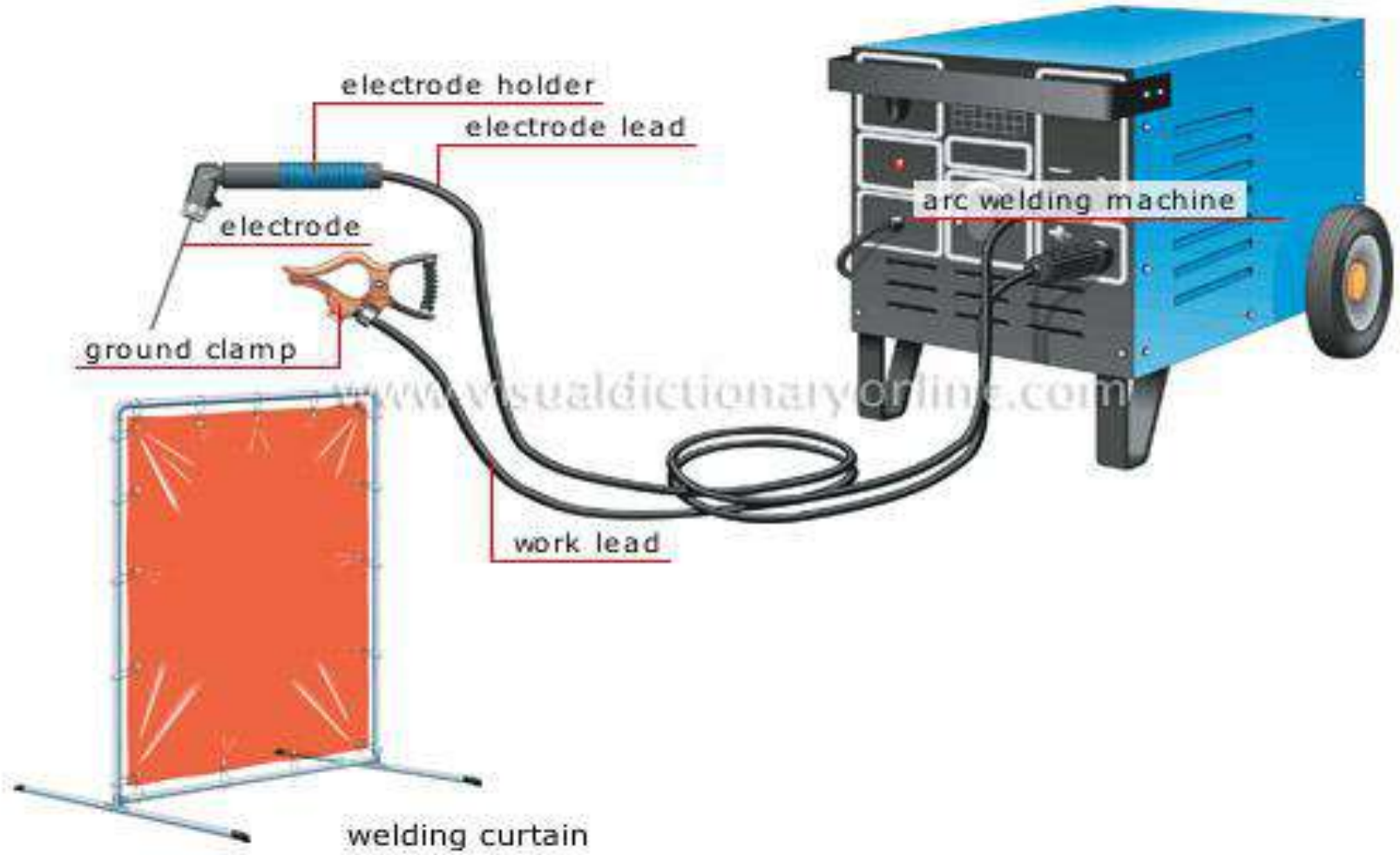
Fusion Welding (Non-Pressure Welding)



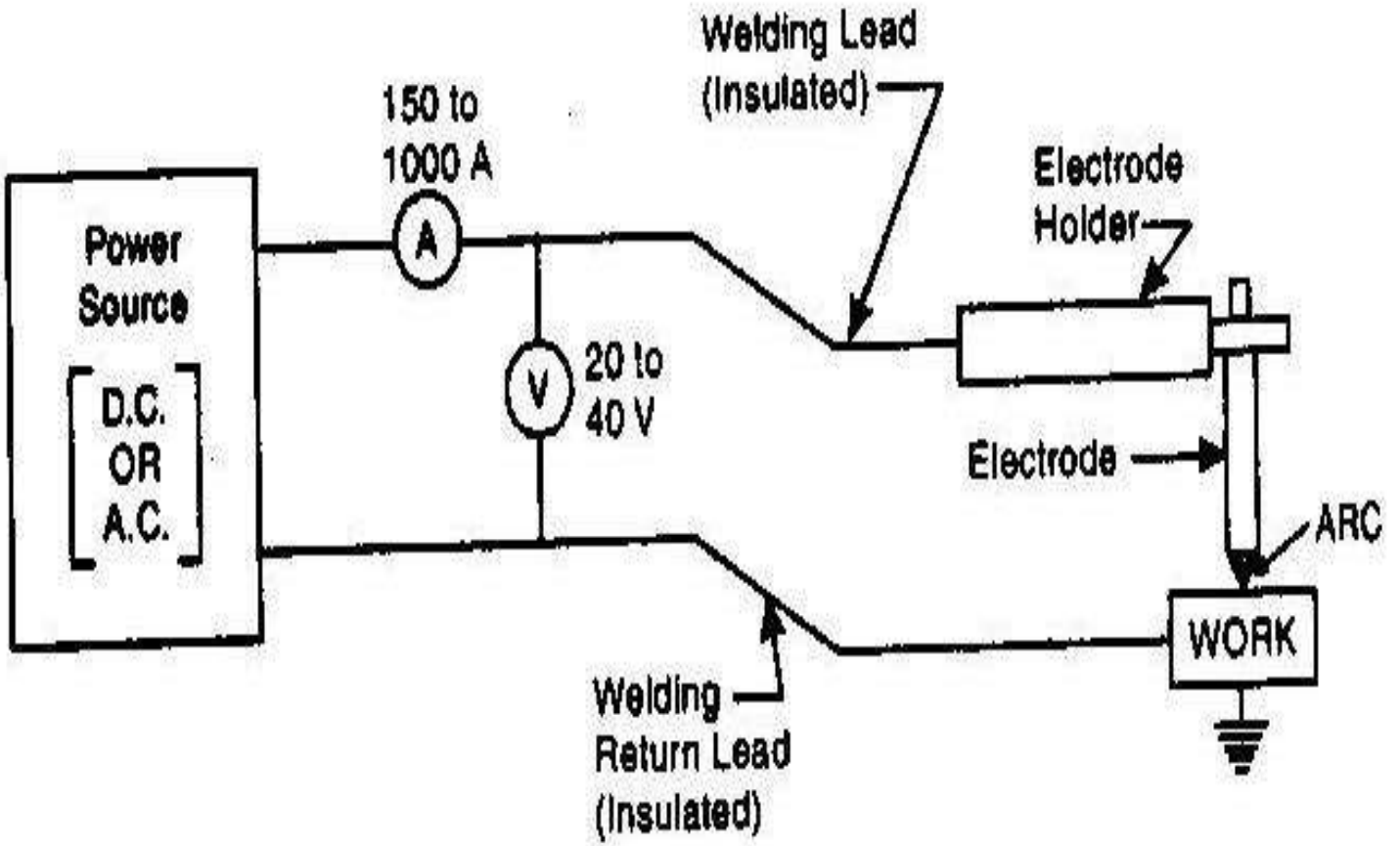
Electric Arc Welding

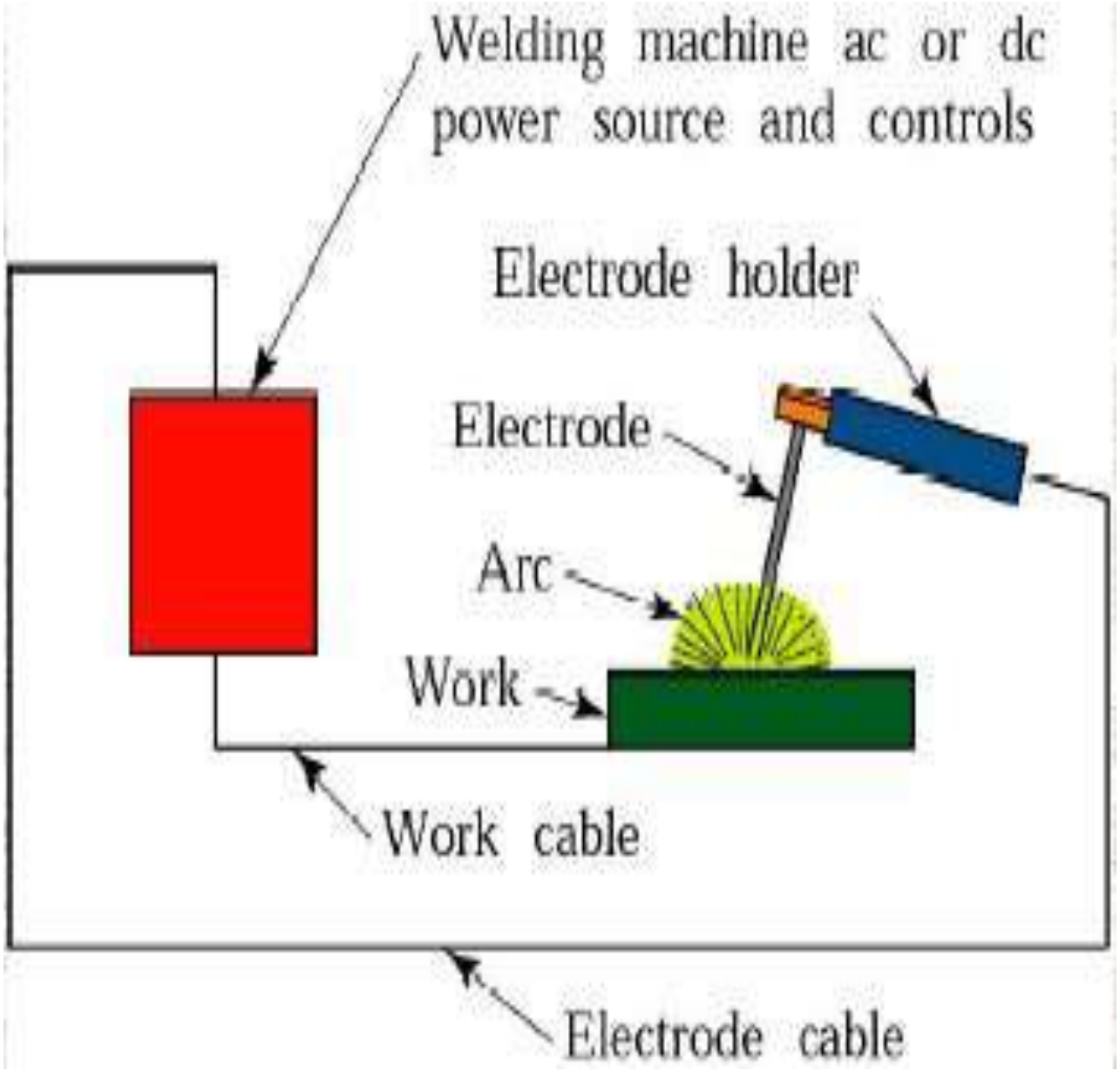
- It is a fusion welding process, in which welding heat is obtained from an electric arc between electrode & work.
- The electrode is first allowed to touch the work to form an electric circuit and then separated by a small distance (4 to 6 mm), so that current continuously flow through the gaseous medium.
- The temp. produced by an electric arc is about 6000°C to 7000°C.
- The base metal is melted by the temp. of the arc, forming a pool of molten metal which is forced out of the pool by blast from the arc.
- Metal of the electrode also gets melted & deposited at the weld.
- Either A.C. or D.C. is used for arc welding.

Electric Arc Welding



Electric Arc Welding





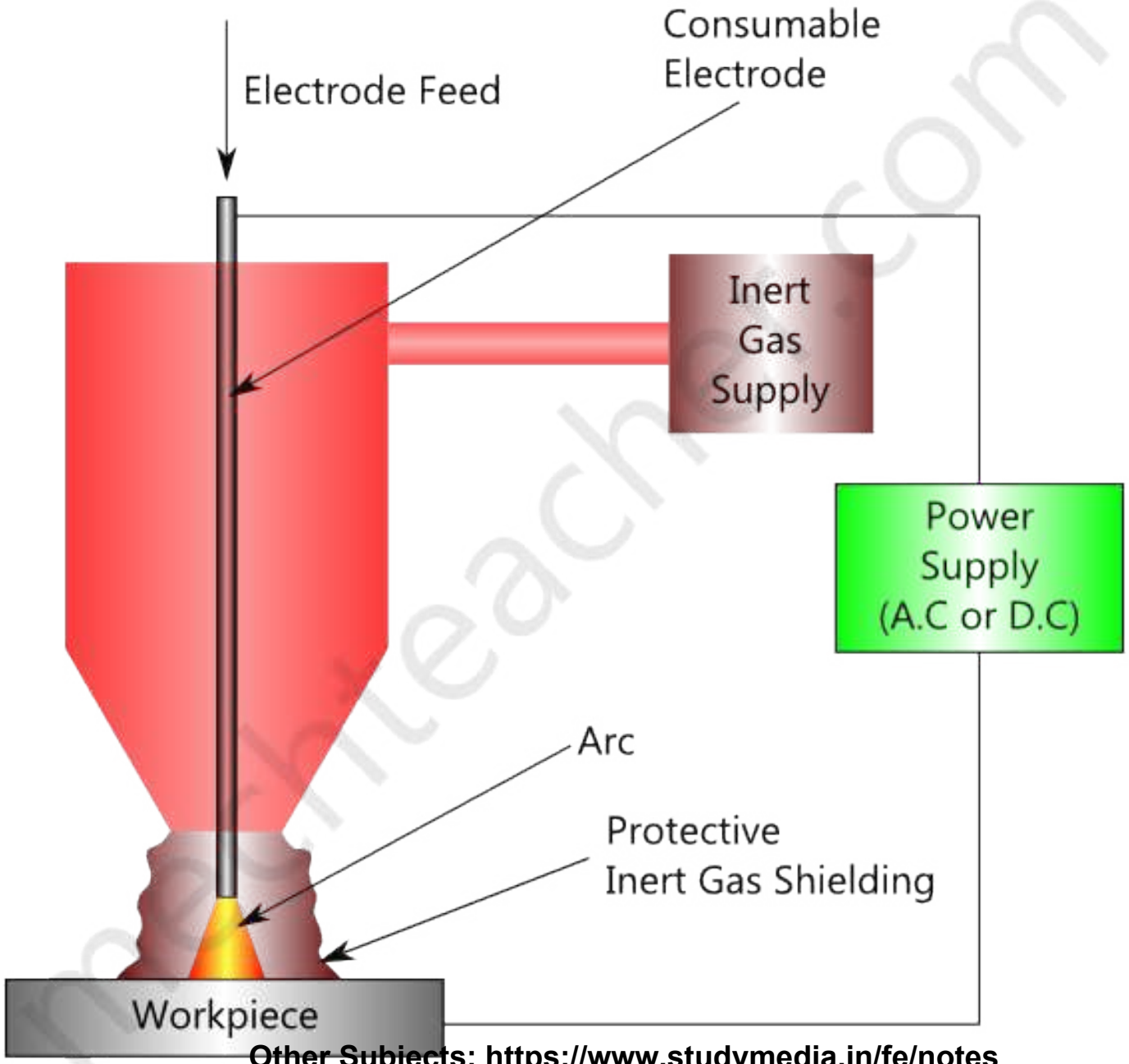
Metal Inert Gas Welding (MIG)

- The workpiece to be welded and the consumable electrode (in the form of wire) are connected to the Power Supply (D.C or A.C).

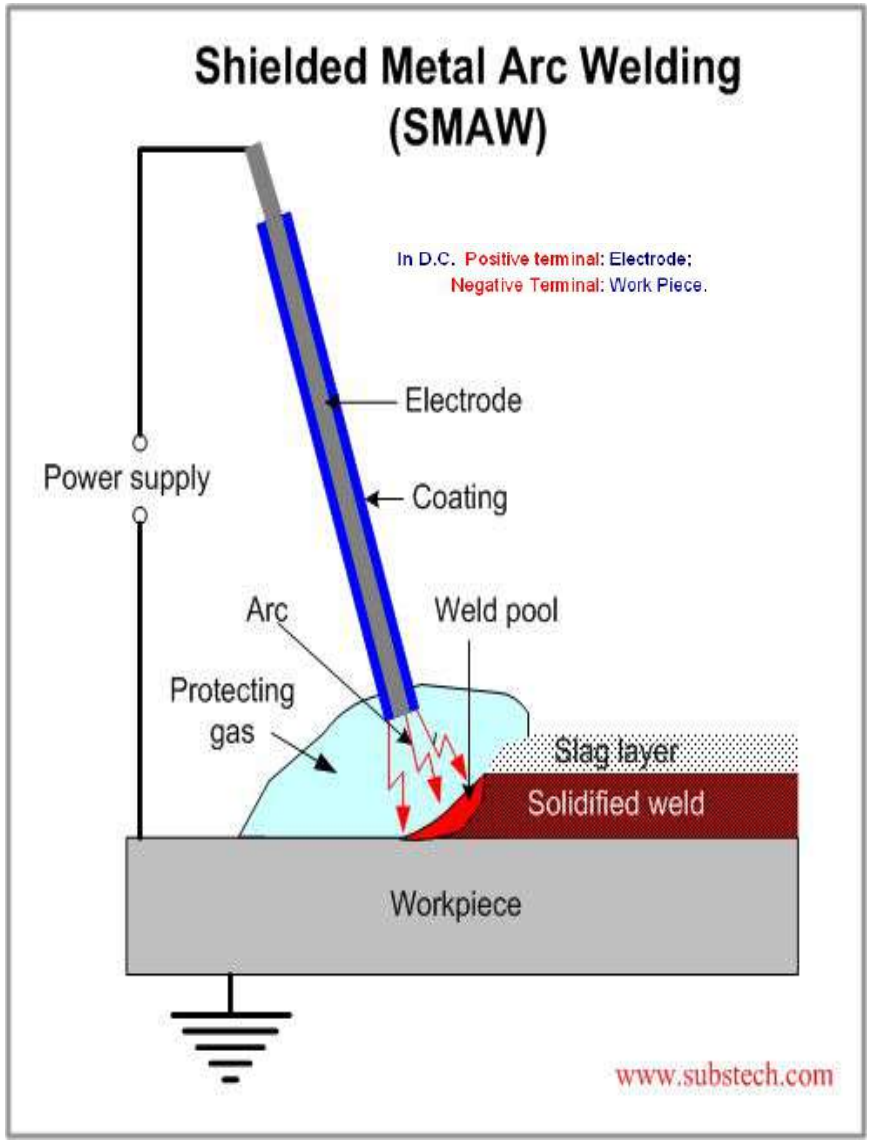
- Whenever the consumable electrode is brought near the workpiece (with a small air gap), an arc is produced. This arc melts the electrode.

- The melted electrode fills uniformly over the required regions of the workpiece.

- An inert gas supply is provided around the electrode (hence the name 'Metal Inert Gas Welding'). **During the welding process ,it forms a gas shield around the arc and the weld This is intended to protect the weld from the external atmosphere.**



Shielded Metal Arc Welding (SMAW)



- The arc temperature produce immense heat with temp. ranging from 2400^0C to 4000^0C
- **The electrodes are coated with a shielding flux (Borax flux) of a suitable composition.**
- Heat is generated by an electric arc between flux coated consumable metal electrode and the work piece.
- **Consumable electrodes** usually have a coating on its outer surface which on melting release gases like **hydrogen or carbon dioxide** to form a protective covering around the molten pool from atmosphere contamination.

Advantages of Welding:

- Gives light weight construction.
- High strength joint.
- High rate of production.
- Ability to produce complicated shapes.
- Used effectively for repairing broken parts.
- Low cost process.
- Ability to produce fluid tight joints.

Limitations of Welding:

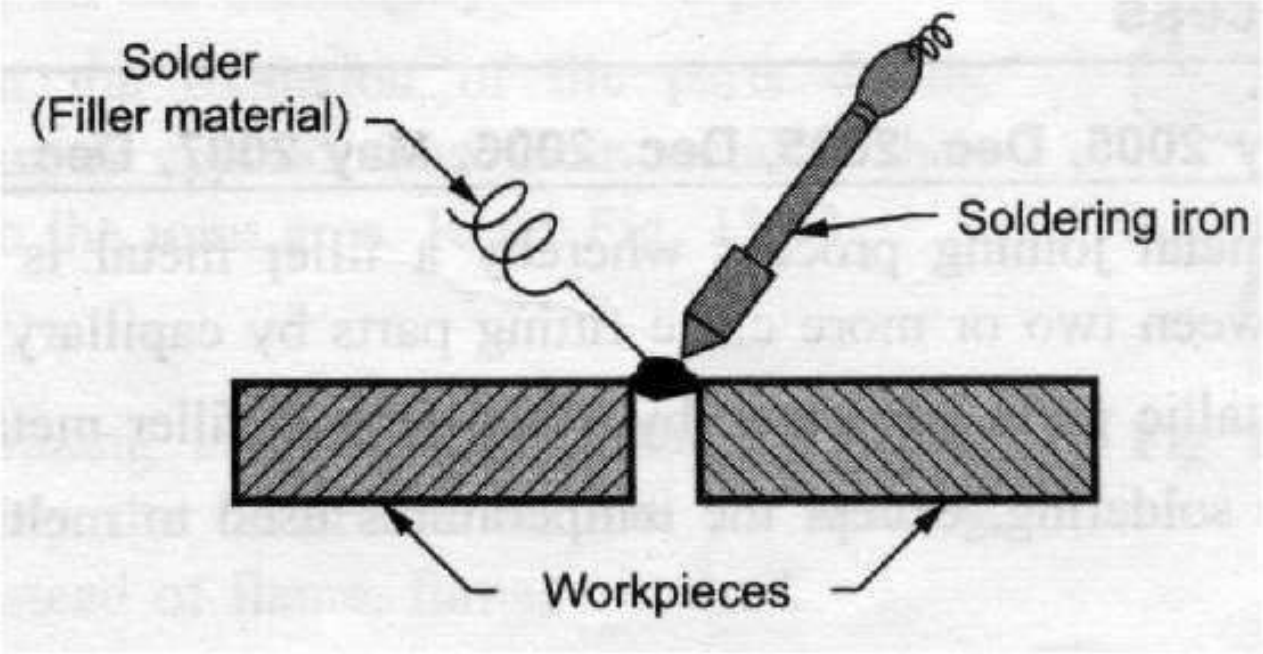
- Not possible to disassemble the parts.
- Joints weak against vibrations.
- Quality and strength of joint is operator dependant.
- Gives harmful radiations.

Applications :

- Fabrications of Bridges, Electric and Transmission Towers.
- Manufacturing of Automobile bodies.
- Building of Ships and Aircrafts.
- Manufacturing of Boiler, Pressure Vessels, Storage Tanks, Pipelines
- Manufacturing of Steel Furniture, Window and Door Frames, Window Grills. etc

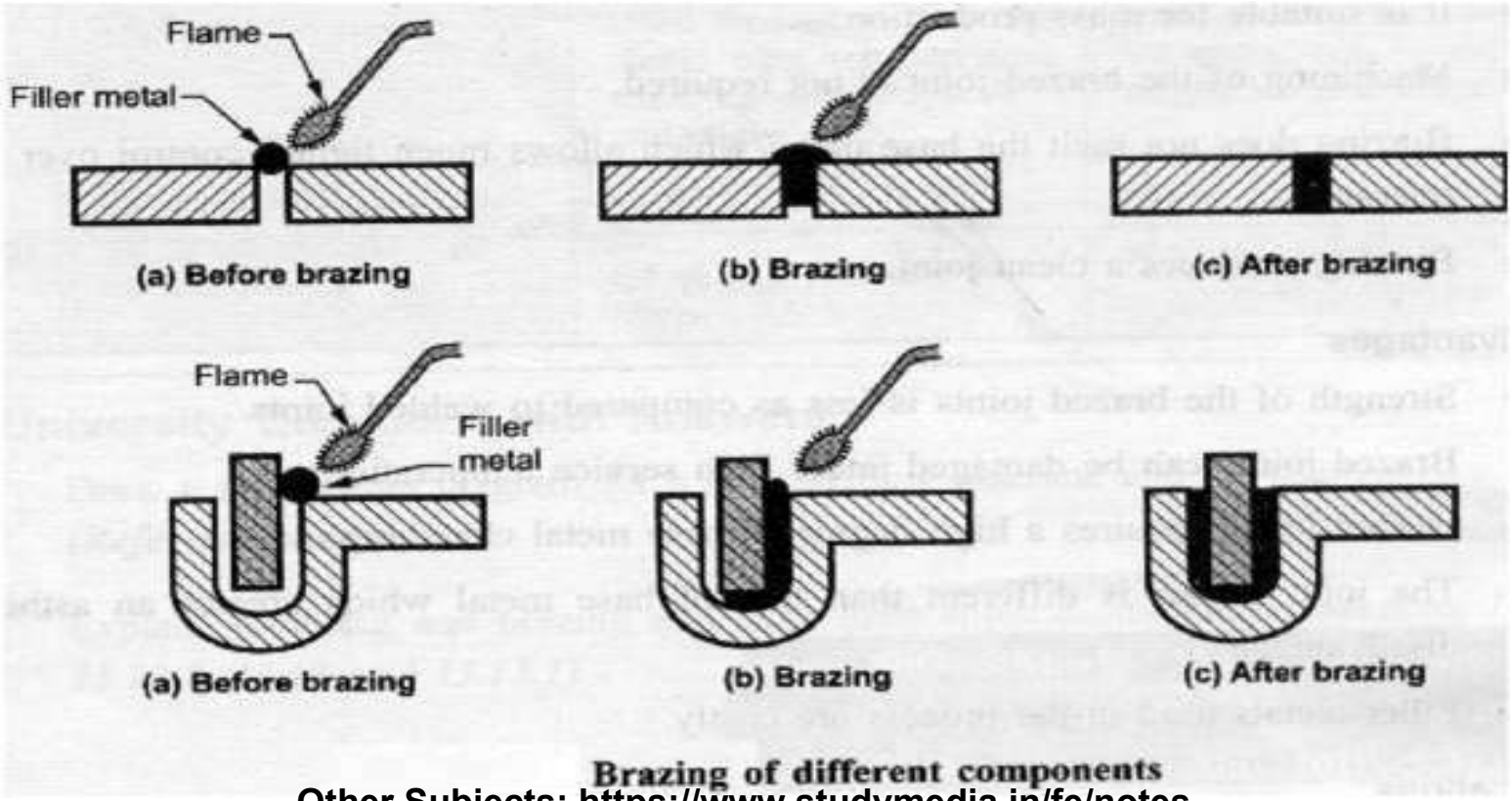
Soldering

is a process in which two or more metal items are joined together by melting and flowing a nonferrous filler metal into the joint. (below 450^{o}C) tin-lead alloy



Brazing

is a metal joining process whereby a filler metal is heated above and distributed between two or more close fitting parts by capillary action. (above 450^{o}C) copper alloys



Brazing of different components

Comparison b/w Brazing and Soldering

Parameters	Brazing	Soldering
Heating Temperature	Above 450ºC	Below 450ºC
Filler Material	Alloys of copper, silver or Nickel	Tin- Lead alloy Zinc-Aluminum
Surface Finish	Good	Not good
Strength of Joint	Lower than welded joint but relatively good	Very Low

Comparison b/w Welding Brazing and Soldering

Parameters	Welding	Brazing	Soldering
Definition	Process of joining the two metallic parts together by heating them to a plastic or semi molten state with or without pressure and filler material	Process of joining two work piece made of similar or dissimilar materials by heating them above 450^0C but below melting temperature of work piece and using non ferrous filler material.	Process of joining two work piece made of similar or dissimilar materials by heating them below 450^0C as well as the below the melting temperature of work piece and using non ferrous filler material.

Heating of work piece	By electric arc or by gas flame or by chemical reaction	By gas flame or in furnace	By gas flame or by electric soldering iron.
Strength of joints	High	Lower than welded joints but good	Very Low
Surface finish	Not very good	Good	Not very good
Thickness of sheet	Thin sheets can not be joined	Can be joined	Can be joined
Cost	Costly	Costly	Cheap

	Fabrication of bridges, electric towers, Transmission powers, etc.	Fabrication of heat exchangers, Pipe Fitting, Electrical repair work, etc	Electric circuits,
Applications	Manufacturing of two and four wheeler bodies Building of ships and aircrafts, Boiler, Pressure Vessel, Storage tanks etc.	Joining of Carbide tips with metal shanks in cutting tools, etc	In electrical equipments, Joining Wires., etc

Systems In Mechanical Engineering

UNIT 5

LATHE, DRILLING & MILLING MACHINE

Mr. Girish G Khope

Introduction

Machine Tool

- **It is defined as the machines used for carrying out metal cutting processes & surface finishing processes.**

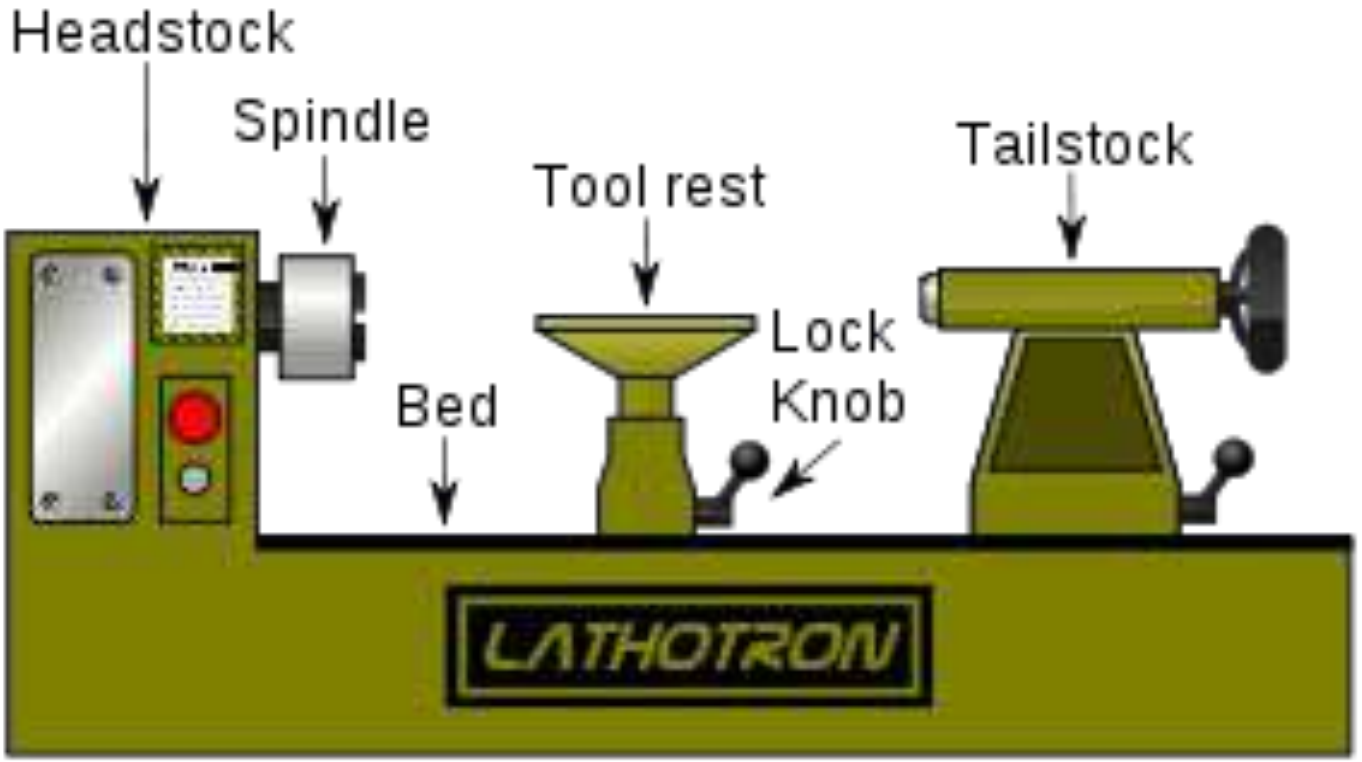
- Machine tool is a power driven machine used for producing the components of required shape & size with desired accuracy & surface finish by removing the material from the workpieces.

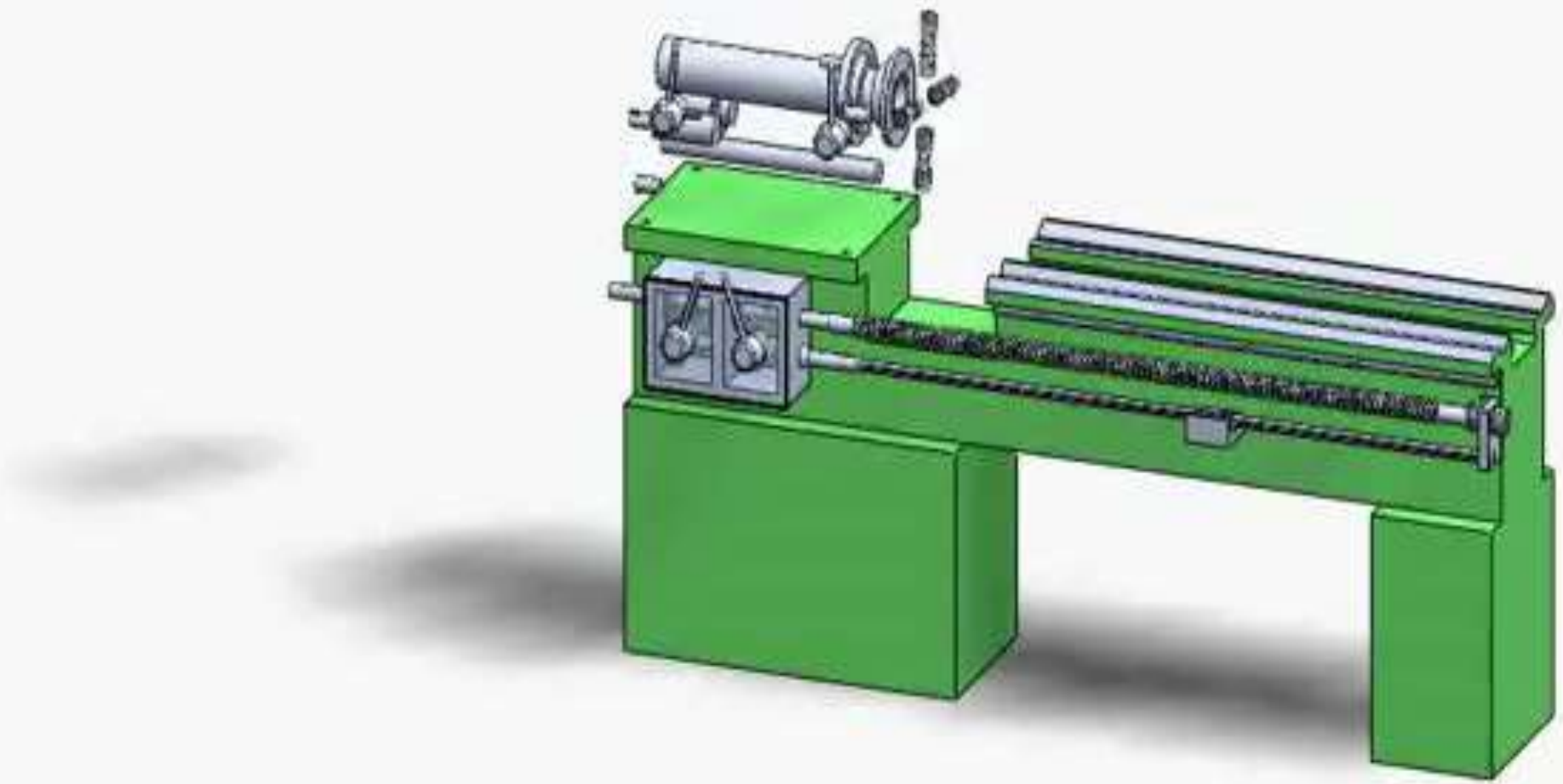
- Machine Tools
  - According to size of chip removed
    - Larger sized chips like lathe machine, drilling machine etc.
    - Smaller sized chips like grinding machine ,lapping machine etc
  - According to desired purpose
    - Single-purpose , Multi –purpose & Special purpose machine tool

Lathe Machine(Turning Machine)

- **It is known as the mother of all the machine tools & most widely used machine tool.**
- Lathe was first machine tool which came into being as a useful machine for metal cutting.

Block Diagram of Lathe Machine





Working Principle

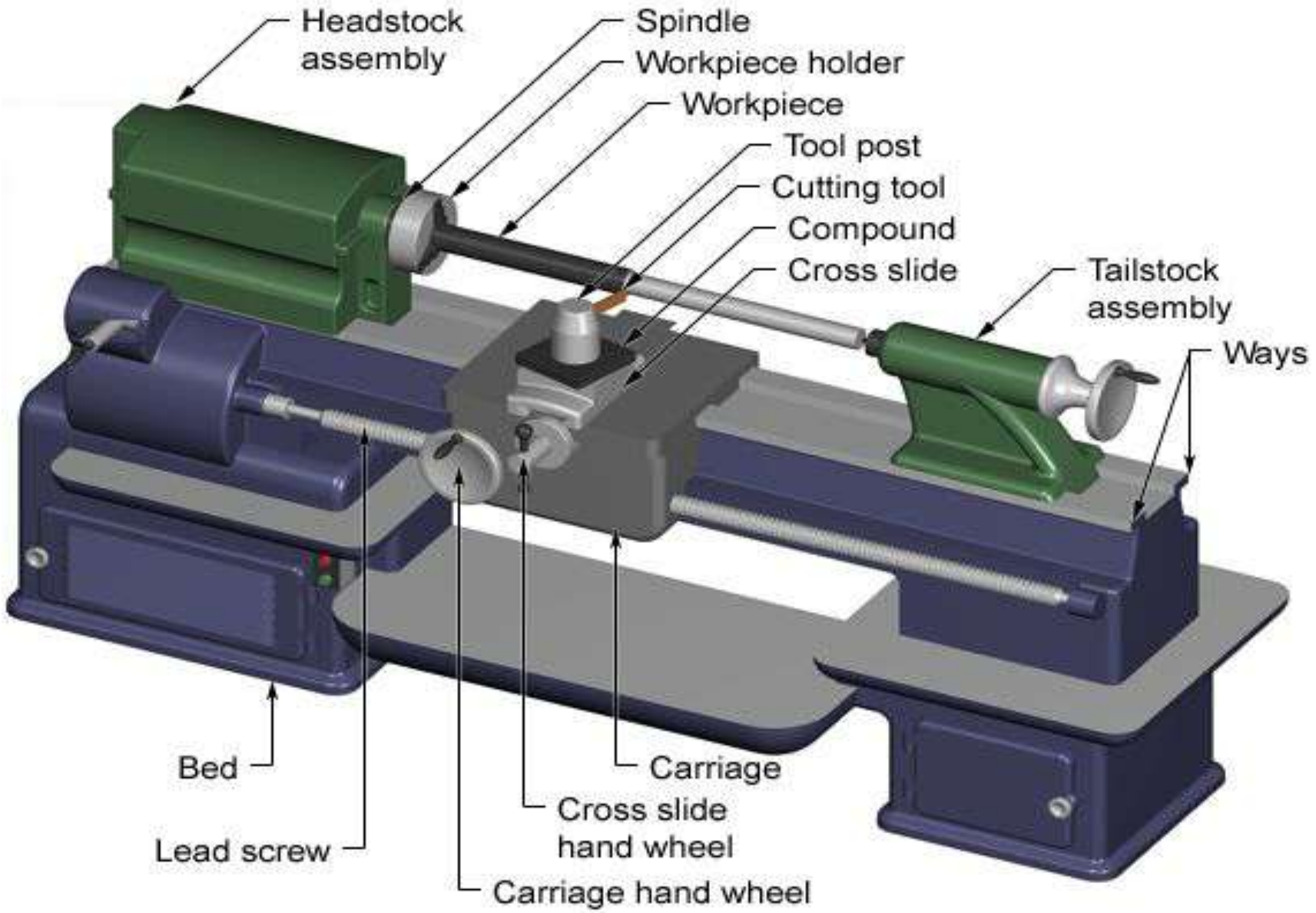
- Lathe is a machine tool which holds workpiece securely between two rigid & strong supports, called as **centres or in a chuck or face plate,** while workpiece revolves.

- The cutting tool is rigidly held & supported in **a tool post** & fed against revolving workpiece.

- While workpiece revolves about its own axis, tool is made to move in parallel or at an inclination with axis of material to be cut.

- So the metal is removed to give desired shape & size.

Lathe Machine



Basic Elements of Lathe Machine

a) Bed :

It acts as a base of machine on which, different fixed & operating parts of lathe are mounted.

It is made up of cast alloy with nickel & chromium. And used to support all elements of lathe.

b) Headstock :

It is a box-like casting mounted permanently on bed to left hand end of machine. It supports spindle & contains a gear-box.

Spindle is hollow rotating shaft used for holding workpiece.

work holding device **chuck** is mounted on spindle.

Gear box is used to drive spindle & change spindle speed.

c)Tailstock : It is also called as loose or puppet head & situated at right hand end of bed & can be moved on innerways of bed.

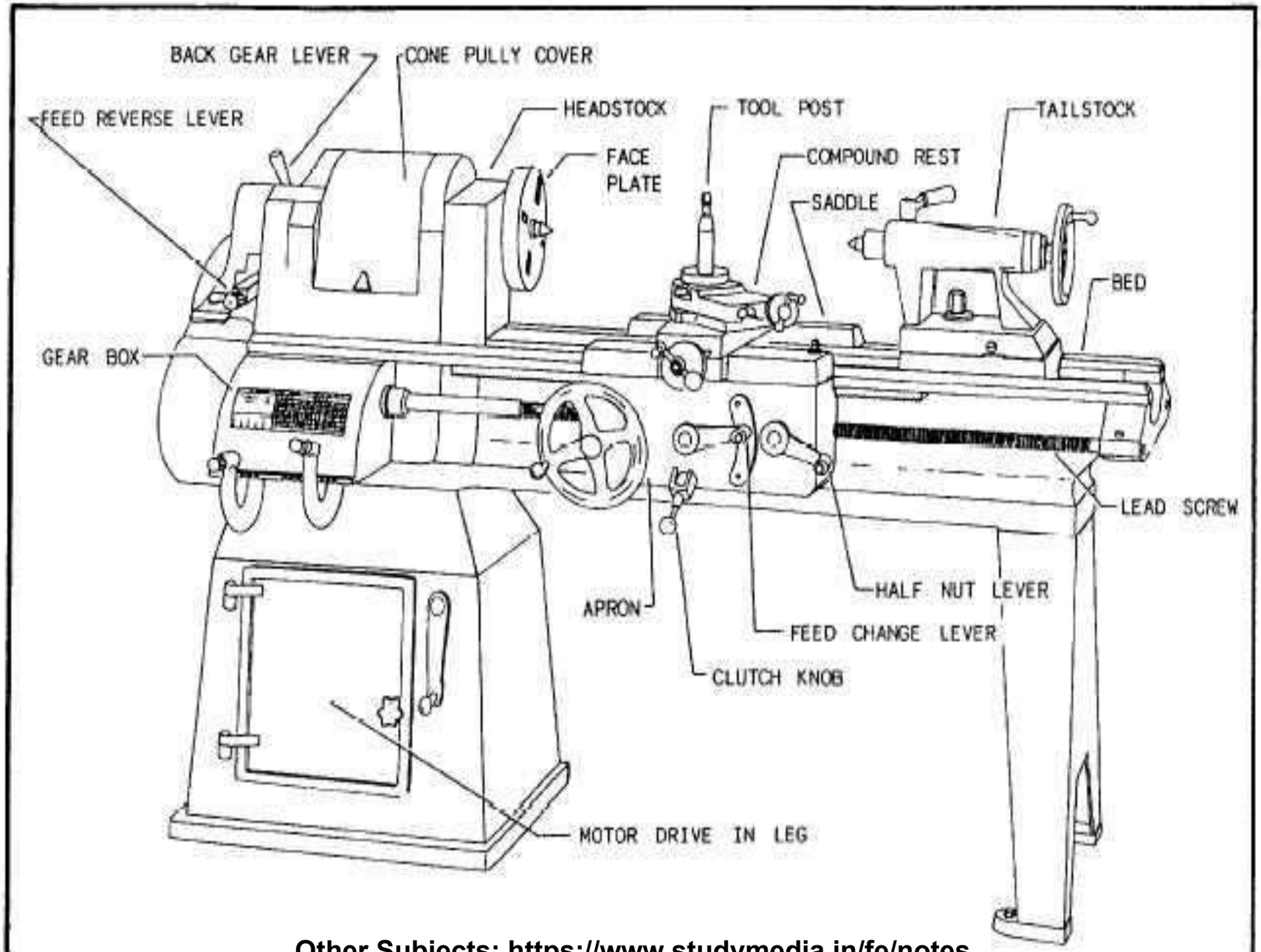
It hold a tool for performing operations such as drilling, reaming, tapping etc.

d)Carriage : It is located between headstock & tailstock of lathe. It carries cutting tool & precisely controls its movements.

It is used for supporting, guilding & feeding tool against workpiece during the operation on the lathe.

e)**Feed Mechanism** : **The movement of tool relative to workpiece is known as feed**. Feed mechanism has various units through which motion is transmitted from headstock spindle to the carriage. It is used to transmit motion from headstock spindle to carriage by using various units.

f)**Thread cutting mechanism(Lead Screw**) : It is a long threaded shaft which is used as a master screw & it is brought into operation only when threads to be cut. It gives mechanised motion to carriage for cutting threads on workpiece.



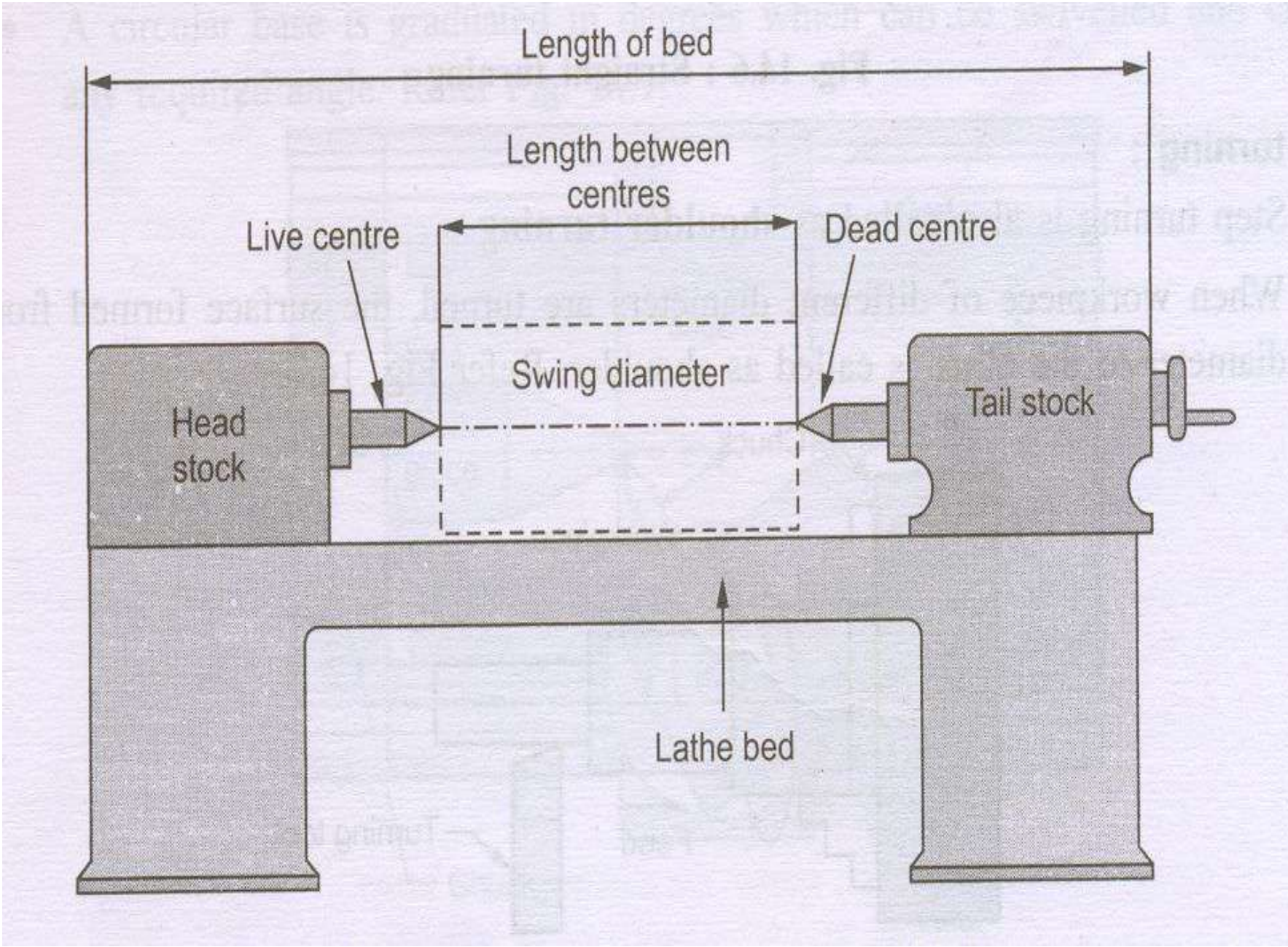
Specifications of Lathe Machine

a) **Length of bed** : It is total length of lathe bed.

b) **Distance between centres** : It is maximum length of workpiece that can be mounted between centres. Distance between live centre & dead centre.

c) **Swing:-**It is maximum diameter of workpiece that can revolve between centres without touching bed.

d) **Maximum & Minimum spindle speeds**:-Maximum & minimum speed at which spindle rotates.



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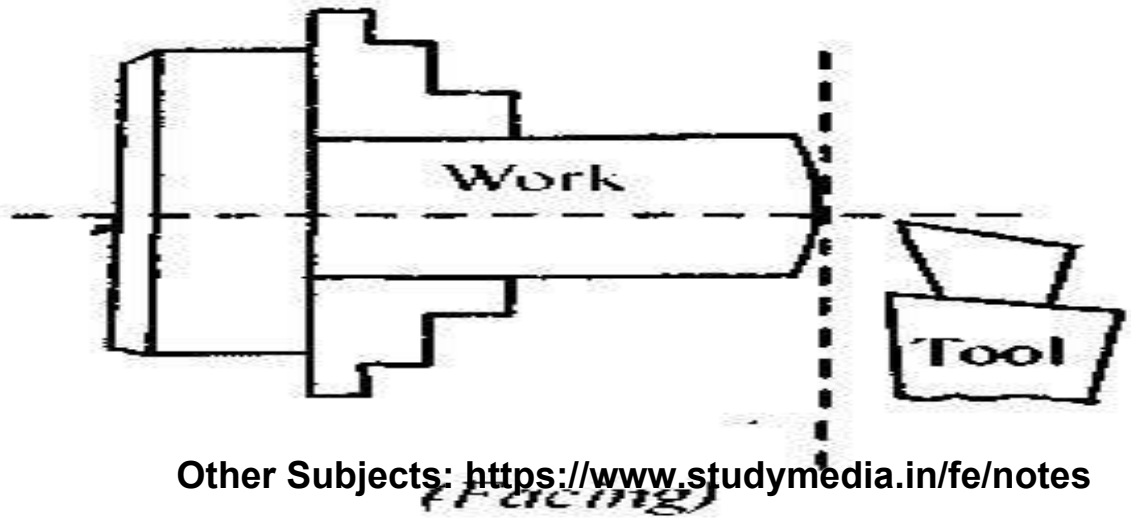
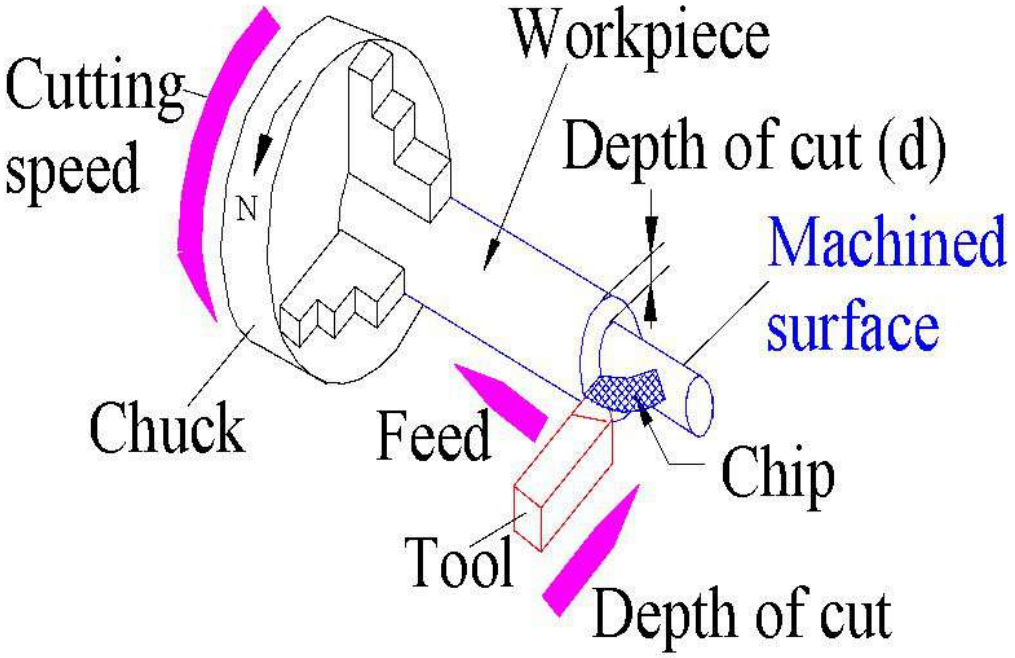
Lathe Machine Operations

1. **Straight turning** : Operation is performed for producing a cylindrical surface by removing excess material from workpiece. The cutting tool is held in tool post & fed into rotating work parallel to lathe axis. It may be rough turning. Tool used in this operation is called as **turning tool**.

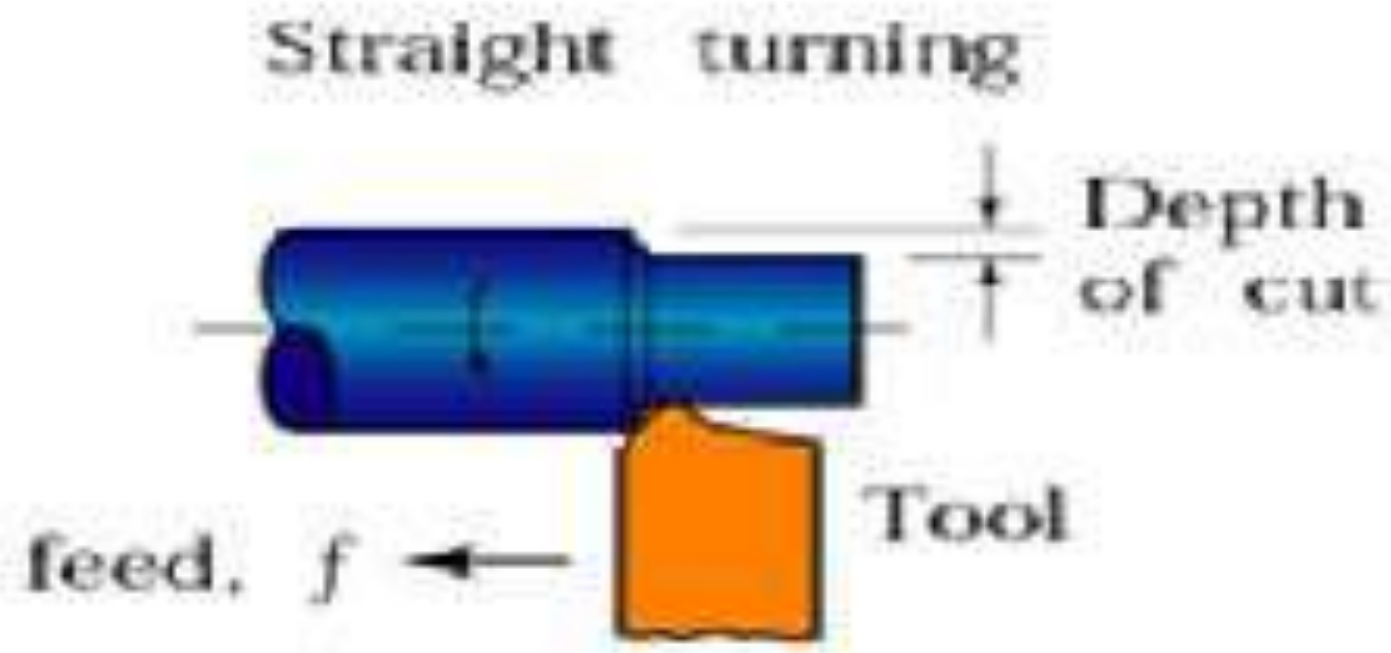


Turning ..

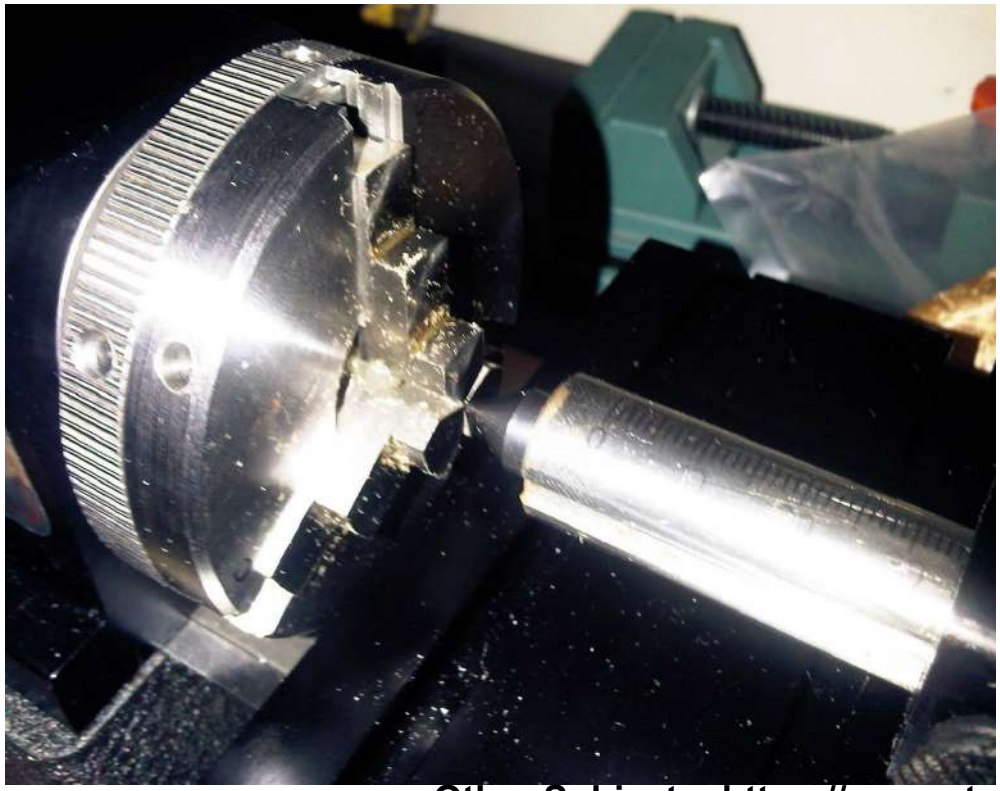
Cylindrical job

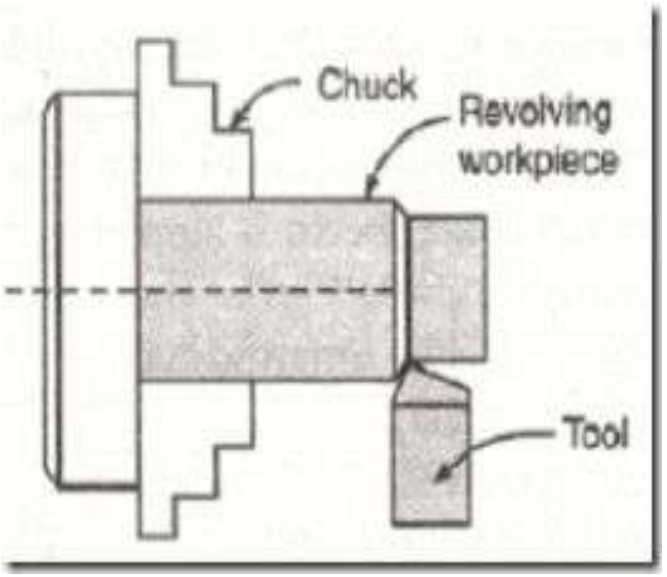


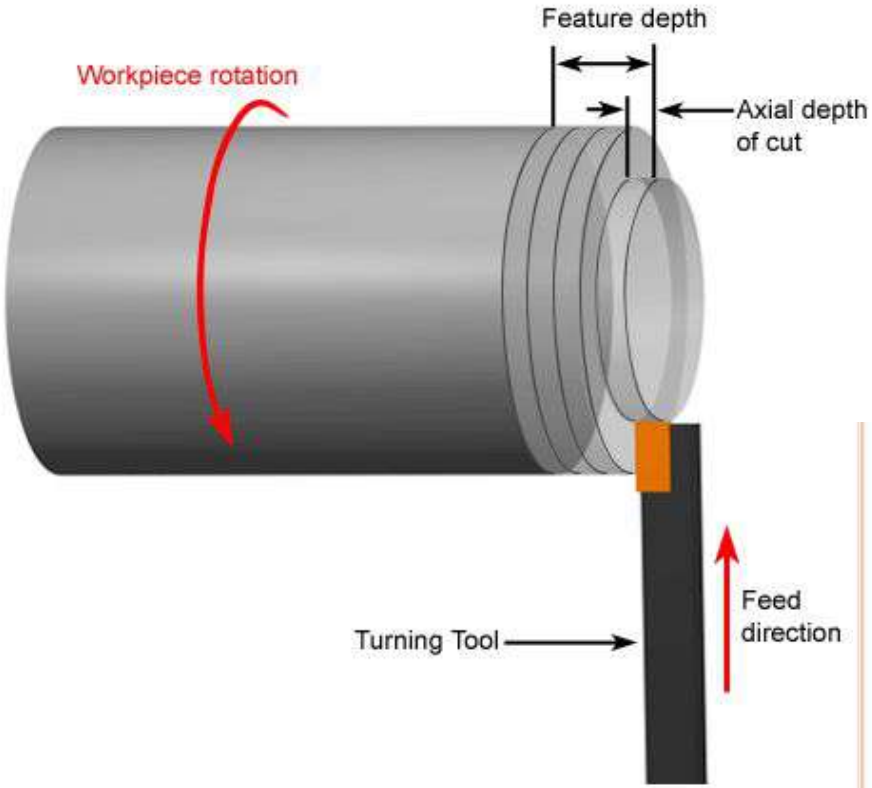
Turning



2. **Step turning** : It is also called as **Shoulder turning**. When workpiece of different diameters are turned, the surface formed from one diameter to the other is called as **shoulder**.







STEP TURNING

- It is an operation of producing various steps of different diameters in the workpiece, as shown in Fig.4 This operation is carried out in the similar way as plain turning.

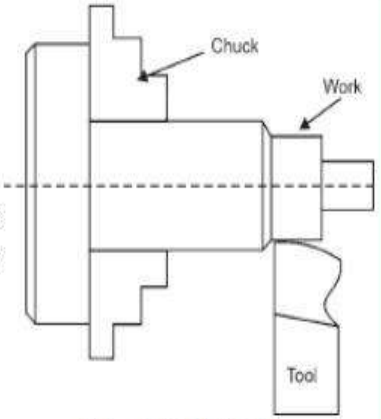
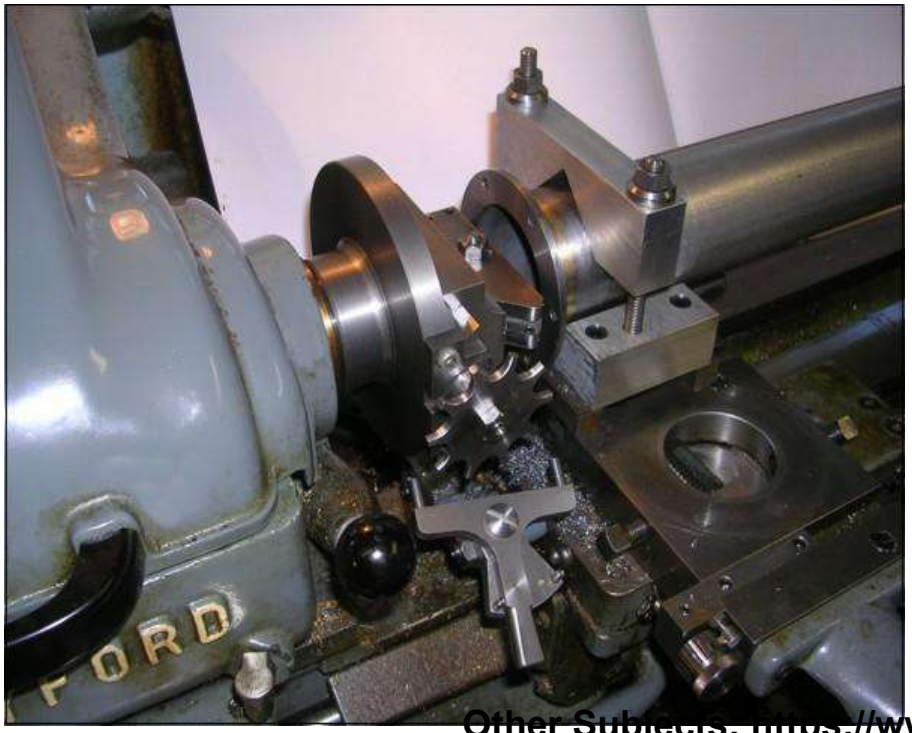


Fig. .4: Step turning

3. **Eccentric turning** : If cylindrical workpiece has two separate axis of rotation one being out of centre to other, then workpiece is called as Eccentric & turning of these different surfaces of workpiece is known as **Eccentric Turning**.

Axis of workpiece is offset from axis of lathe



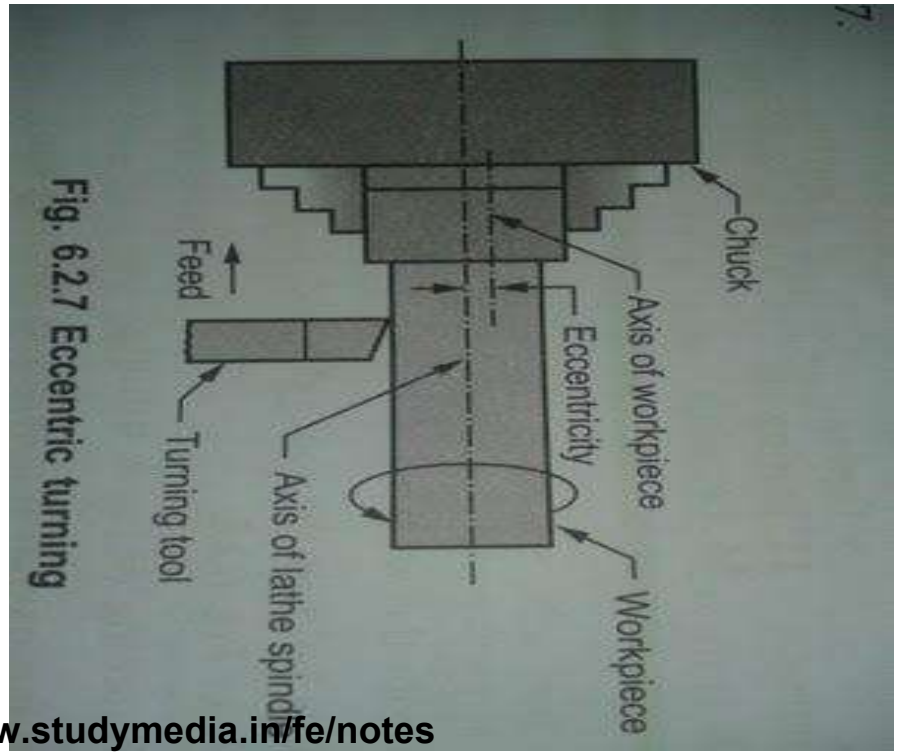
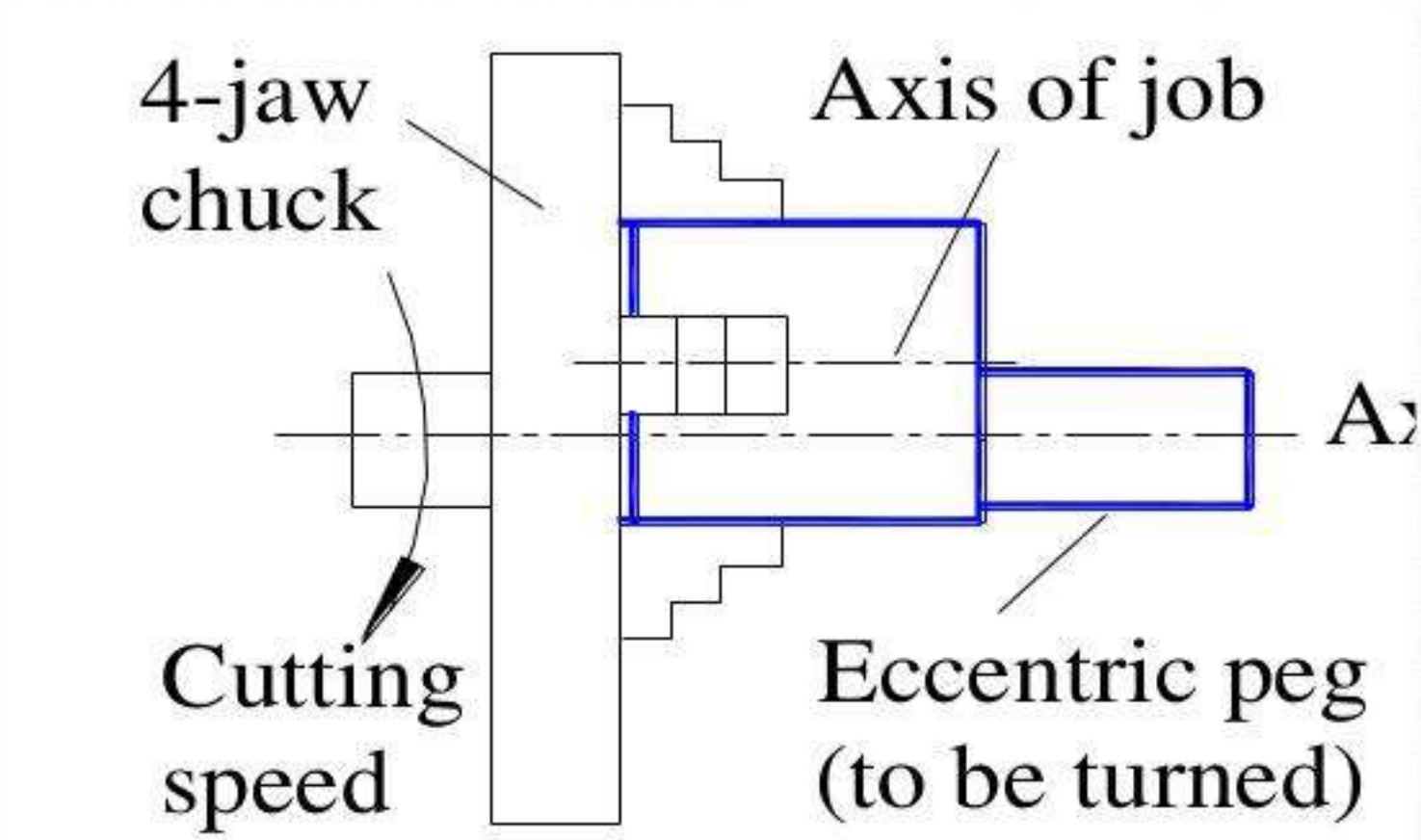
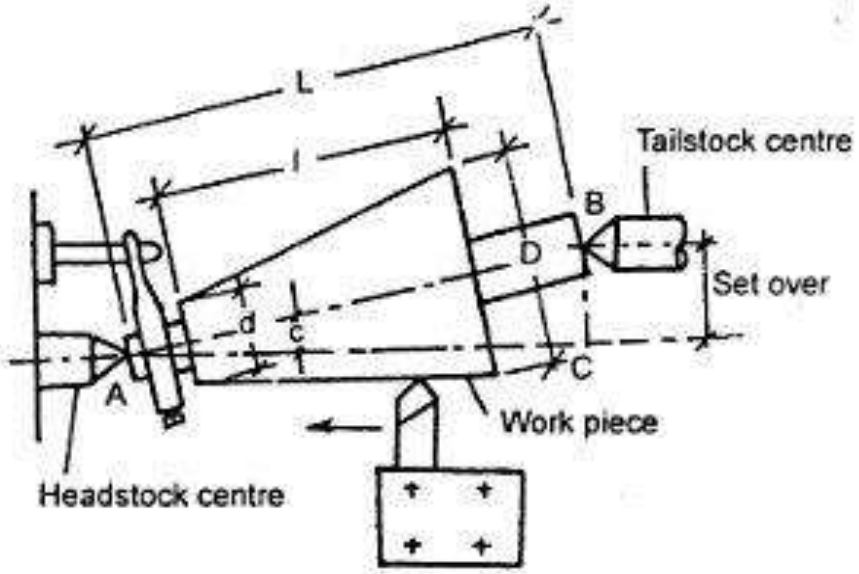


Fig. 6.2.7 Eccentric turning

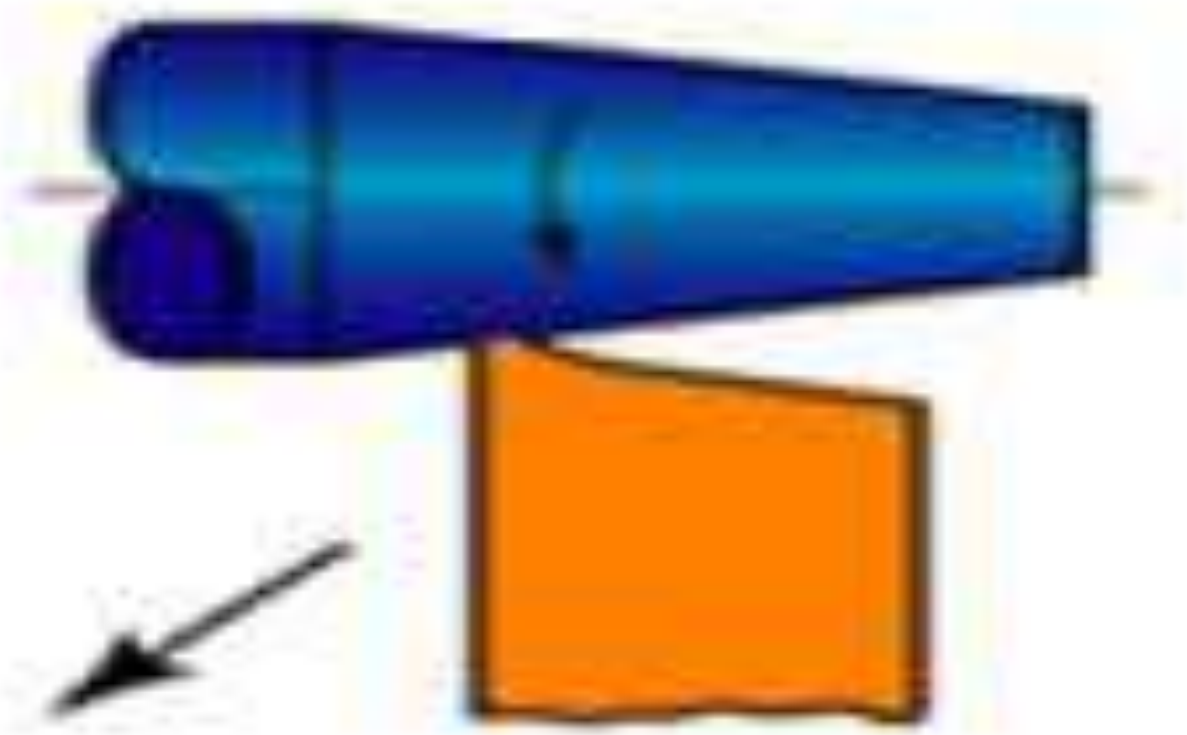
Eccentric Turning



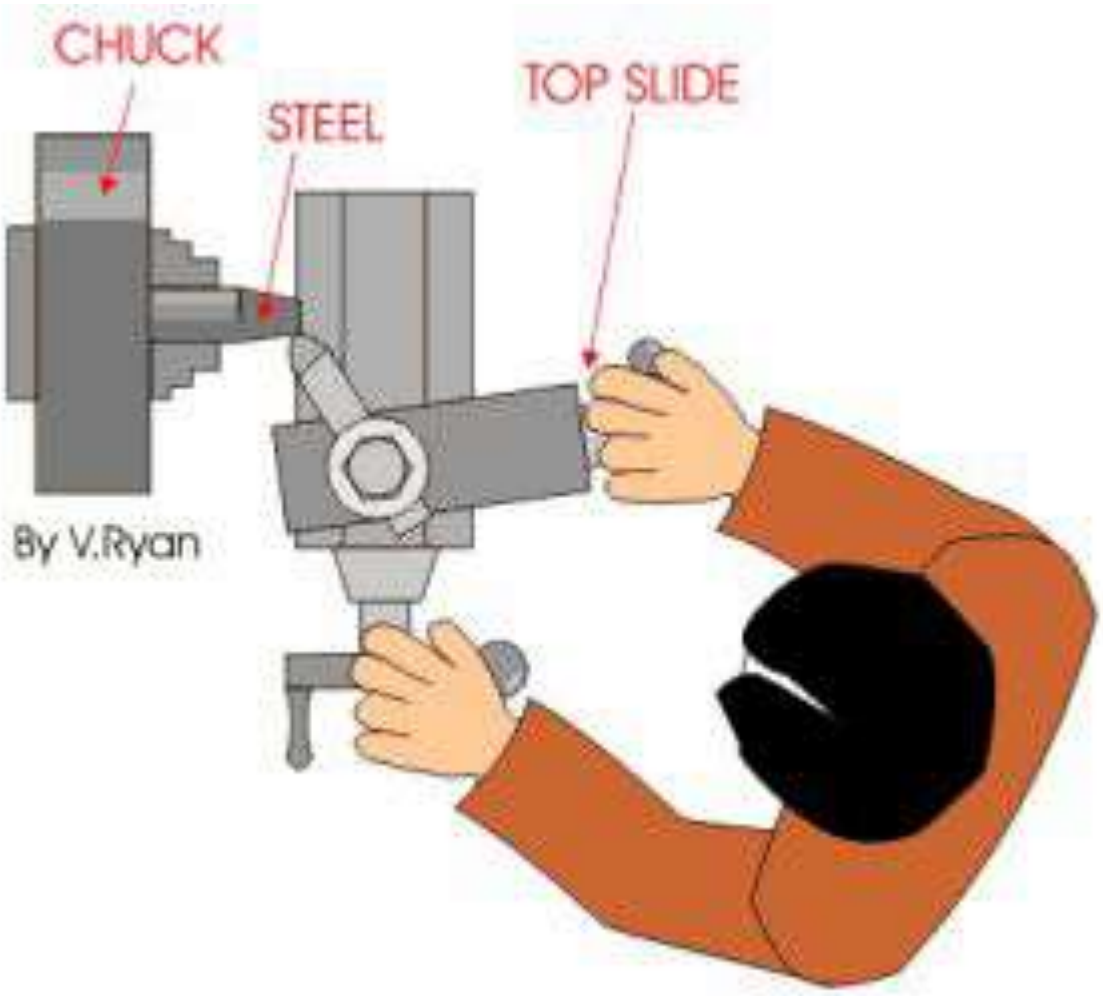
4.Taper turning : In taper turning, workpiece is rotated on lathe axis & tool is fed at an angle to axis of rotation of workpiece. Tool is mounted on compound rest which is attached to circular base. Base is graduated in degrees which can be swivelled & clamped at any required angle.



Taper turning



Taper Turning



5.Facing : It is operation of machining ends of a workpiece to produce a flat surface with axis **& it involves feeding of tool perpendicular to axis of rotation of workpiece.** The tool used for facing is properly ground & mounted in a tool holder of tool post.

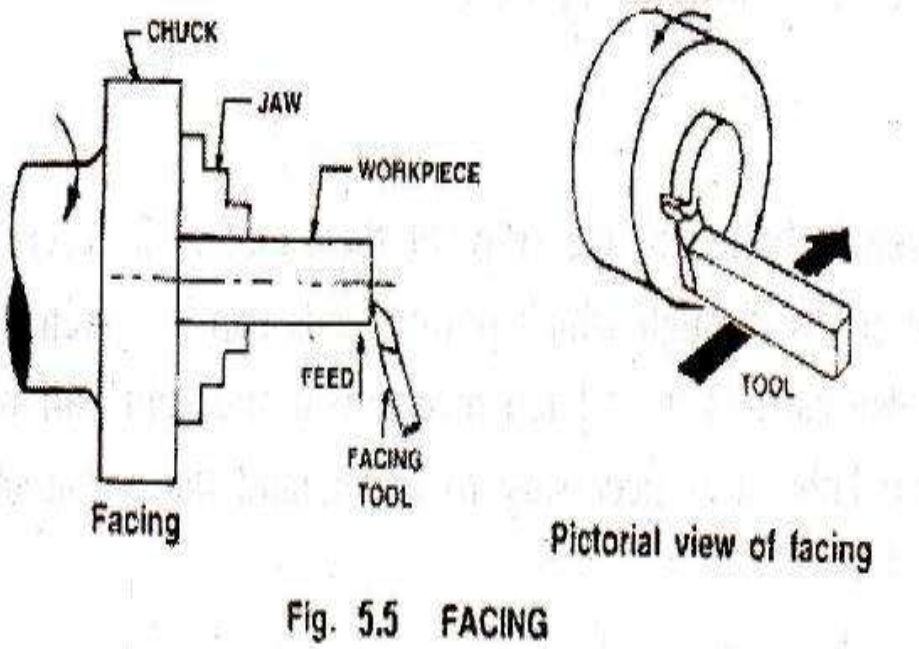
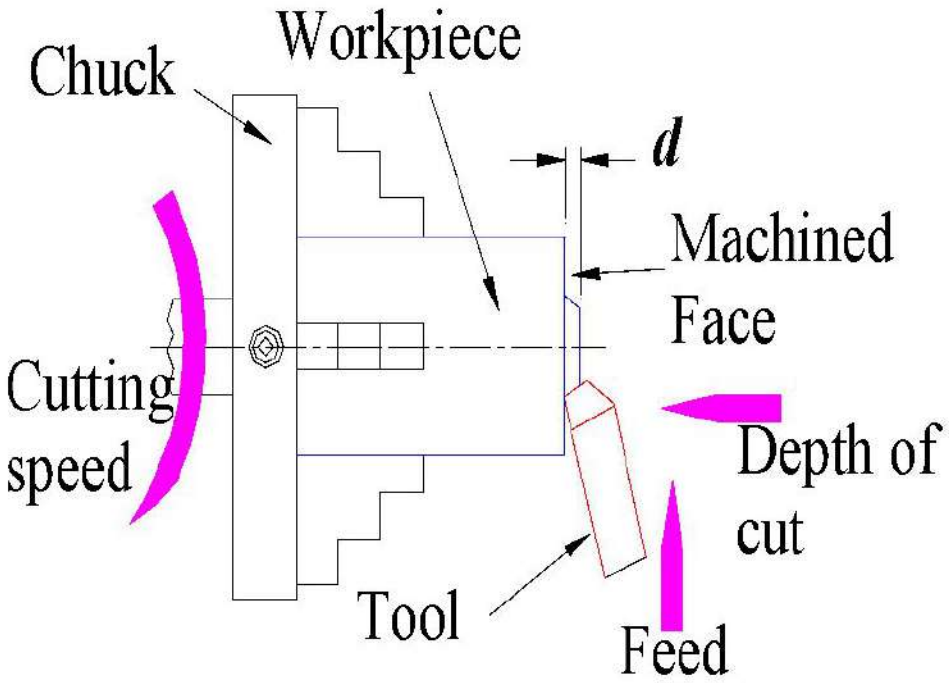


Fig. 5.5 FACING

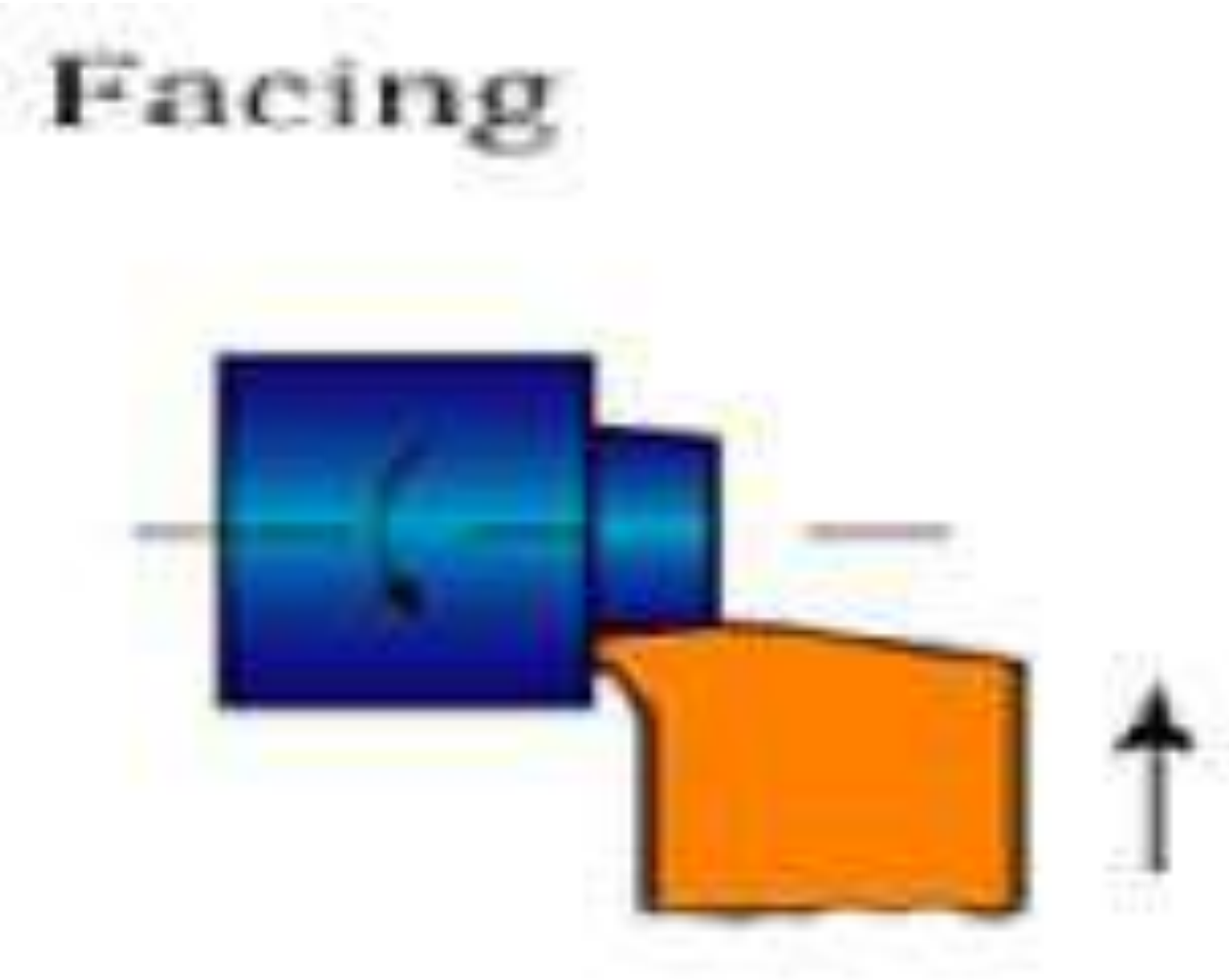
Operations on Lathe ..

Facing

Flat Surface/Reduce length



Facing



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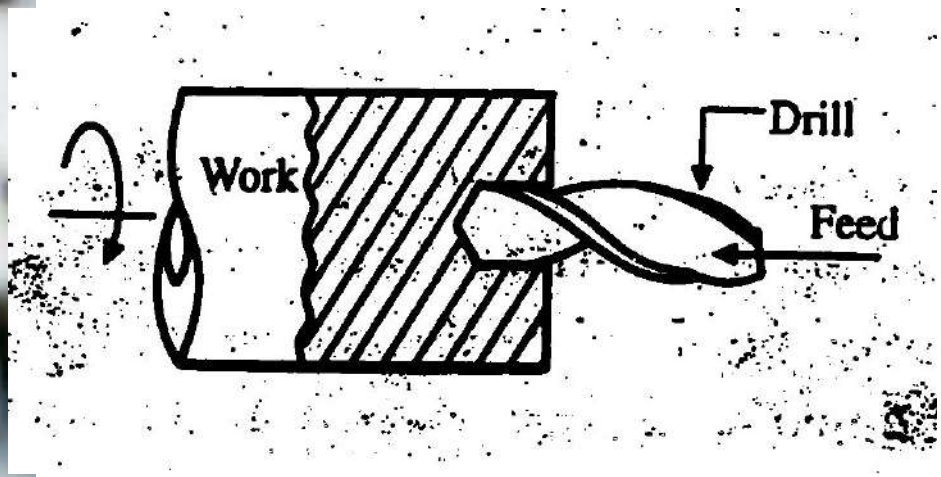
6.Drilling : This is process of producing cylindrical hole in the workpiece. In operation, workpiece is held in a chuck & drill is held in a tailstock. During operation drill is fed by rotating handwheel of the tailstock in clockwise direction.



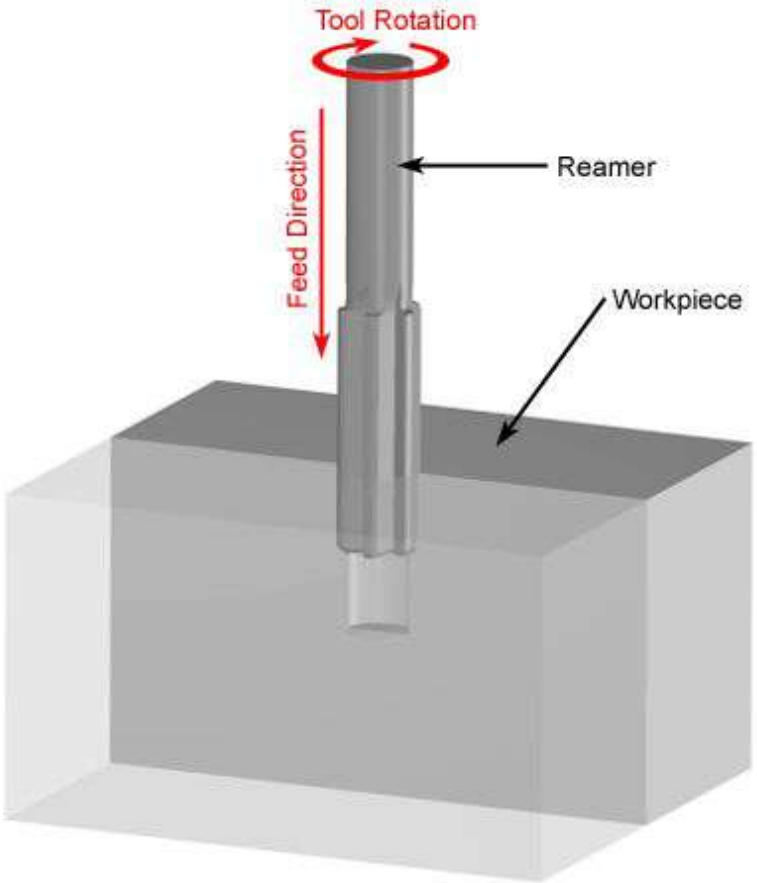
7.Reaming :

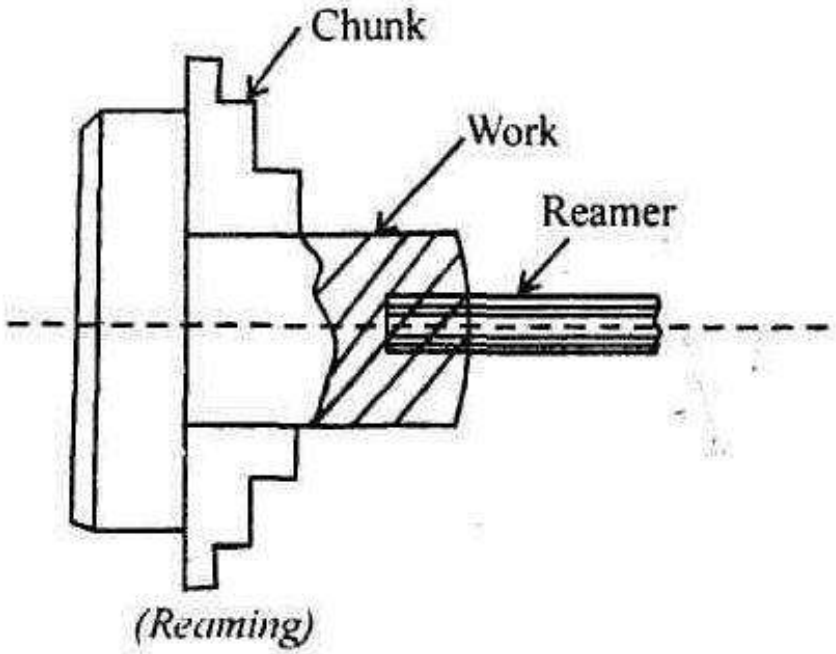
It is a finishing operation because a very small amount of material is removed during this operation.

A **reamer** is a type of rotary cutting tool used in metalworking.

Precision **reamers** are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy to leave smooth sides. ... The process of enlarging the hole is called **reaming**.

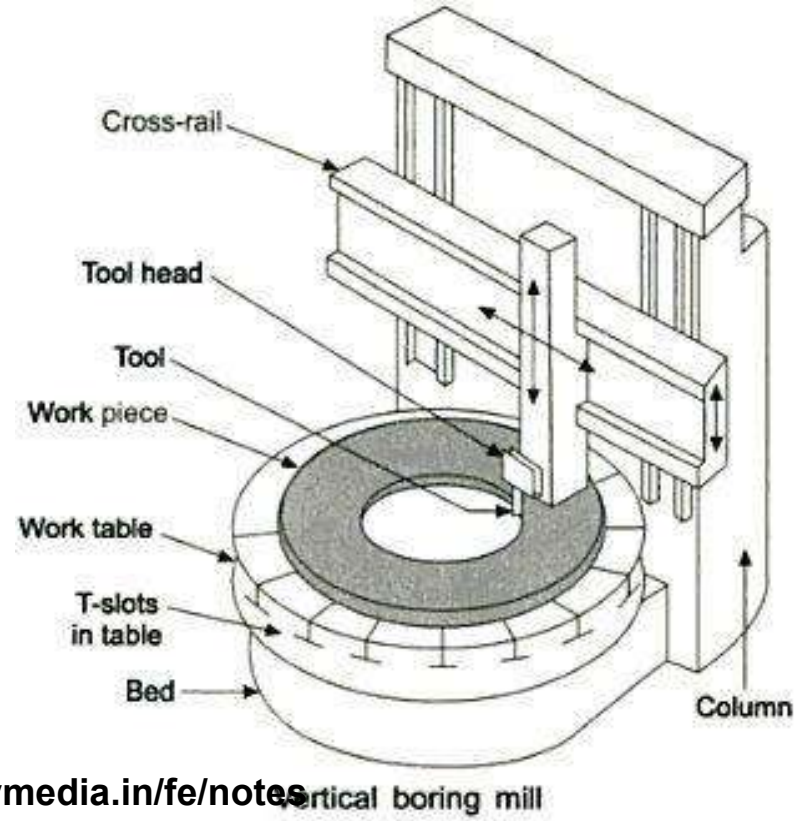
For performing reaming a multi teeth tool is used, which is called as reamer.





(Reaming)

8.Boring : It is an operation which is employed for machining surfaces, hence also called as Internal Turning. It is done to enlarge the already drilled hole & bring them to the exact required size. Generally, used for a single point solid boring tool.



Vertical boring mill

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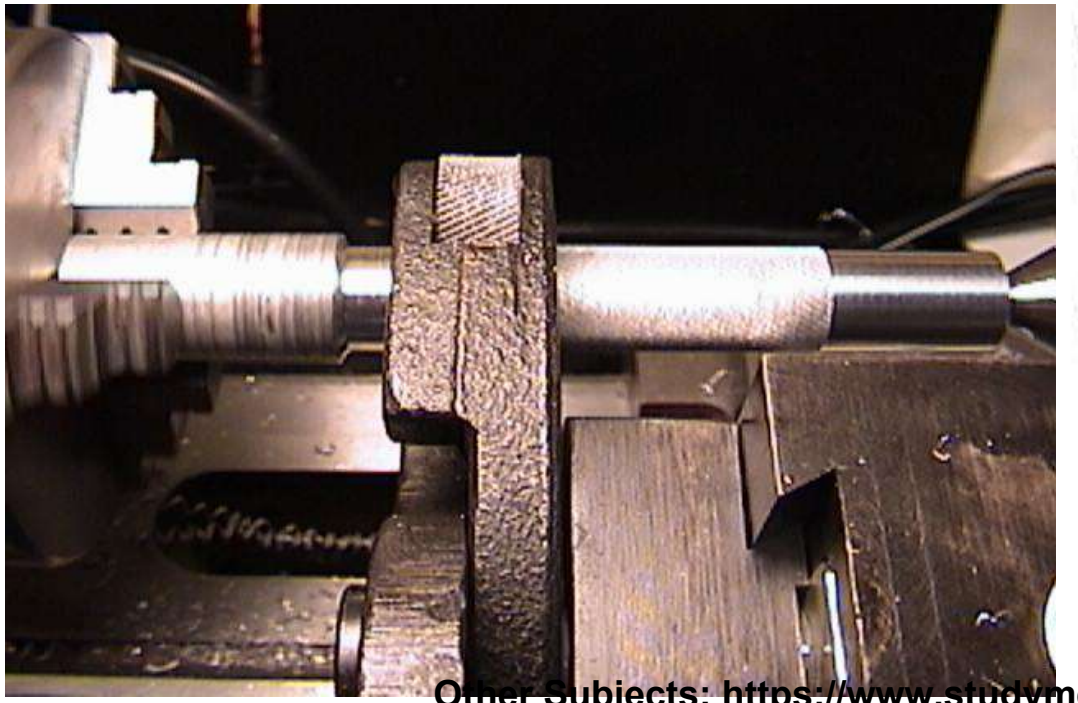
9.Knurling : It is a process of embossing a diamond shape regular pattern on surface of workpiece using a tool called knurling tool. It consists of a straight shank fitted with one or two knurling wheels.(grip).



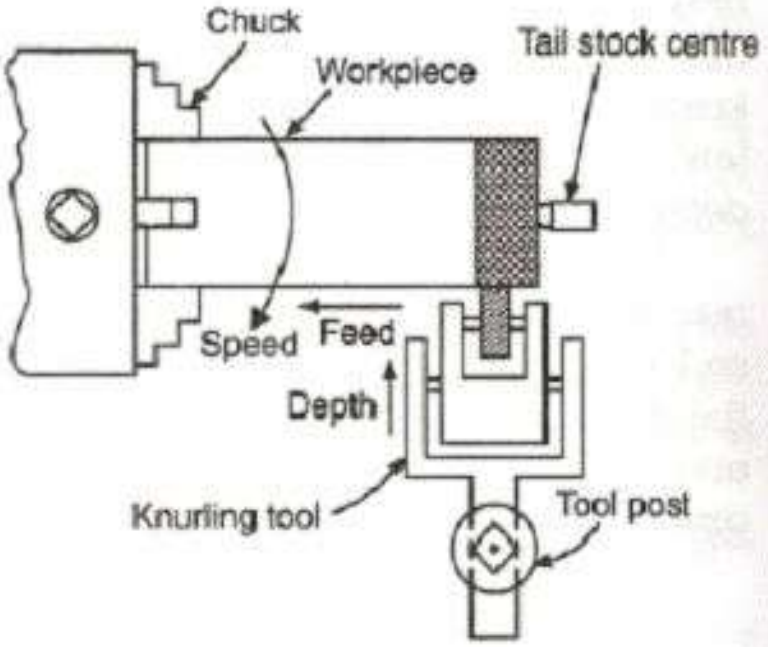
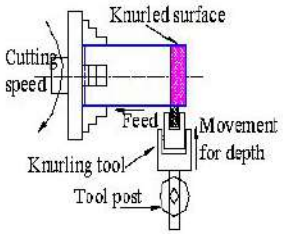


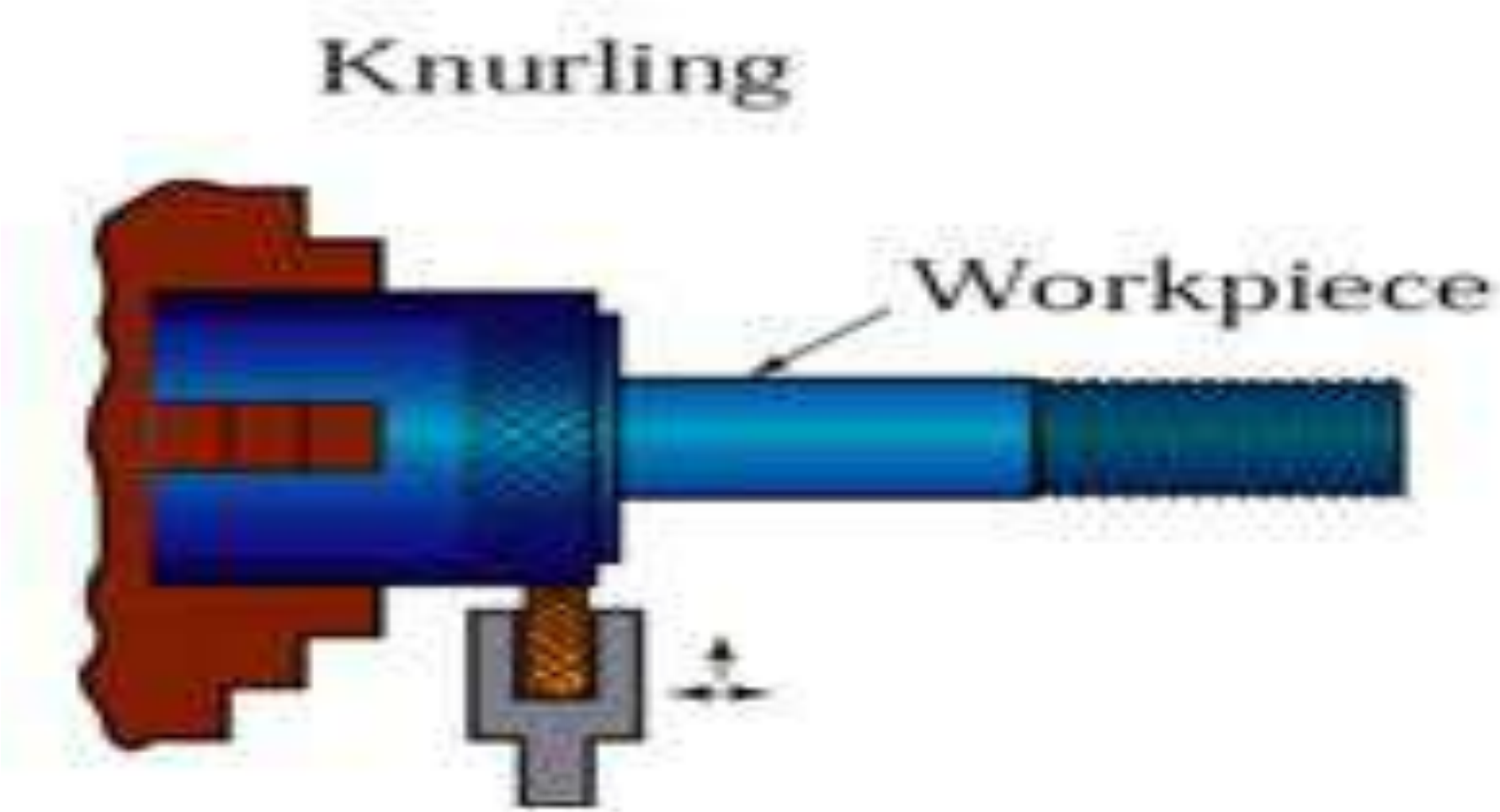
Fig. 7.17. Knurling

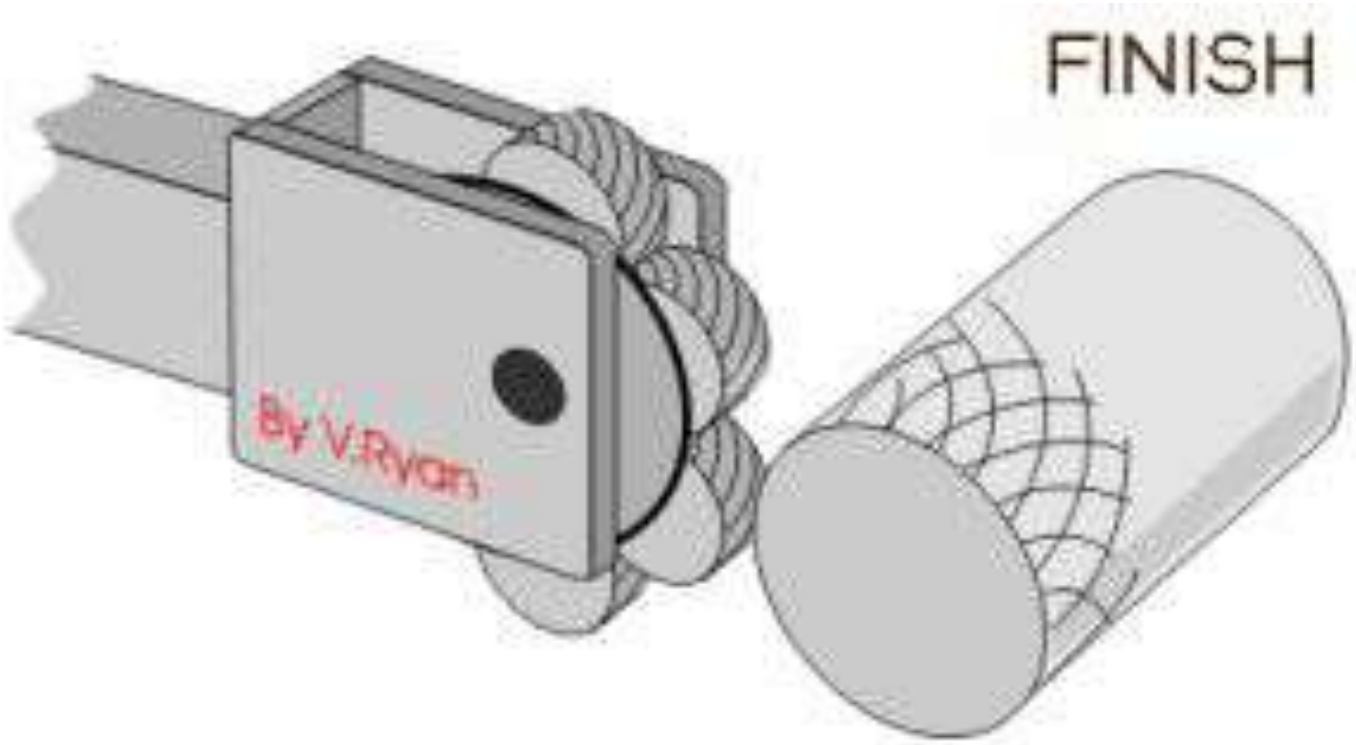
Operations on Lathe ..

Knurling

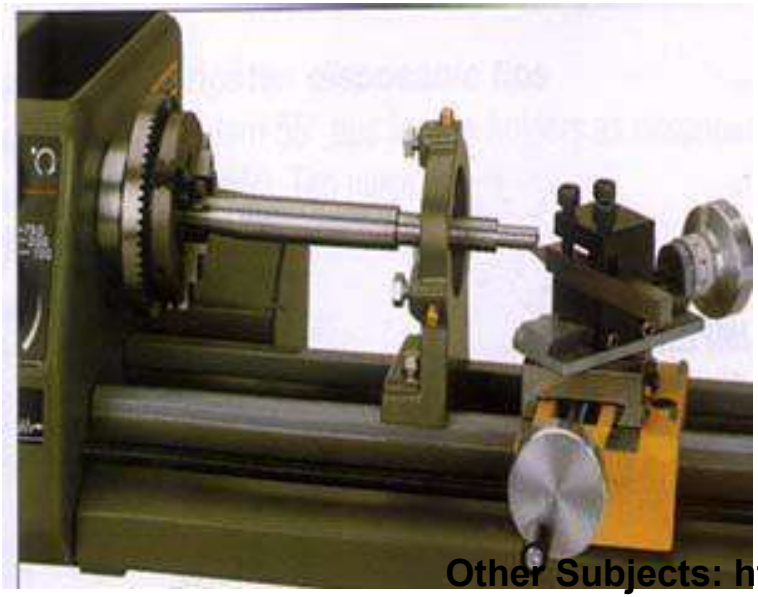


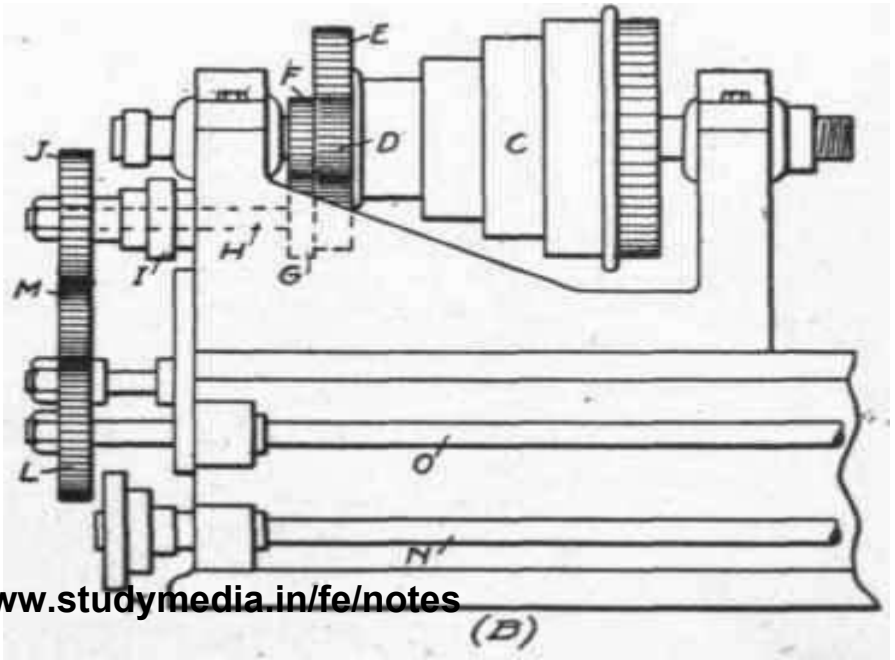
Knurling

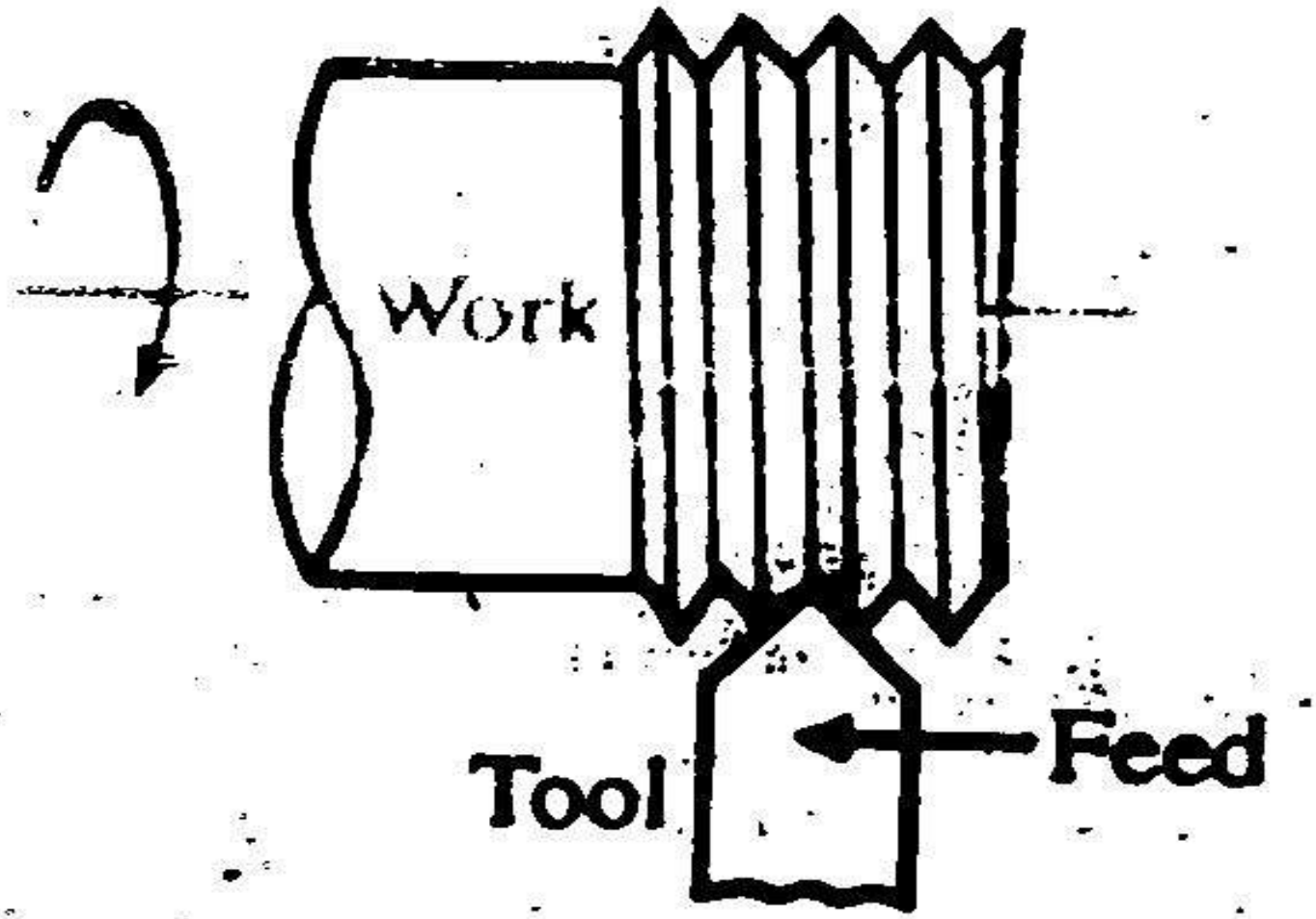




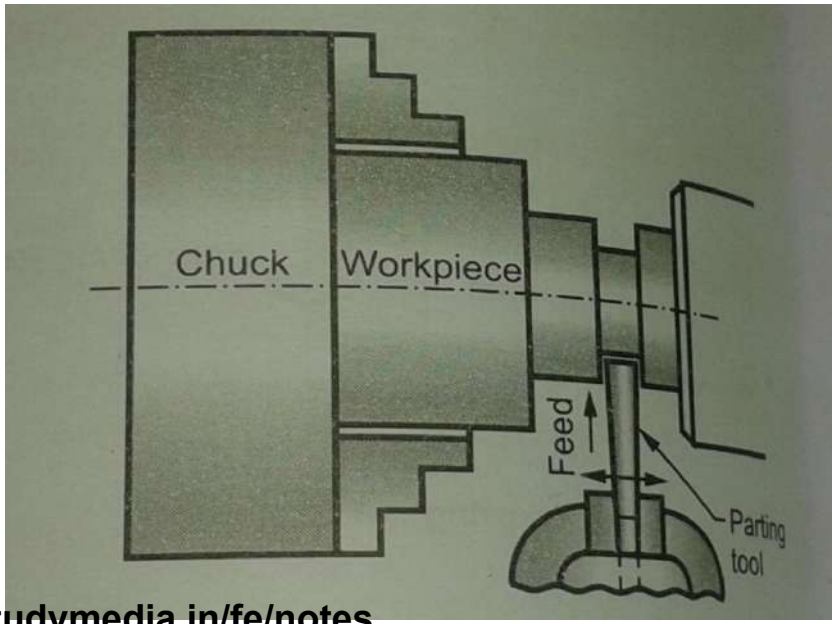
10.Thread Cutting : It is a process of producing a helical groove of V or square shape on a cylindrical surface. Tool motion is parallel to axis of lathe.For one rotation of workpiece tool automatically travels distance equal to pitch of thread.





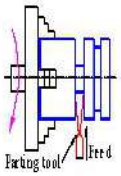


11.Parting Off : It is a process of cutting a workpiece into two parts.Tools used for this operation is known as Parting Tool which is a longer point as they are required to cut from the outside surface right upto centre of the job.

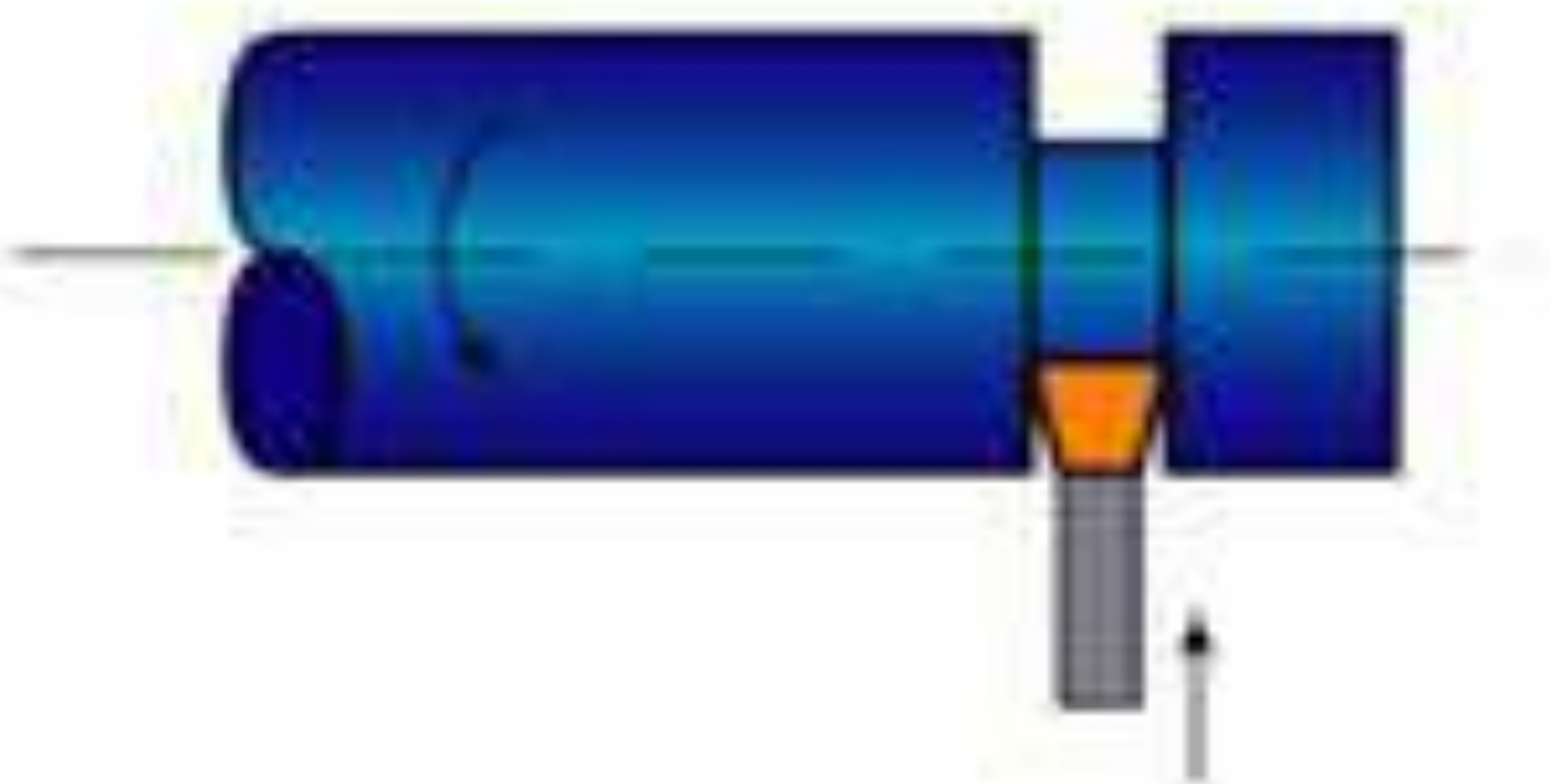


Operations on Lathe ..

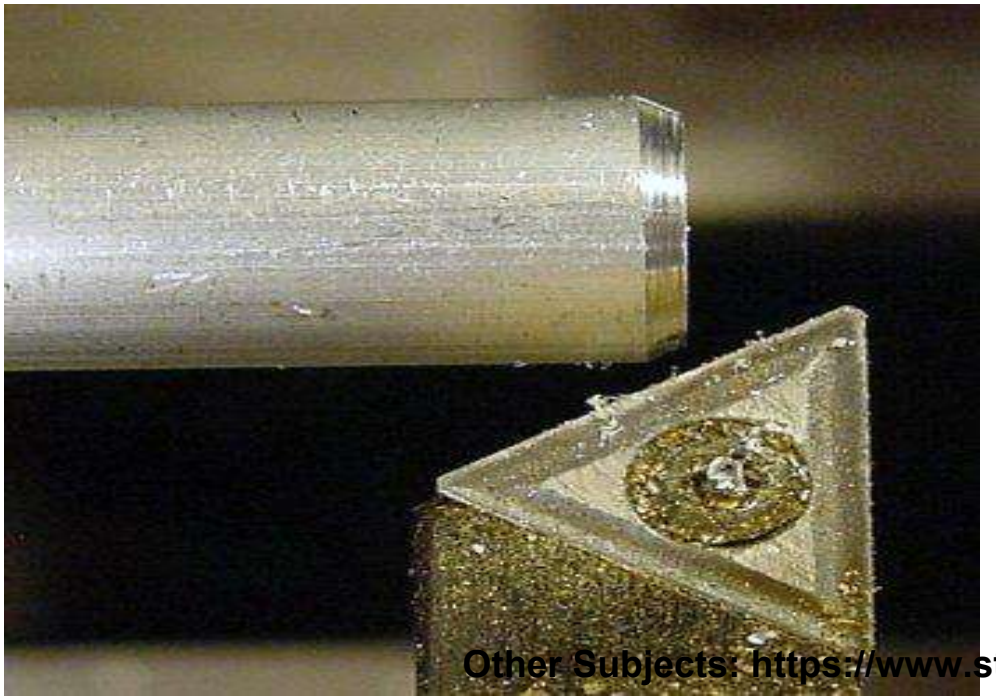
Parting Off/cutting off ..

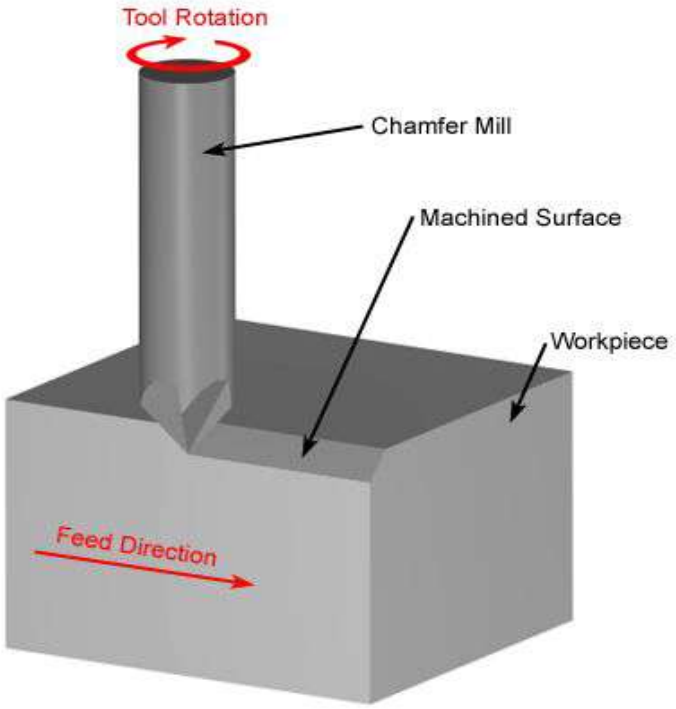


Cutting off

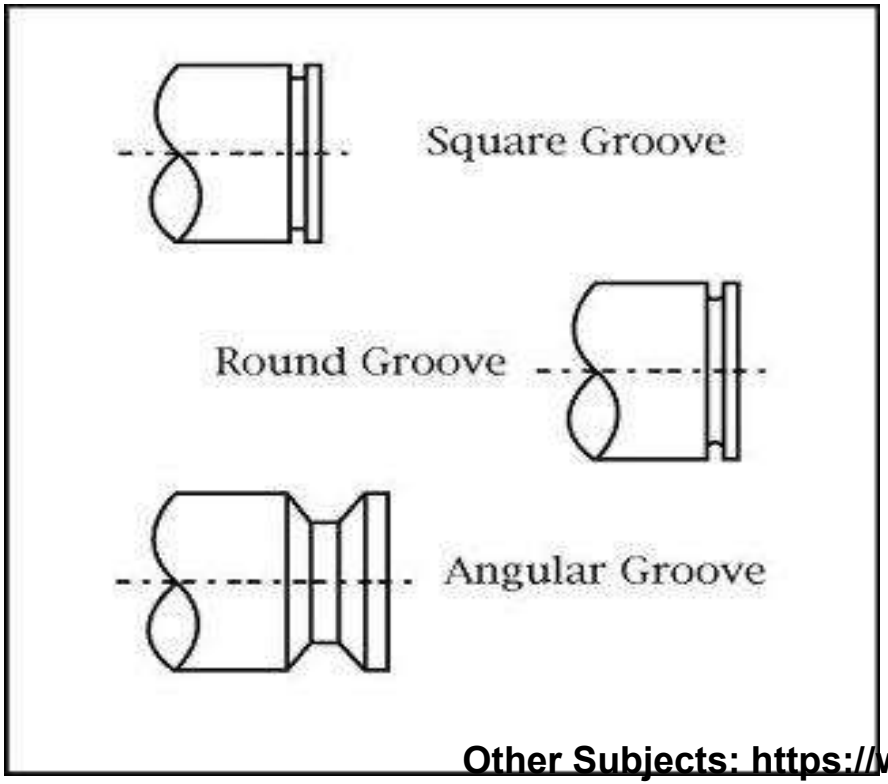


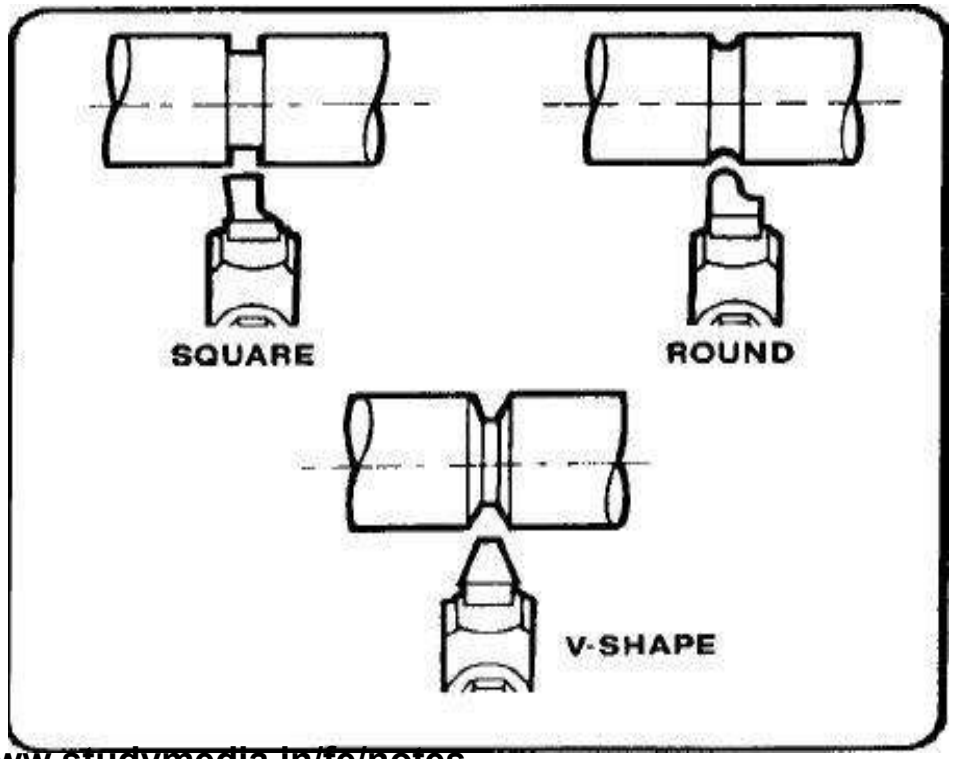
12.Chamfering : It is an operation of bevelling the extreme end of a workpiece. Chamfering is done to remove the burrs & to protect end of workpiece from being damaged & to have better appearance. And it is generally performed at the end of all the operations

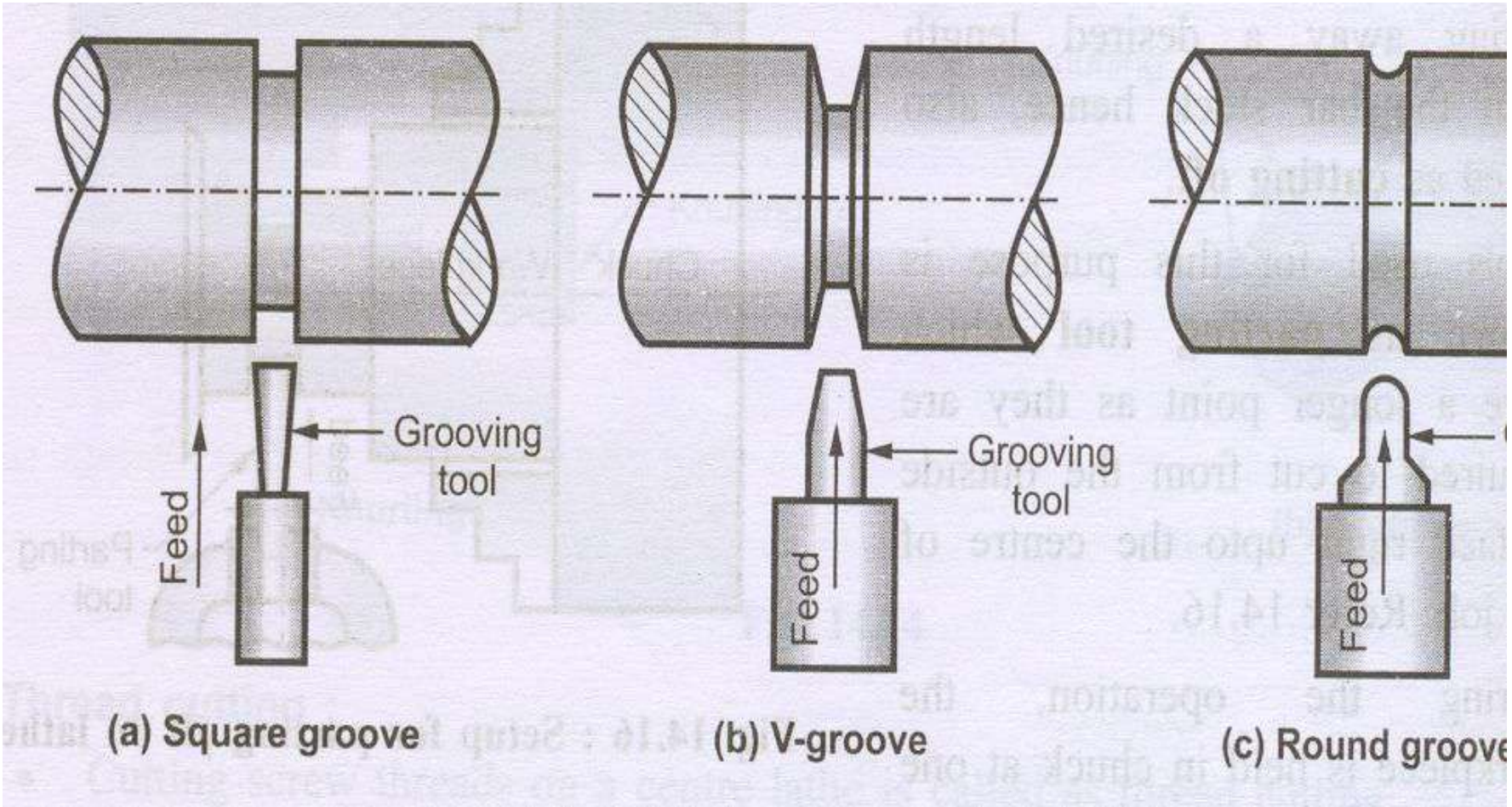




13.Grooving : It is an operation through which a groove of approximately same width is produced on the job as that of cutting edge of the tool. Hence this process is also known as **form turning** operation.

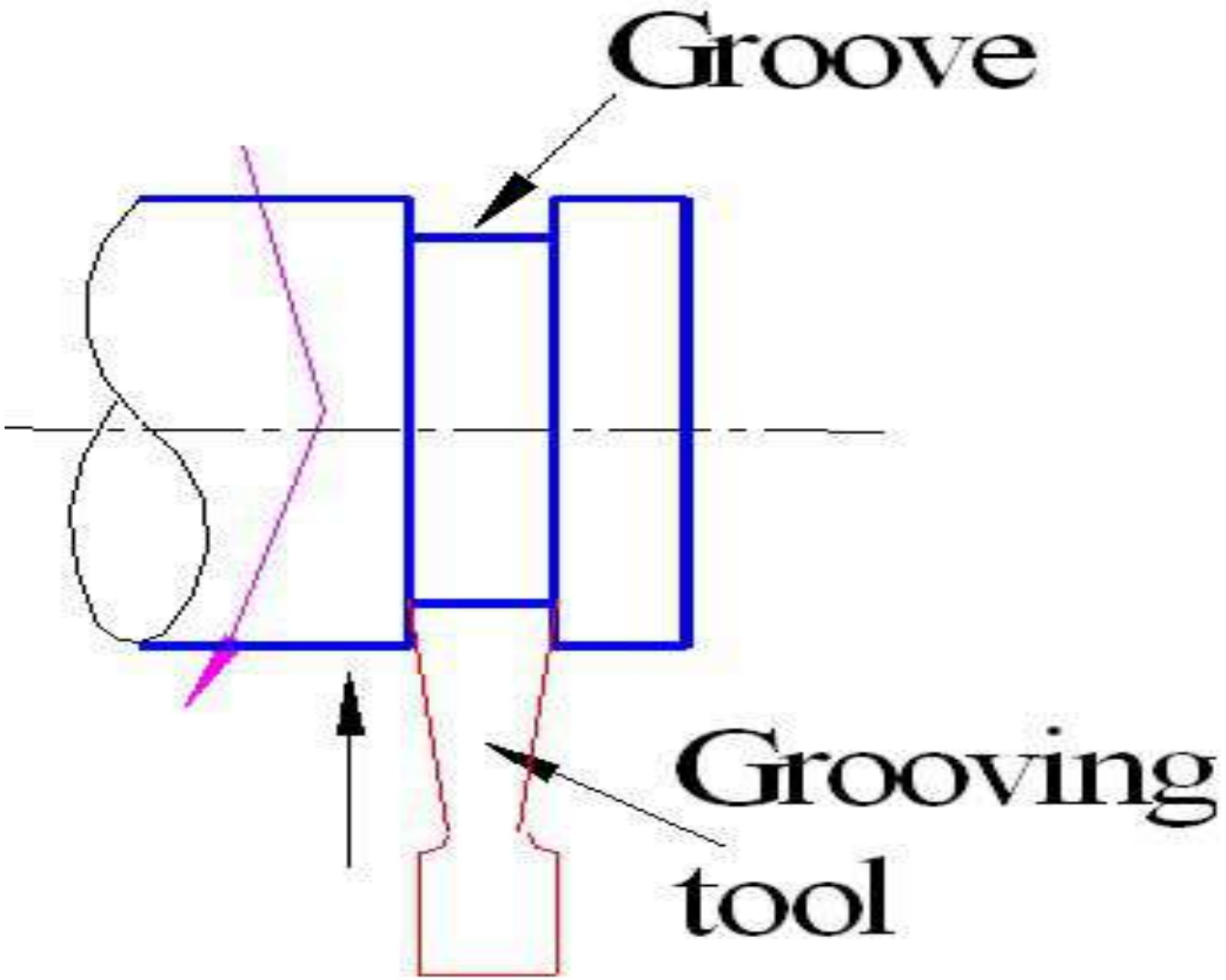




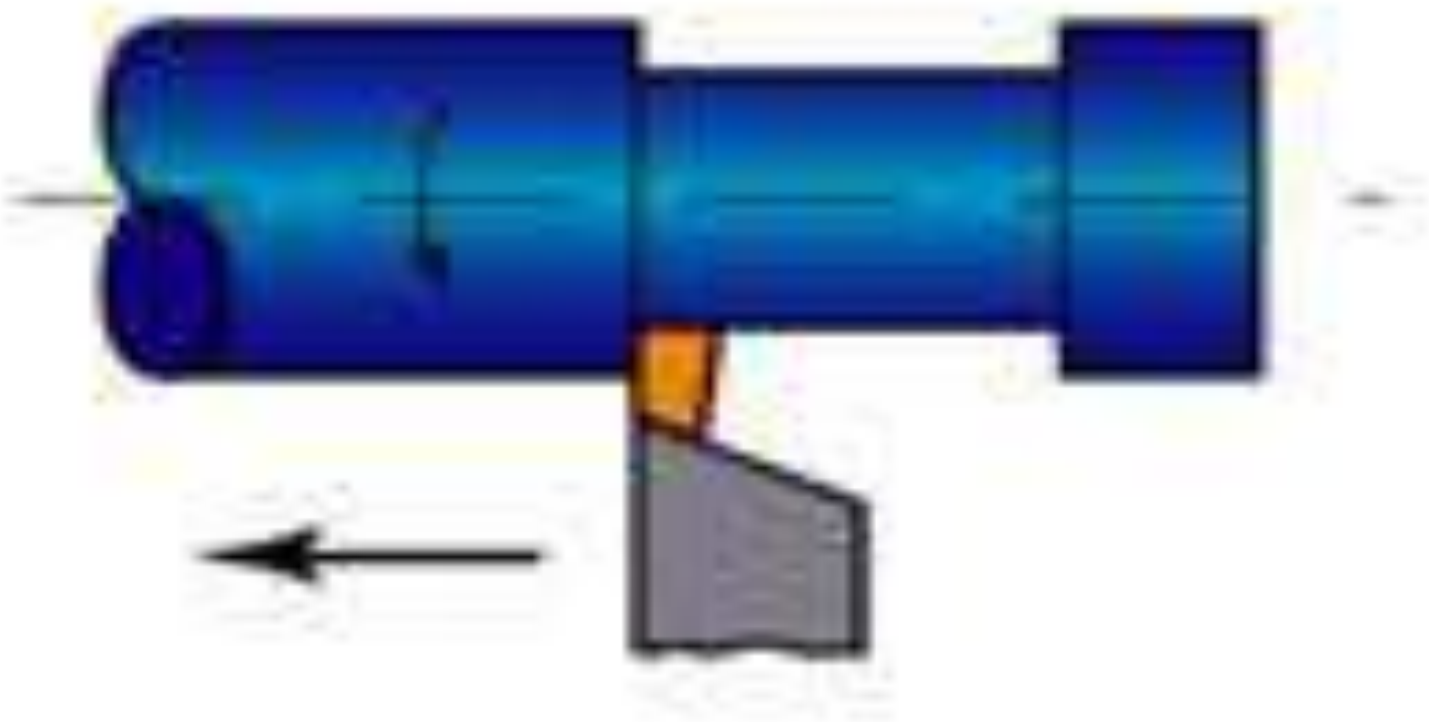


(a) Square groove (b) V-groove (c) Round groove

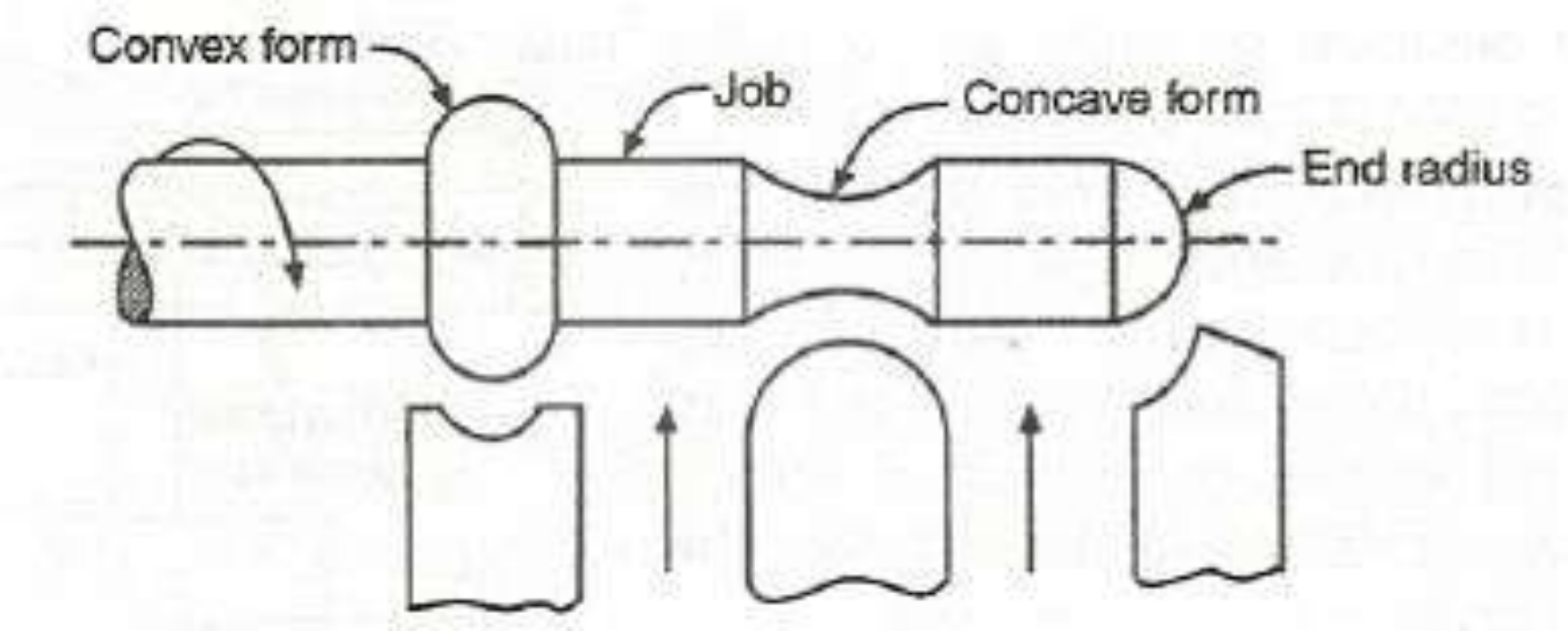
Grooving ..



grooving



14.Forming : Some components having neither cylindrical nor tapered surfaces are said to have shaped or formed surfaces. For machining such shapes, special tools are used which are called as **Form Tools.**



Drilling Machine

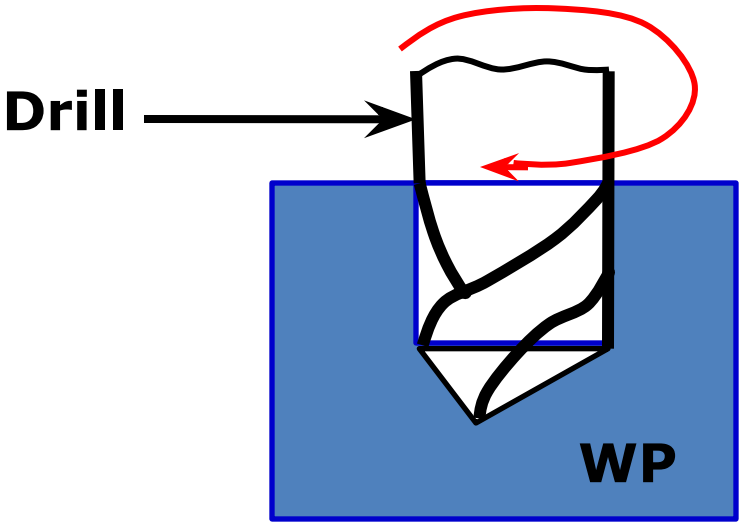
DRILLING MACHINES

- Drilling is an operation through which cylindrical holes are produced in a solid material by using a revolving tool which is **called as drill**.

- The machine tool used for producing the holes in workpiece by forcing rotating tool into stationary workpiece is called as drilling machine.

Drilling

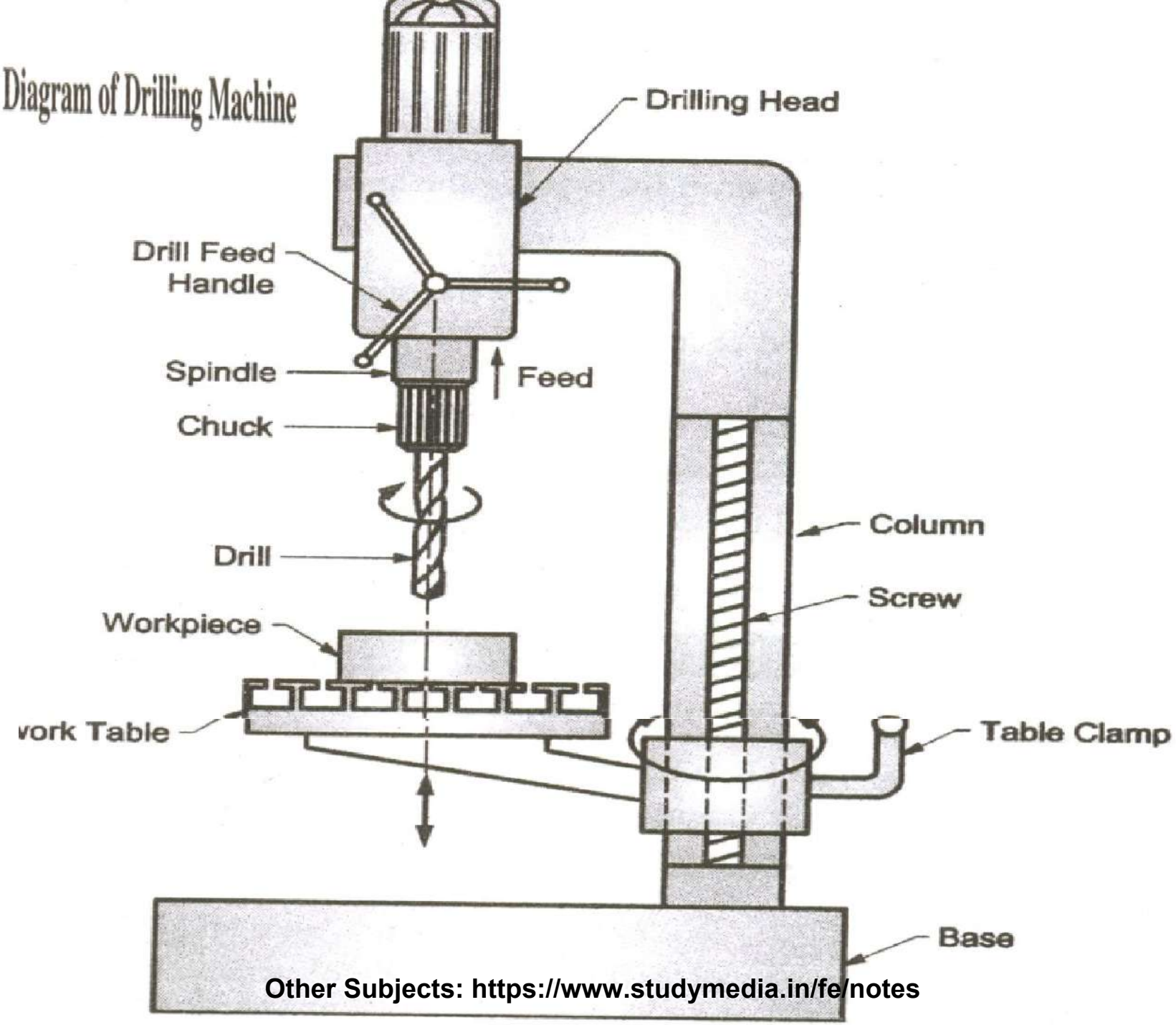
- Drilling is the operation of originating a cylindrical hole
- Hole is generated by rotating cutting edges of drill, which exerts large force on the WP to originate a hole

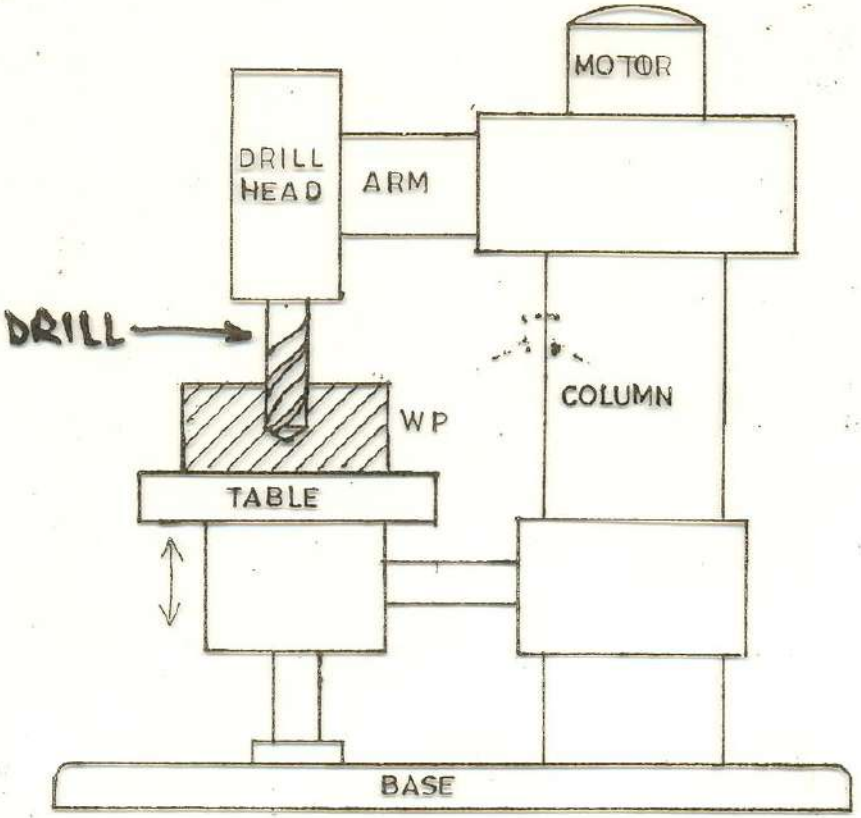


1. WORKING PRINCIPLE

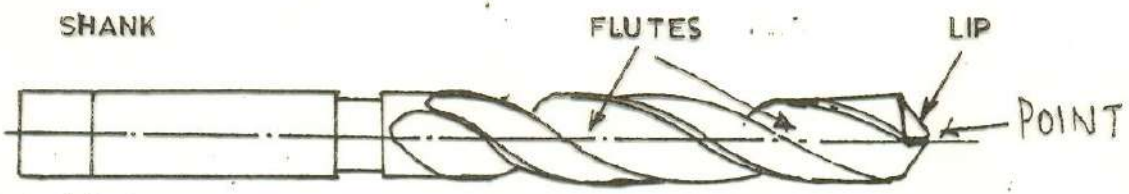
- The work piece is clamped firmly on the work table by using nuts and bolts.
- The tool used to produce holes in solid material called as drill is press fitted in drill chuck.
- The rotating drill is made of harder material than that of the workpiece and it is fed against the stationary work piece.
- During the operation, 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.

Block Diagram of Drilling Machine





Drill Machine



Twist Drill

1)BASE:-

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

2) COLUMN:-

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

3) WORK TABLE:-

- The table is mounted on the column, it may be round or rectangle in shape.

- The table has following type of motion
  (i) vertical motion (up and down)
  (ii) circular motion (swing)
  out its own axis.

4) DRILL HEAD:-

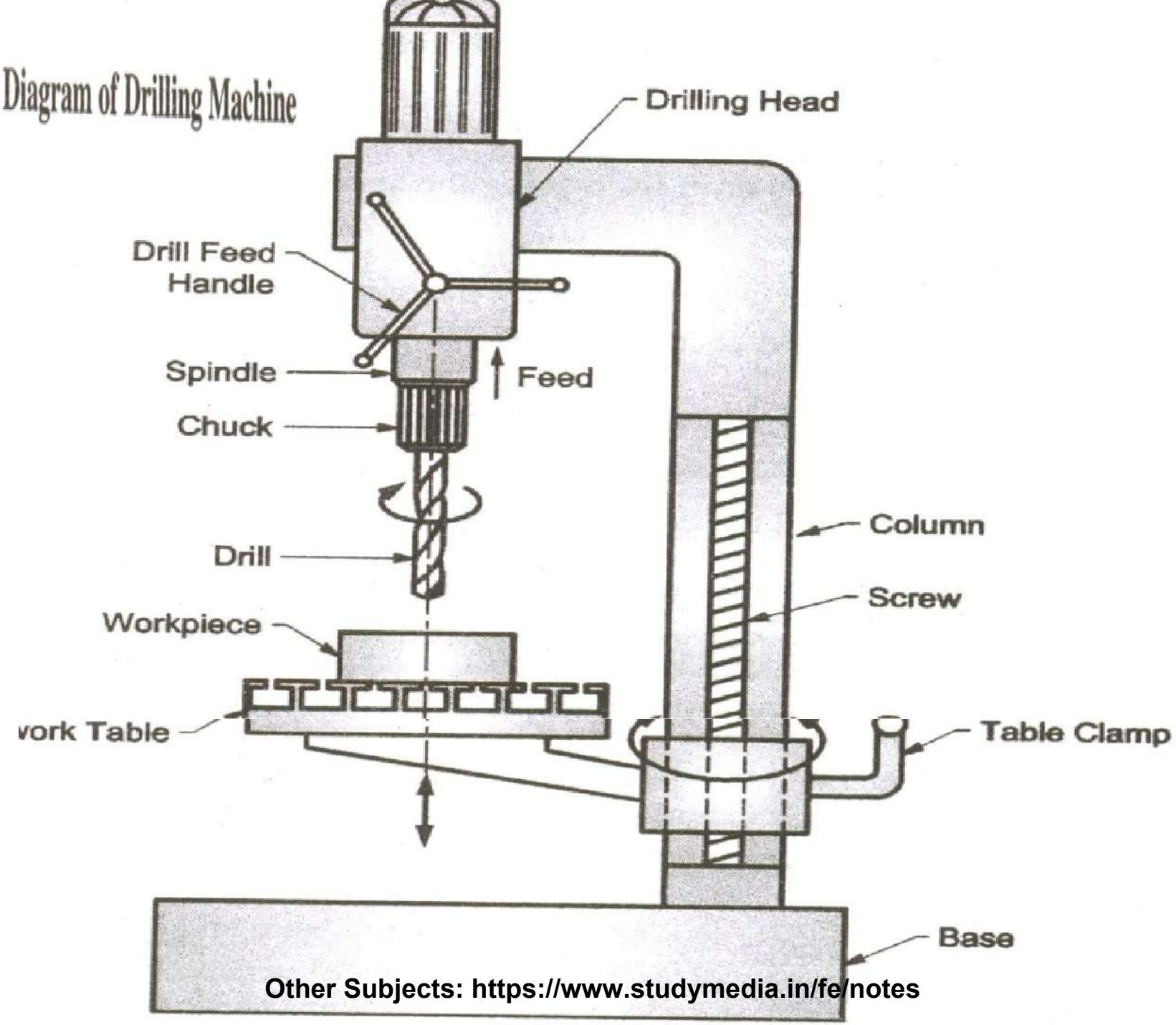
- The drill head carries driving and feeding mechanism for the spindle, the driving mechanism is used for driving the drill spindle. The drill head is mounted on the top of the column

5) SPINDLE DRIVE:-

- Spindle is a hollow part in which drill(tool) is inserted.

- During the operation spindle rotates, as well as move up and down. Hence the drill also rotates as well as moves up and down.

Block Diagram of Drilling Machine



TYPES OF DRILLING MACHINES:-

Drilling machine are manufactured in different sizes and varieties to suit different types of workpieces. They are classified as follows:

1) Portable drilling machine
2) Sensitive or Bench drilling machine
3) Upright drilling machine
4) Radial drilling machine
5) Gang drilling machine
6) Multi-spindle drilling machine
7) Deep hole drilling machine
8) Automatic drilling machine

1. PORTABLE DRILLING MACHINE:-

- Portable drilling machine is very small, compact and self contained unit carrying a small electric motor inside it.

- It is generally used for drilling holes in components which cannot be transported to the workshop, because of their size or weight.In such cases, the drilling operations is performed on the site by using portable electric drill.

- Portables drills are light in weight and manufactured in different sizes and capacities.

- One of the major advantage of portable drill is that, the holes can be drilled at any desired inclination.

- As small size of drill is used, the machine is operated at high speed.

Portable Drilling Machine

2. SENSITIVE OR BENCH DRILLING MACHINE

- This type of drilling machine is designed for drilling small holes at high speed in light workpieces.

- It is small machine having simple construction and operation.
  Fig., shows sensitive drill machine which consist of a base, which may be mounted on a bench or on the floor.

- The vertical column carries a swivelling table, the height of which can be adjusted along the column. Also, the table can be swung to any required position.

- At the top, the column is provided with belt-pulley arrangement. One of the pulley is mounted on the motor shaft and other on the machine spindle.

- Different spindle speed can be obtained by shifting a V-belt to different pairs of driver and driven pulleys,while the motor continues to rotate at the same speed.

Sensitive Drilling Machine

- Drill holes from 1.5 to 15mm
- Operator senses the cutting action so sensitive drilling machine

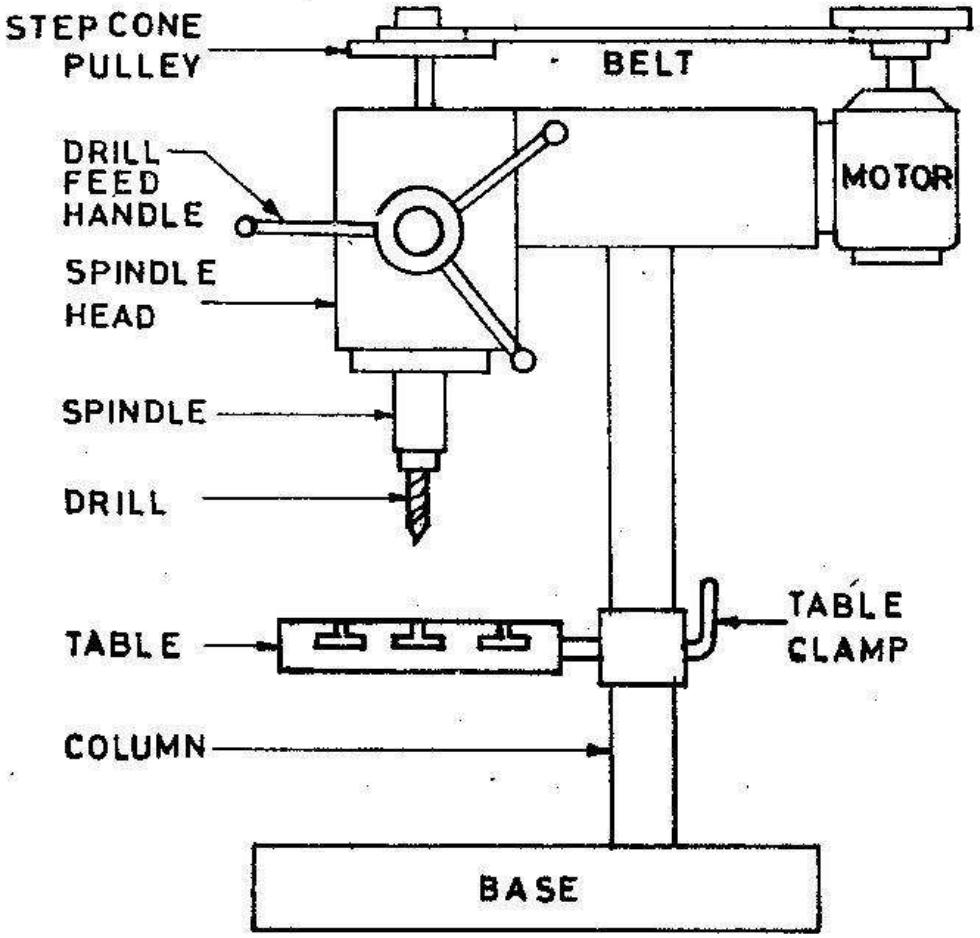


Fig.

- There is no arrangement for automatic feed of the drill spindle and hence the drill is fed into the work by hand control.

- For drilling small holes, high speed and hand feed are necessary.

- Hand feed enables the operator to feel the gradual penetration of the drill into the work piece and sense obstruction, if any.

- As the operator sense the cutting action at any instant, it is known as sensitive drilling machine.

3. UPRIGHT OR PILLAR DRILLING MACHINE

Upright drilling machine is similar to sensitive drilling machine but differs in the following manners:-

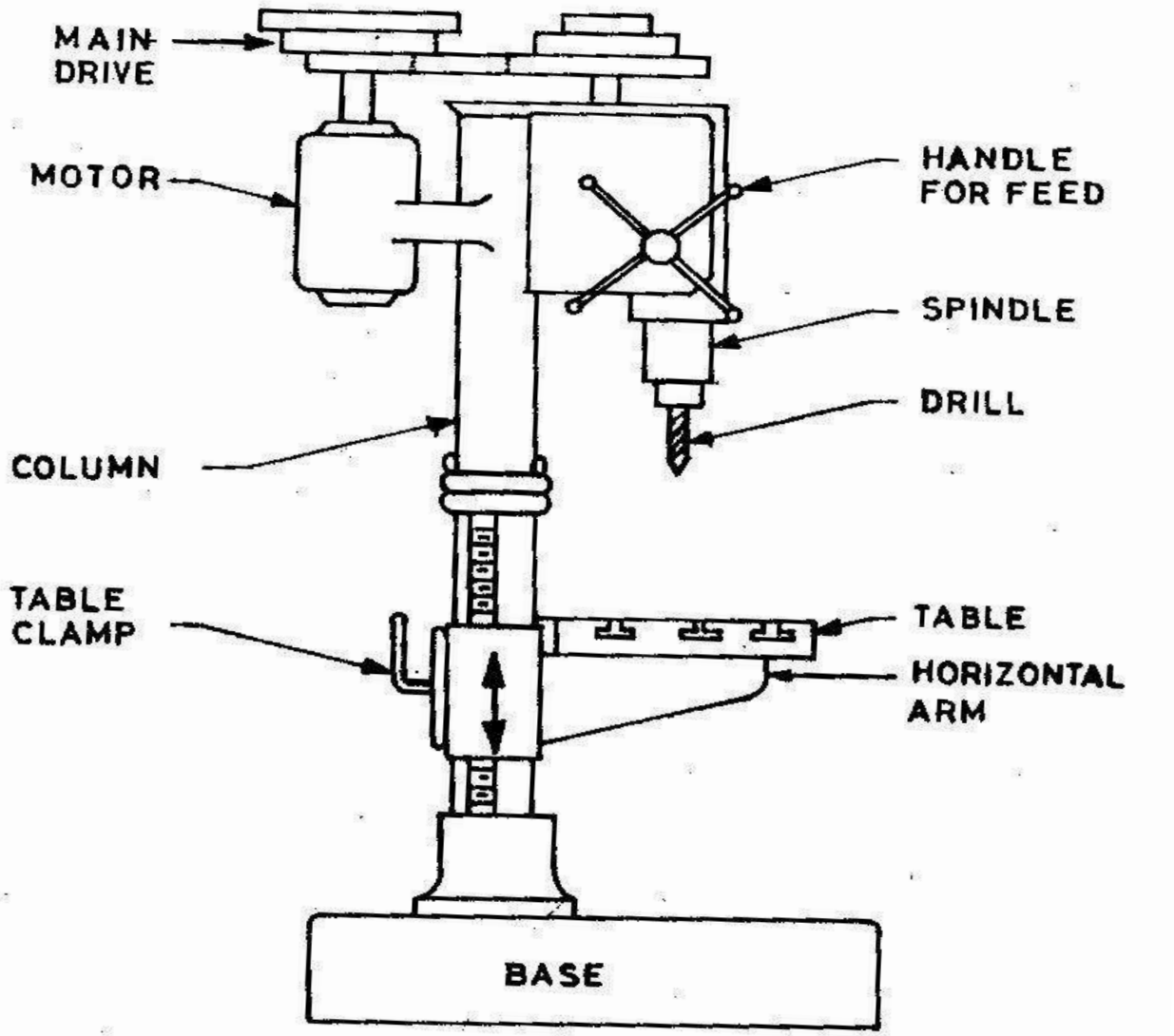
- Upright drilling machine is larger and heavier then sensitive drilling machine.

- Upright drilling machine is used for handling medium sized work pieces.

- In this machine, large no. of spindles speeds and feeds are available for drilling different types of work pieces .The spindle feed is power feed or automatic.

- The table of the machine has different types of adjustments

Up-Right Drilling Machine



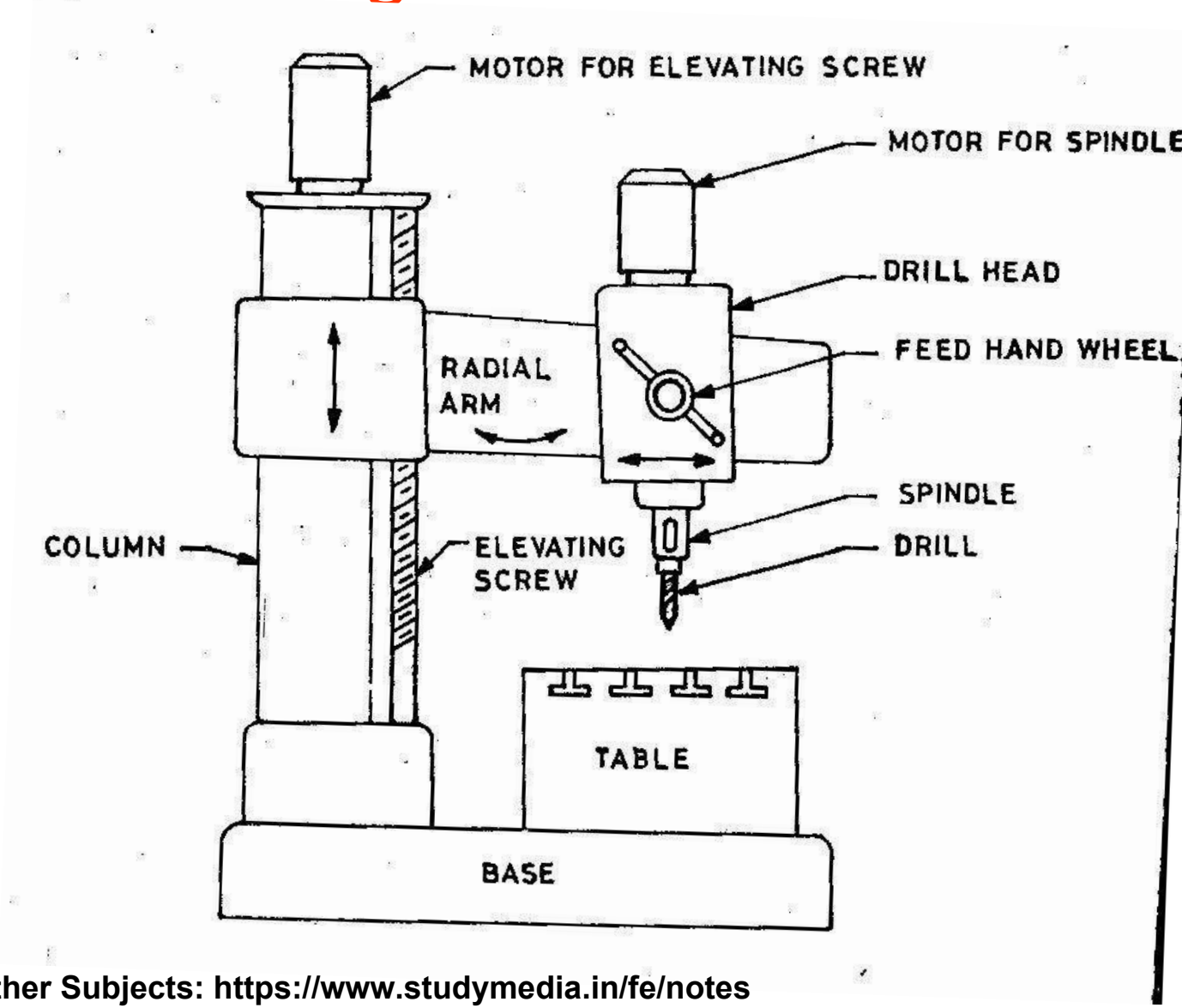
- Drill holes upto 50mm
- Table can move vertically and radially

4. RADIAL DRILLING MACHINE

- Radial drilling machine is designed for drilling medium to large and heavy work pieces.
- It consists of a heavy, round and vertical column mounted on a large base.
- To accommodate work pieces of different heights, the column supporting a radial arm can be raised or lowered.
- When several holes are to be drilled on a larger work piece, the position of the arm and the work head is changed, so that the drill spindle may be moved from one position to another position without changing the setting of the work piece.

Radial Drilling Machine

- It is the largest and most versatile used for drilling medium to large and heavy work pieces.



DRILLING MACHINE OPERATIONS

1. DRILLING

Drilling is the operation of producing a circular hole in a solid metal by using revolving tool which is called drill.

2. REAMING

- Reaming is the operation of finishing a hole which has been previously drilled and has a coarse surface finish.
- The operation is performed by using a multitooth tool called as reamer.

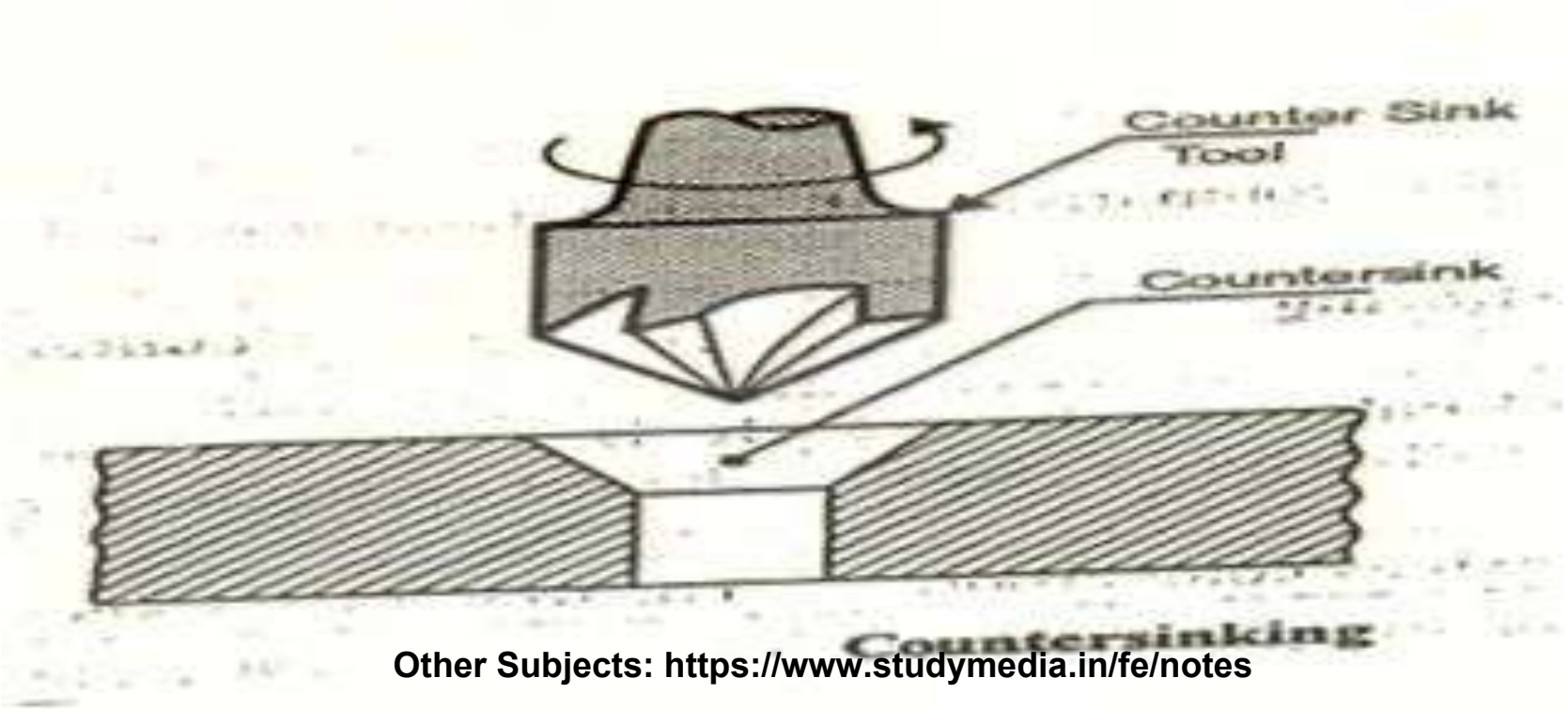
3. BORING

- The boring is the process of enlarging a drilled hole by using an adjustable cutting tool which is called as boring tool.
- It is important to note that the boring tool is having only one cutting edge.

4. COUNTER SINKING

- Counter sinking operation is used for enlarging the end of a hole and to give it a conical shape for a short distance.

- The standard countersinks have the included angles of 60, 82 or 90 degrees and cutting edges of tool are at the conical surface.

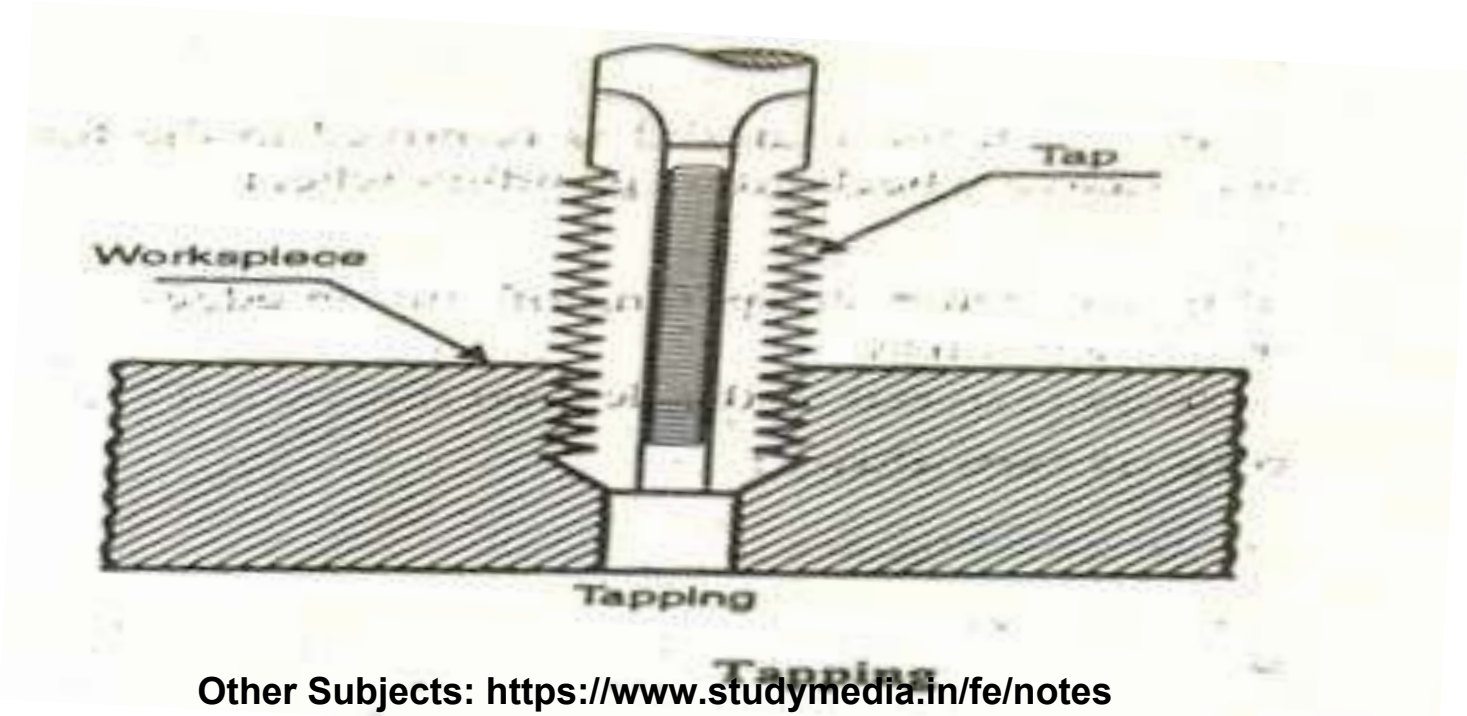


5. SPOT FACING

- It is the operation of smoothing and squaring the surface around a hole for the seat of a nut or the head of a screw.
- For spot facing counterbore or special spot facing tool is used.

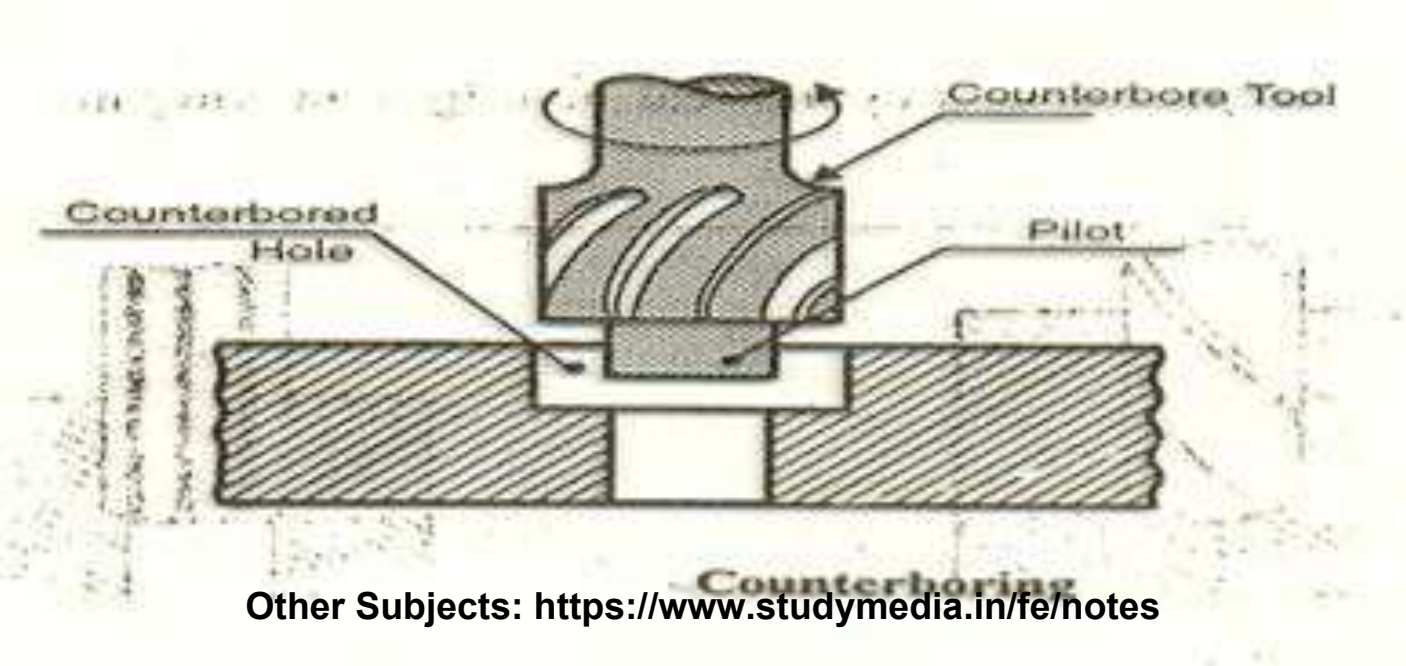
6. TAPPING

- 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.



7. COUNTER BORING OPERATION:

It is the operation of enlarging the end of a hole cylindrically. The enlarged hole forms a square shoulder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins.

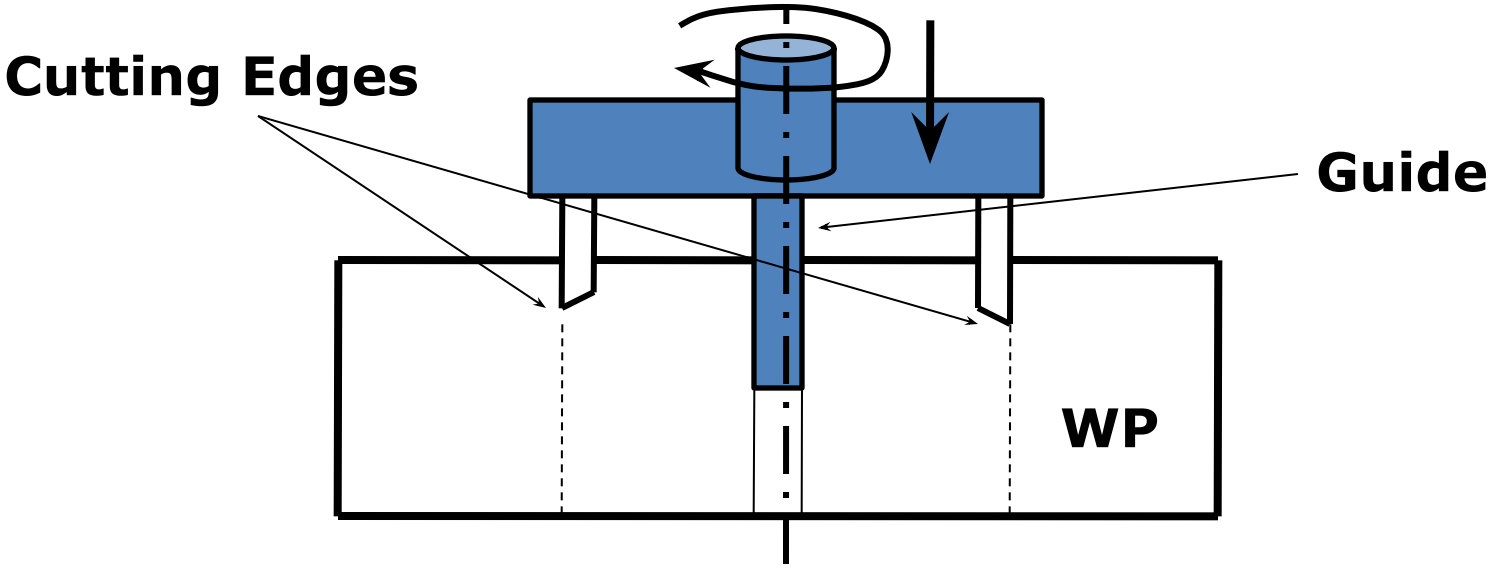


8. TREPANNING

- When large diameter holes are required in a sheet metal, then trepanning operation is carried out by using trepanning tool.

- A small hole , to suit the pilot is drilled at the center 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.

Trepanning



- Trepanning is the operation of producing a hole by removing metal along the circumference of a hollow cutting tool
- Trepanning is performed for producing large holes which can not be produced by any drilling operations

Milling Machine

It is a machine which removes excess materials from the work pieces by a cutting tool called as milling cutter.

It is one of the important machines of a tool room since almost all the operation can be performed on it very accurately.

The milling cutter has multiple cutting edges, so it removes metal at a very fast rate.

The machine can be mounted with a number of cutter at a time. So milling machine finds wide application in production work.

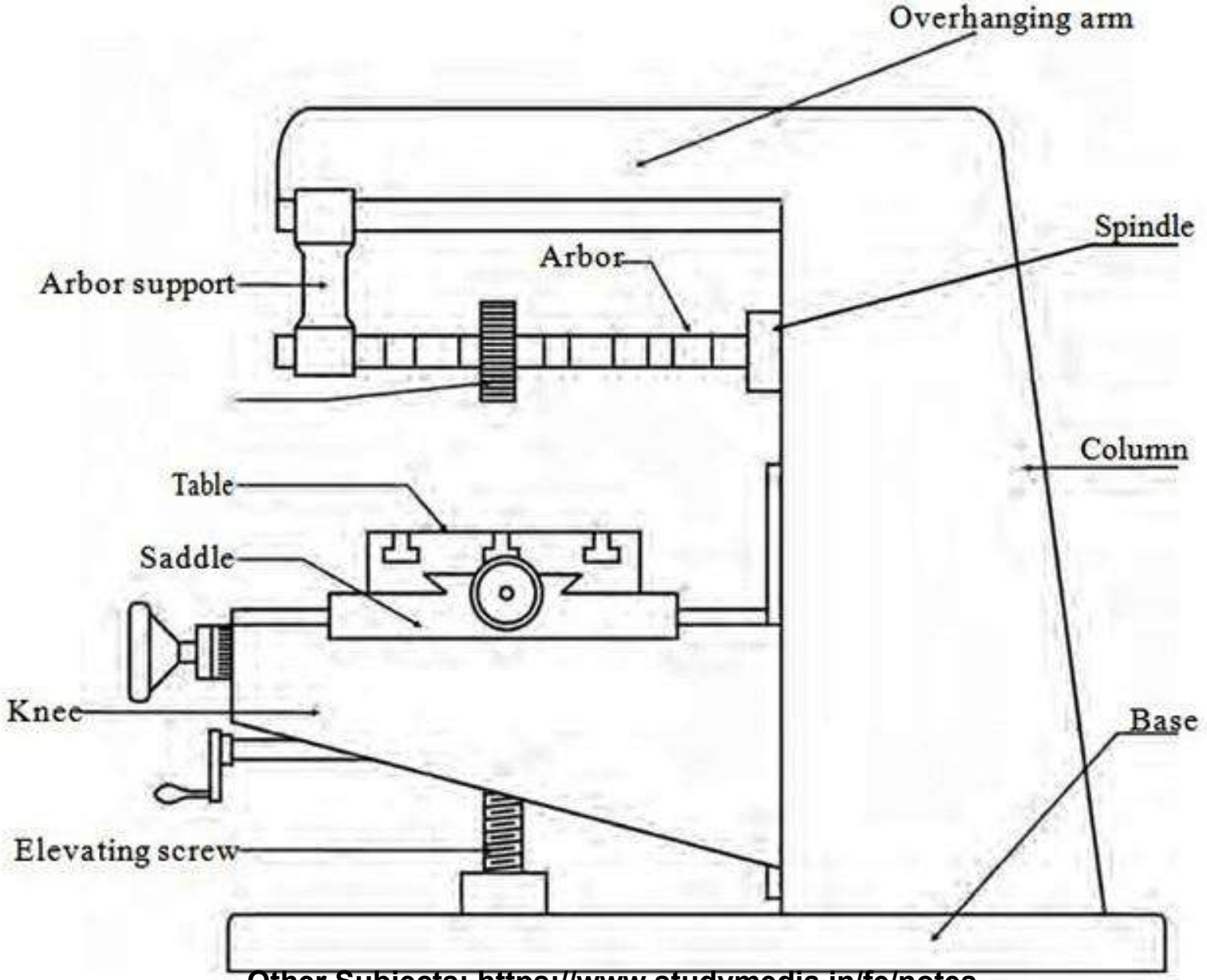
Milling machine can be used to obtain:

A) Flat surfaces
B) Countoured surfaces
C) Slots
D) Internal and external threads
E) Gear cutting

Types of milling machine

- vertical milling machine
- Horizontal milling machine

Basic Elements of Milling Machine



Basic Elements of Milling Machine

- **Base:**

  It is the foundation part of a milling machine. All other parts are jointed on it. It carries the entire load so it should have high compressive strength so it is made by cast iron. It also works as reservoir of cutting fluid.

- **Column:**

  Column is another foundation part of milling machine. It is mounted vertically on the base. It supports the knee, table etc. Work as housing for the all the other driving member.it is a hollow member which contains driving gears and sometimes motor for spindle and the table.

- **Knee:**

  Knee is the first moving part of milling machine. It is mounted on the column and moves along the slideways situated over the column. It is made by cast iron and moves vertically on slideways It moves up and down on sideways which change the distance between tool and workpiece It is driven by mechanically or hydraulically.

Basic Elements of Milling Machine

- **Saddle:**

It is placed between table and the knee and work as intermediate part between them. It can moves transversally to the column face. It slides over the guide ways provided situated on the knee which is perpendicular to the column face. The main function of it is to provide motion in horizontal direction to work piece. It is also made by cast iron.

- **Table:**

Table is situated over the knee. It is the part of machine which holds the work piece while machining. It is made by cast iron and have T slot cut over it. The work piece clamp over it by using clamping bolts. The one end of clamping bolt fix into this slot and other is fix to work piece which hold the work piece. It can provide three degree of freedom to work piece.

- **Overhanging arm:**

It is situated over the column on horizontal milling machine. It is overhang over the column surface and other end supports the arbor. It is made by cast iron.

Basic Elements of Milling Machine

- **Spindle:**

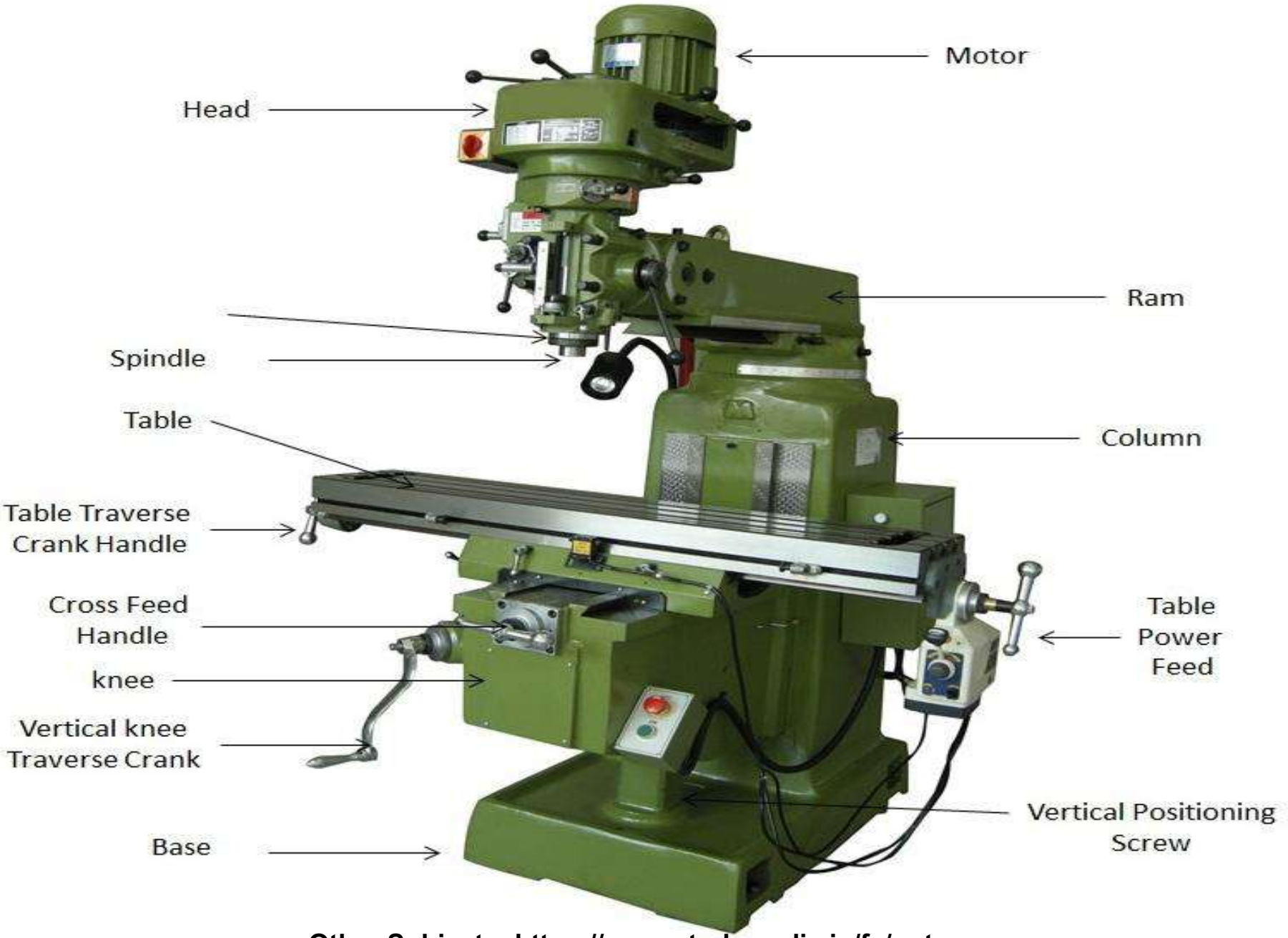
Spindle is the main part of the machine which hold tool at right place in vertical milling machine and hold arbor in horizontal milling machine. It is a moving part which is in rotary motion. It is motor driven and drives the tool. It has a slot on the front end of it. The cutting tool fix in that slot.

- **Arbor:**

It is a mechanical part on which is used as extension part of the spindle in horizontal milling machine. It is fitted on the spindle whenever required. It holds the tool and moves it in correct direction.

- **Arbor Supports:**

This are used to support arbor at right place. One end of this support is jointed at the overhanging arm and another is jointed with arbor.



Milling Machine Operations

1. Plain Milling

The plain milling is the most common types of milling machine operations. Plain milling is performed to produce a plain, flat, horizontal surface parallel to the axis of rotation of a plain milling cutter. The operation is also known as slab milling.

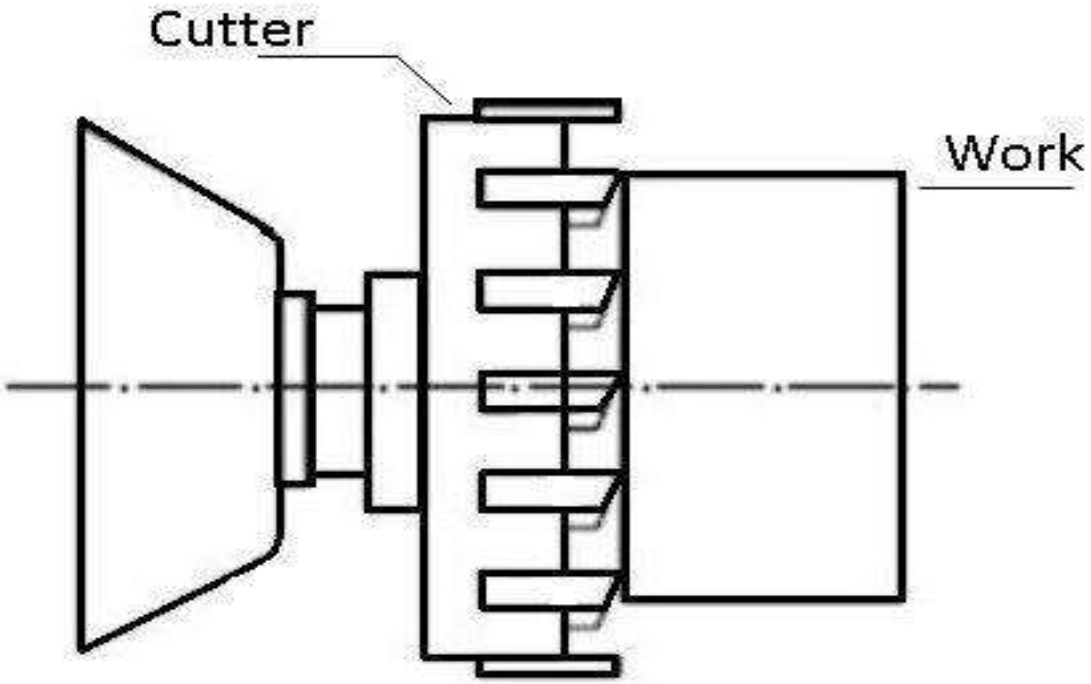
2. Side Milling

The side milling is the operation of producing a flat vertical surface on the side of a workpiece by using a side milling cutter. The depth of cut is set by rotating the vertical feed screw of the table.

Milling Machine Operations

3. Face Milling

Face milling is the simplest milling machine operations. This operation is performed by a face milling cutter rotated about an axis perpendicular to the work surface.

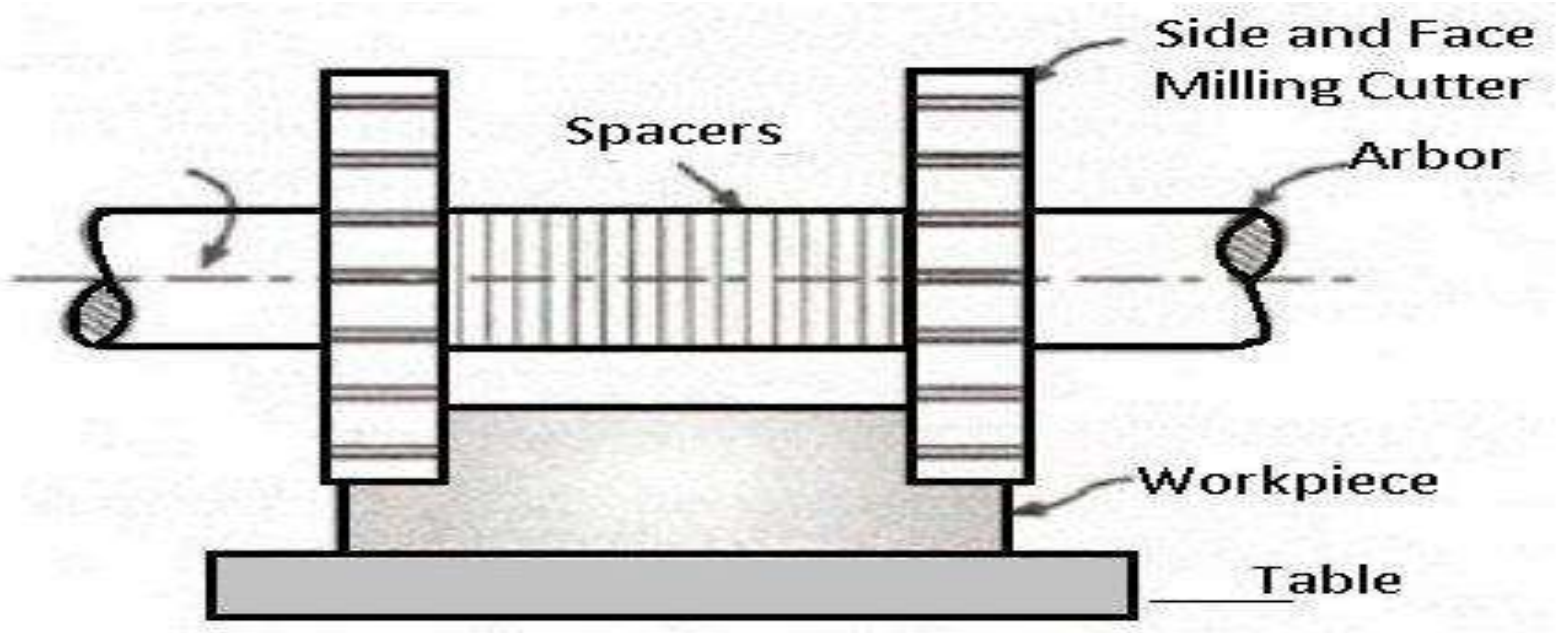


Face Milling Operation

Milling Machine Operations

4. Straddle Milling

The straddle milling is the operation of producing a flat vertical surface on both sides of a workpiece by using two side milling cutters mounted on the same arbor.

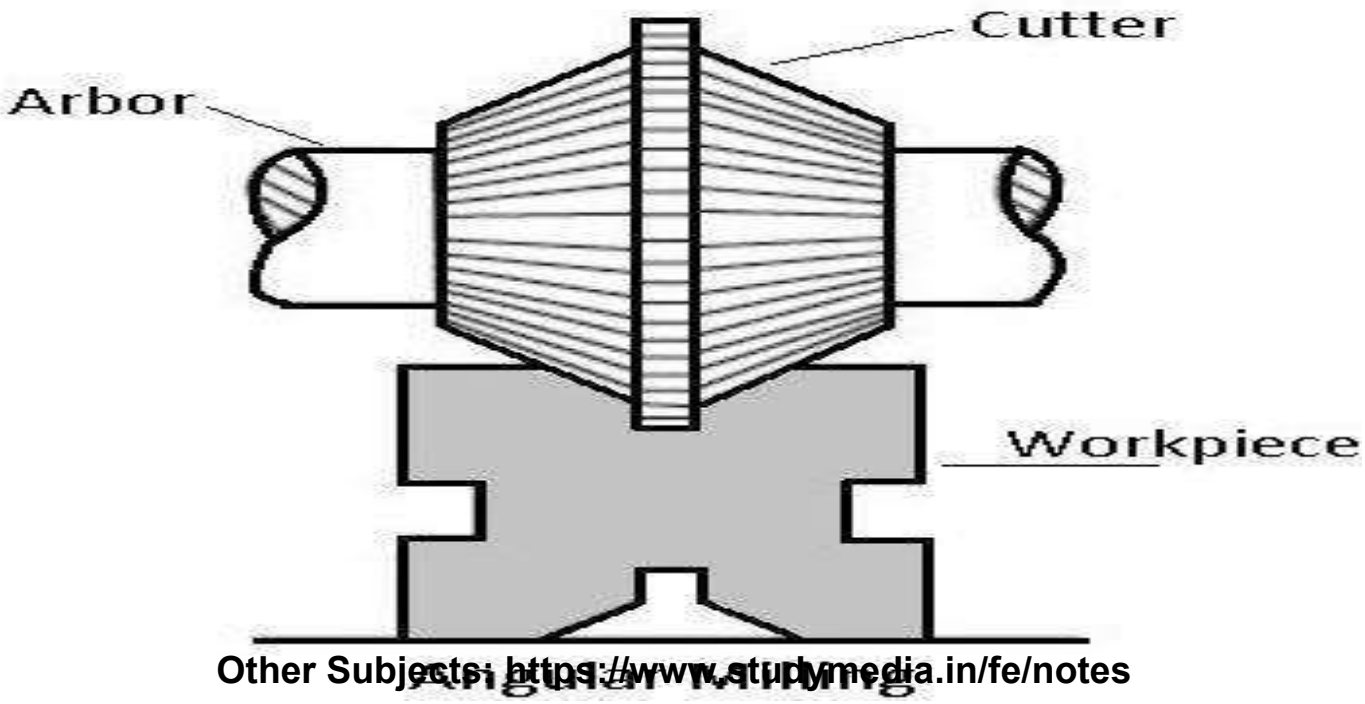


Straddle Milling Operation

Milling Machine Operations

5. Angular Milling

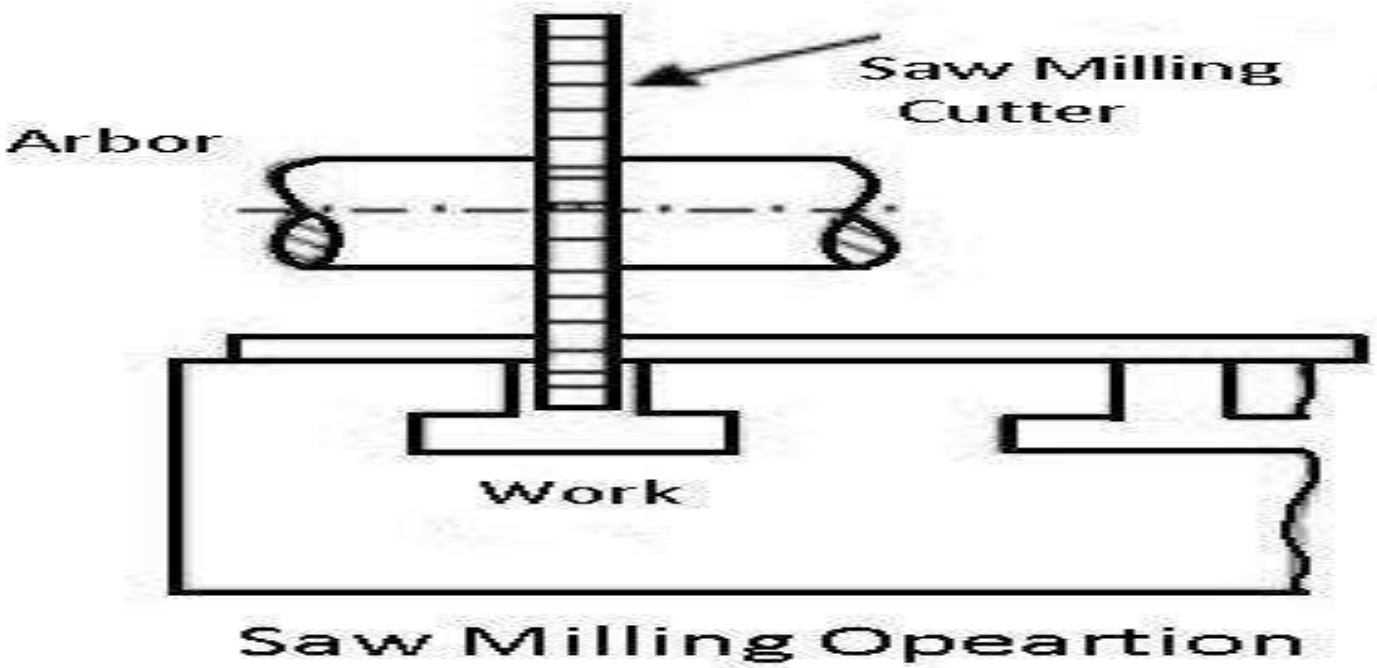
The angular milling is the operation of producing an angular surface on a workpiece other than at right angles of the axis of the milling machine spindle.



Milling Machine Operations

6. Saw Milling

- The saw-milling is the operation of producing narrow slots or grooves on a workpiece by using a saw-milling cutter.

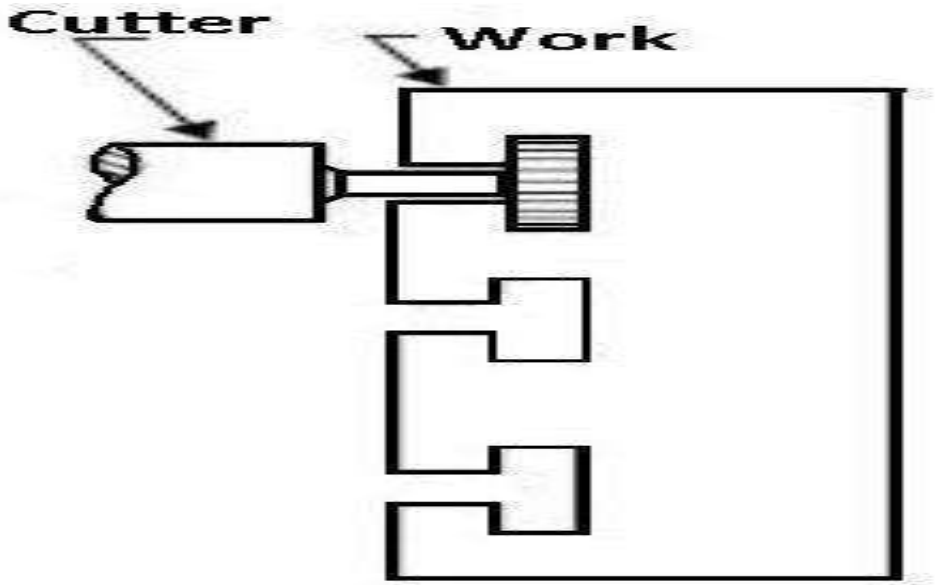


Saw Milling Opeartion

Milling Machine Operations

7. Slot & Groove Milling:

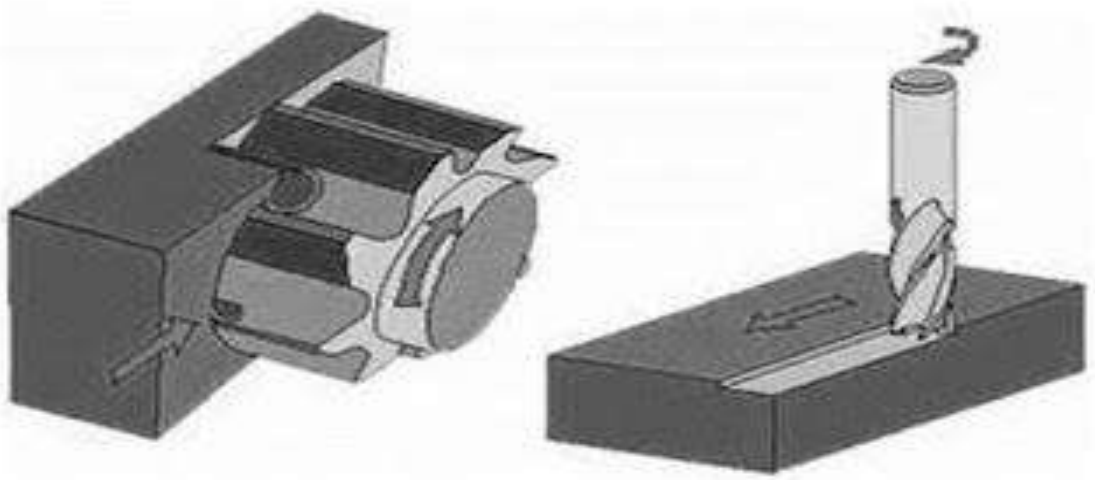
The operation of producing of keyways, grooves and slots of varying shapes and sizes can be performed in a milling machine. It is done by using a plain milling cutter, a metal slitting saw, an end mill or by a side milling cutter.



Milling Machine Operations

8. End milling:

- This operation is also used to get plain surface. In this operation, the cutting tool axis is perpendicular to the machining surface or the face of the machining surface. It is also used to slot cutting on the milling axis.



End Milling

Systems In Mechanical Engineering

UNIT 5

ADVANCED MANUFACTURING PROCESSES

Mr. Girish G Khope

Micromachining

- *Removal of material in the form of chips or debris having the size in the range of microns.*

- *Creating micro features or surface characteristics (especially surface finish) in the micro/nano level.*

- *Definition: material removal at micro/nano level with no constraint on the size of the component being machined.*

Micromachining

- The term micromachining usually refers to the fabrication of micromechanical structures with the aid of **etching techniques** to remove part of the substrate or a thin film.

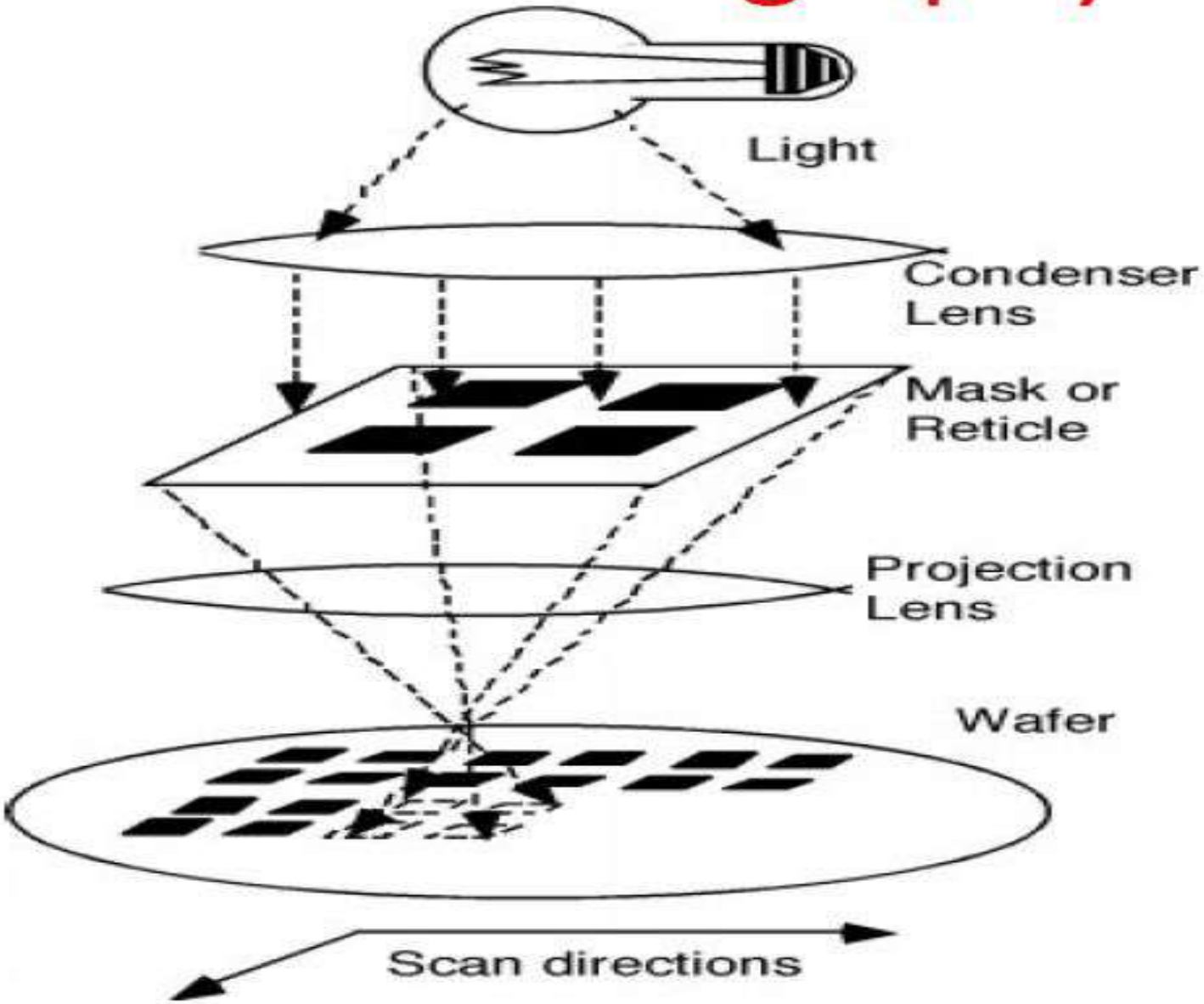
- **Silicon** has excellent mechanical properties making it an ideal material for machining.

- Micromachining usually refers to the fabrication process of MEMS(Micro Electro Mechanical System) , microsensors and microstructure in general.

Different Micromachining Techniques

- ***Photolithography***
- *Etching*
- *Silicon Micromachining*
- *LIGA*
- *Mechanical Micromachining*

Photolithography



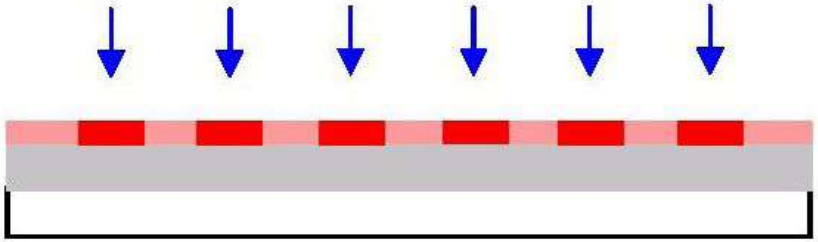
Steps Involved in Photolithography

Step 1: Clean substrate

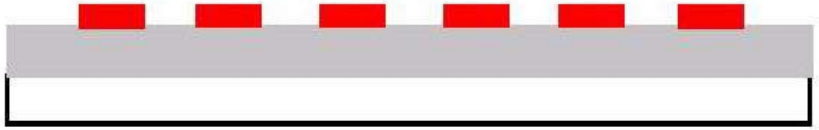
Step 2: Coat substrate with ≈40μm of lead

Step 3: Dip coat with photoresist

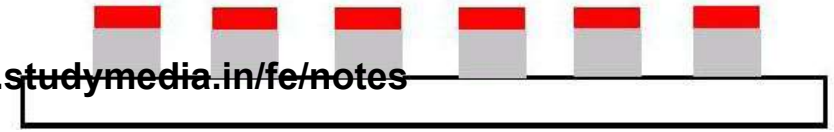
Step 4: Expose with laser



Step 5: Develop away unexposed resist



Step 6: Wet etch



Photolithography Process Description

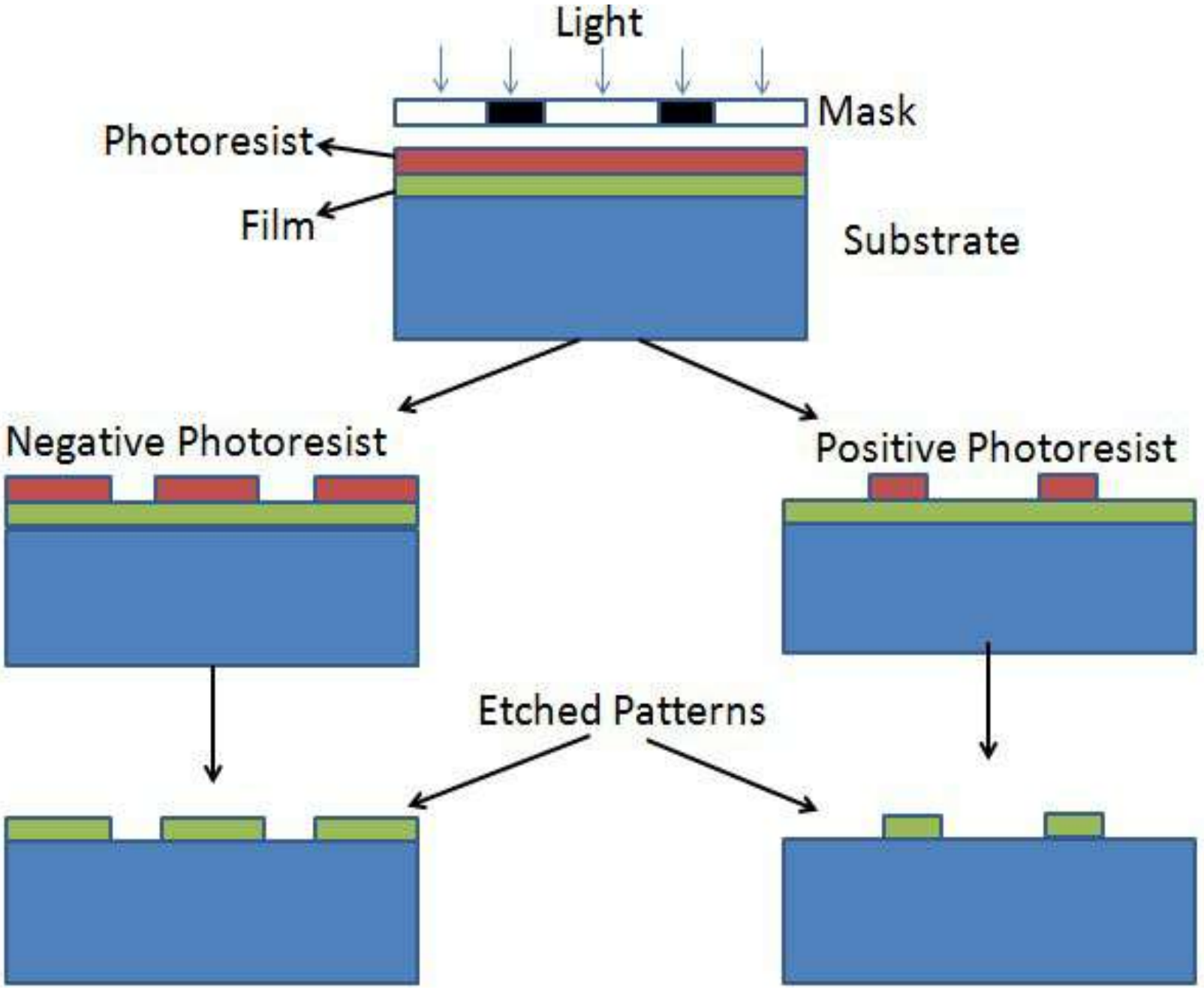
- *The wafers are chemically cleaned to remove particulate matter, organic, ionic, and metallic impurities.*

- *High-speed centrifugal whirling of silicon wafers known as "Spin Coating" produces a thin uniform layer of photoresist (a light sensitive polymer) on the wafers*

- *Photoresist is exposed to a set of lights through a mask often made of quartz*

- *Wavelength of light ranges from 300-500 nm (UV) and X-rays (wavelengths 4-50 Angstroms)*

- *Two types of photoresist are used:*
  - *Positive: whatever shows, goes*
  - *Negative: whatever shows, stays*



Abrasive Jet Machining

Definition:

In abrasive jet machining, a focused stream of abrasive particles, carried by high pressure air or gas is made to impinge on the work surface through a nozzle and work material is removed by erosion by high velocity abrasive particles.

Additive manufacturing

- Additive manufacturing, also known as 3D printing, is a process that creates a physical object from a digital design.

- Additive manufacturing, also known as 3D printing, is a transformative approach to industrial production that enables the creation of lighter, stronger parts and systems.

- It is yet another technological advancement made possible by the transition from analog to digital processes.

- Additive manufacturing uses data computer-aided-design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes.

- As its name implies, additive manufacturing adds material to create an object.

Additive manufacturing

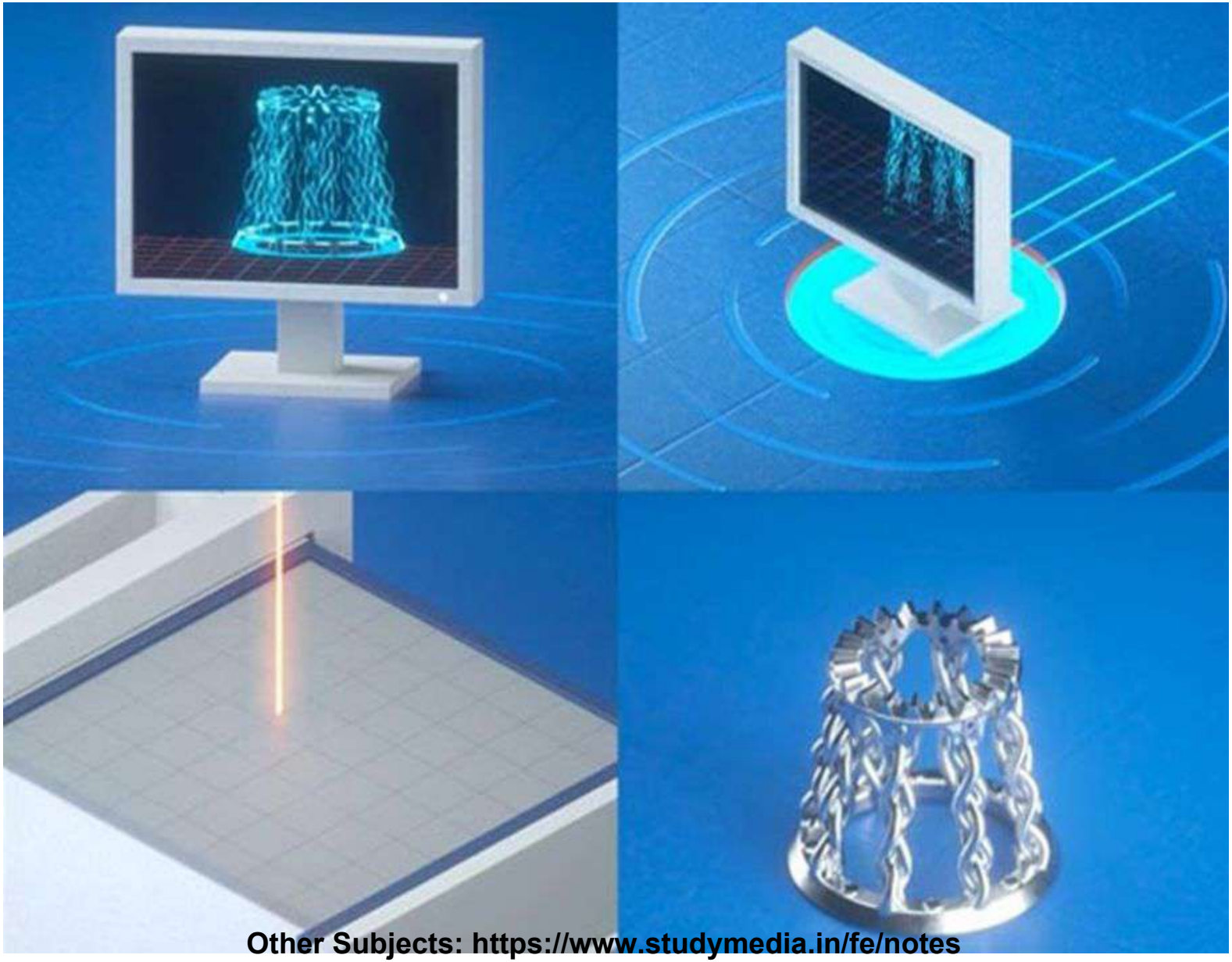
- The term “additive manufacturing” references technologies that grow three-dimensional objects one superfine layer at a time.

- Each successive layer bonds to the preceding layer of melted or partially melted material.

- It is possible to use different substances for layering material, including metal powder, thermoplastics, ceramics, composites, glass and even edibles like chocolate.

- The journey from .stl file to 3D object is revolutionizing manufacturing. Gone are the intermediary steps, like the creation of molds or dies, that cost time and money.

Fig. of additive manufacturing -3D Printer



Additive manufacturing processes

- **Material Extrusion**

  Material extrusion is one of the most well-known additive manufacturing processes.

  Spooled polymers are extruded, or drawn through a heated nozzle mounted on a movable arm.

  The nozzle moves horizontally while the bed moves vertically, allowing the melted material to be built layer after layer.

  Proper adhesion between layers occurs through precise temperature control or the use of chemical bonding agents

- **Directed Energy Deposition**

  The process of directed energy deposition (DED) is similar to material extrusion, although it can be used with a wider variety of materials, including polymers, ceramics and metals.

  An electron beam gun or laser mounted on a four- or five-axis arm melts either wire or filament feedstock or powder.

- **Material Jetting**

With material jetting, a print head moves back and forth, much like the head on a 2D inkjet printer.

However, it typically moves on x-, y- and z-axes to create 3D objects. Layers harden as they cool or are cured by ultraviolet light.

- **Binder Jetting**

The binder jetting process is similar to material jetting, except that the print head lays down alternate layers of powdered material and a liquid binder.

- **Powder Bed Fusion**

Powder Bed Fusion (PBF) technology is used in a variety of AM processes, including direct metal laser sintering (DMLS), selective laser sintering (SLS), selective heat sintering (SHS), electron beam melting (EBM) and direct metal laser melting (DMLM).

Additive manufacturing materials

AM technology fabricates jet engine parts from advanced metal alloys, and it also creates chocolate treats and other food items.

- **Thermoplastics**
- **Metals**
- **Ceramics**
- **Biochemicals**

- **Additive manufacturing applications-**
- **Aerospace**

AM excels at producing parts with weight-saving, complex geometric designs. Therefore, it is often the perfect solution for creating strong aerospace parts.

- **Automotive**
- CNN reported that the McLaren racing team is using 3D-printed parts in its Formula 1 race cars.

Healthcare

At the New York University School of Medicine, a clinical study of 300 patients will evaluate the efficacy of patient-specific, multi-colored kidney cancer models using additive manufacturing

Product Development

As the potential for AM's design flexibility is realized, once impossible design concepts are now being successfully re-imagined. Additive manufacturing unleashes the creative potential of designers who can now operate free of the constraints under which they once labored.

Rapid Prototyping (RP)

- **Rapid prototyping is the fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD).**

- **The creation of the part, model or assembly is usually completed using additive manufacturing, or more commonly known as 3D printing.**

- Rapid prototyping (RP) includes a variety of manufacturing technologies, although most utilise layered additive manufacturing.

- However, other technologies used for RP include high-speed machining, casting, moulding and extruding.

Types of Rapid Prototyping (RP)

- **Fused Deposition Modelling (FDM) or Material Jetting**

This inexpensive, easy-to-use process can be found in most non-industrial desktop 3D printers.

It uses a spool of thermoplastic filament which is melted inside a printing nozzle barrel before the resulting liquid plastic is laid down layer-by-layer according to a computer deposition program.

While the early results generally had poor resolution and were weak, this process is improving rapidly and is fast and cheap, making it ideal for product development.

- **Stereolithography (SLA) or Vat Photopolymerization**

This fast and affordable technique was the first successful method of commercial 3D printing. It uses a bath of photosensitive liquid which is solidified layer-by-layer using a computer-controlled ultra violet (UV) light.

Types of Rapid Prototyping (RP)

- **Selective Laser Sintering (SLS)**

  Used for both metal and plastic prototyping, SLS uses a powder bed to build a prototype one layer at a time using a laser to heat and sinter the powdered material.

  However, the strength of the parts is not as good as with SLA, while the surface of the finished product is usually rough and may require secondary work to finish it.

- **Selective Laser Melting (SLM) or Powder Bed Fusion**

  Often known as powder bed fusion, this process is favoured for making high-strength, complex parts. Selective Laser Melting is frequently used by the aerospace, automotive, defence and medical industries.

  This powder bed based fusion process uses a fine metal powder which is melted in a layer by layer manner to build either prototype or production parts using a high-powered laser or electron beam.

  Common SLM materials used in RP include titanium, aluminium, stainless steel and cobalt chrome alloys.

Types of Rapid Prototyping (RP)

- **Laminated Object Manufacturing (LOM) or Sheet Lamination**

This inexpensive process is less sophisticated than SLM or SLS, but it does not require specially controlled conditions.

LOM builds up a series of thin laminates that have been accurately cut with laser beams or another cutting device to create the CAD pattern design.

Each layer is delivered and bonded on top of the previous one until the part is complete.

- **Digital Light Processing (DLP)**

Similar to SLA, this technique also uses the polymerisation of resins which are cured using a more conventional light source than with SLA.

While faster and cheaper than SLA, DLP often requires the use of support structures and post-build curing, it crosses a light barrier that alters its configuration to create the desired cross-sectional pattern on the plastic.

CNC MACHINE

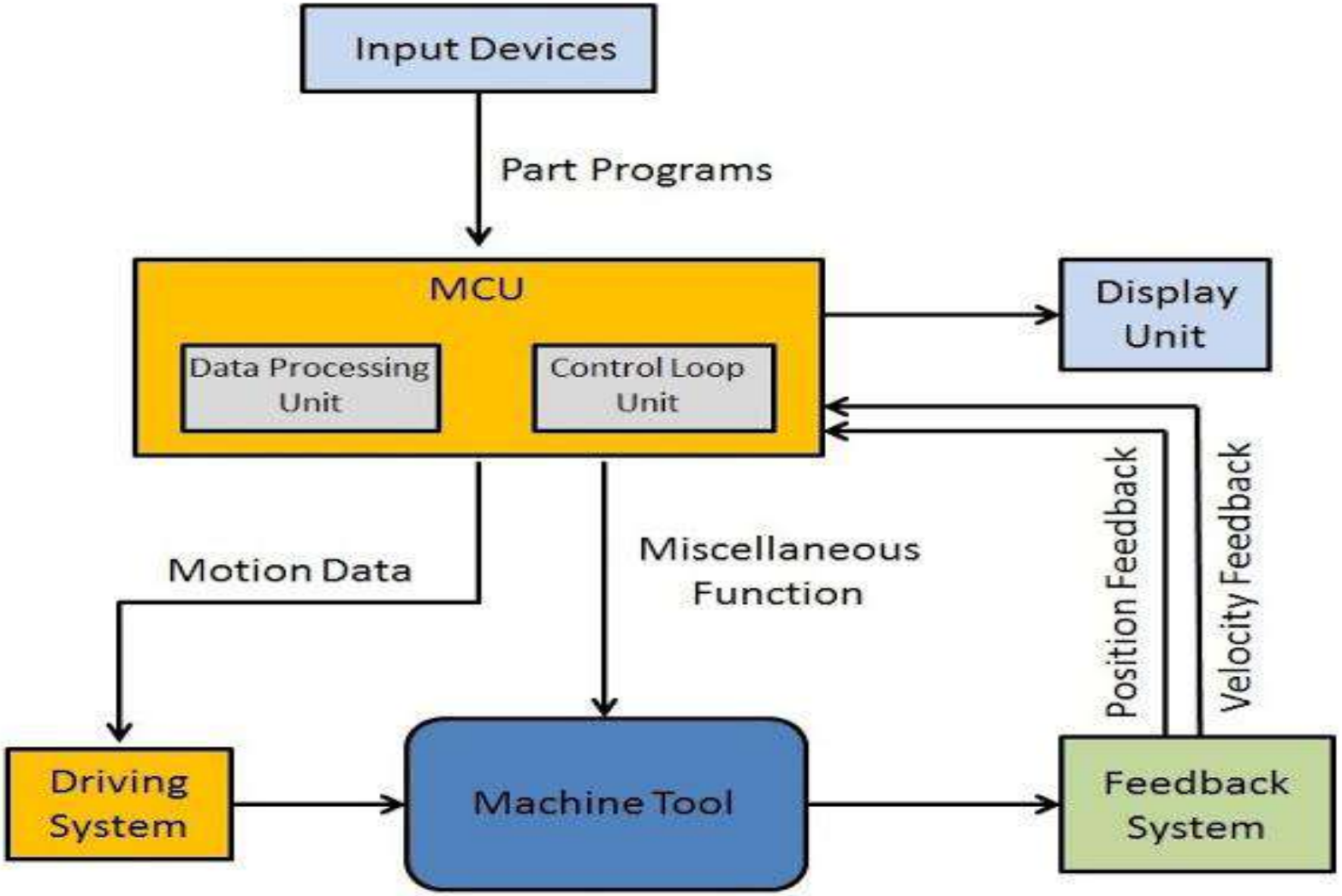
- The use of computers to control machine tools like lathe, mills, shaper etc is called CNC machine.

- The operations which can be carried out by CNC (Computerised Numerically Controlled) machines are mounting the job or machine, rotation of spindle, movement and operations of different tools in sequence as per the requirements of the job, tool changing, ON and OFF operations and releasing the finished job.

- For the operations as mentioned above, a programme is done on a tape and fed to the machine through computer.

- This method helps to change the programme if required with minimum time and cost

Block Diagram of CNC Machine



Main Parts of CNC Machine

(i) Input Devices:

These are the devices which are used to input the part program in the CNC machine. There are three commonly used input devices and these are punch tape reader, magnetic tape reader and computer via RS-232-C communication.

(ii) Machine Control Unit (MCU):

It is the heart of the CNC machine. It performs all the controlling action of the CNC machine, the various functions performed by the MCU are

- It reads the coded instructions fed into it.
- It decodes the coded instruction.
- It implements interpolation (linear, circular and helical) to generate axis motion commands.
- It feeds the axis motion commands to the amplifier circuits for driving the axis mechanisms.
- It receives the feedback signals of position and speed for each drive axis.
- It implements the auxiliary control functions such as coolant or spindle on/off and tool change.

(iii) Machine Tool:

A CNC machine tool always has a slide table and a spindle to control of the position and speed. The machine table is controlled in X and Y axis direction and the spindle is controlled in the Z axis direction.

Main Parts of CNC Machine

iv) Driving System:

The driving system of a CNC machine consists of amplifier circuits, drive motors and ball lead screw.

The MCU feeds the signals (i.e. of position and speed) of each axis to the amplifier circuits. The control signals are than augmented (increased) to actuate the drive motors.

And the actuated drive motors rotate the ball lead screw to position the machine table.

(v) Feedback System:

This system consists of transducers that acts like sensors. It is also called as measuring system.

It contains position and speed transducers that continuously monitor the position and speed of the cutting tool located at any instant.

The MCU receives the signals from these transducers and it uses the difference between the reference signals and feedback signals to generate the control signals for correcting the position and speed errors.

(vi) Display Unit:

A monitor is used to display the programs, commands and other useful data of CNC machine.

Working of CNC Machine

- First, the part program is inserted into the MCU of the CNC. In MCU all the data process takes place and according to the program prepared, it prepares all the motion commands and sends it to the driving system.

- The drive system works, as the motion commands are sent by MCU. The drive system controls the motion and velocity of the machine tool.

- The feedback system records the position and velocity measurement of the machine tool and sends a feedback signal to the MCU.

- In MCU, the feedback signals are compared with the reference signals and if there are errors, it corrects it and sends new signals to the machine tool for the right operation to happen.

- A display unit is used to see all the commands, programs and other important data. It acts as the eye of the machine.

Advantages of CNC

1. It can produce jobs with the highest accuracy and precision than any other manual machine.

2. It can be run for 24 hours a day.

3. The parts produced by it have the same accuracy. There is no variation in the parts manufactured by a CNC machine.

4. A highly skilled operator is not required to operate a CNC machine. A semi-skilled operator can also operate accurately and more precisely.

5. Operators can easily make changes and improvements and reduces the delay time.

6. It has the capability to produce complex designs with high accuracy in minimum possible time.

7. The modern design software, allows the designer to simulate the manufacturer of his/her idea. And this removes the need for making a prototype or model and saves time and money.

8. Fewer workers are required to operate a CNC machine and save labor cost.

Disadvantages of CNC

1. The cost of the CNC machine is very high as compared with a manually operated machine.

2. The parts of the CNC machines are expensive.

3. The maintenance cost in the case of CNC is quite high.

4. It does not eliminate the need for costly tools.

Classification of CNC-Controlled Systems

According to the operations carried out, the systems are classified as follows :

1. **Point to Point System :**

   In this system, the operation is carried out at selected point on the job. During operation, it has no effect on the work-piece during its motion from one point to another point. It is generally used for drilling and reaming operations.

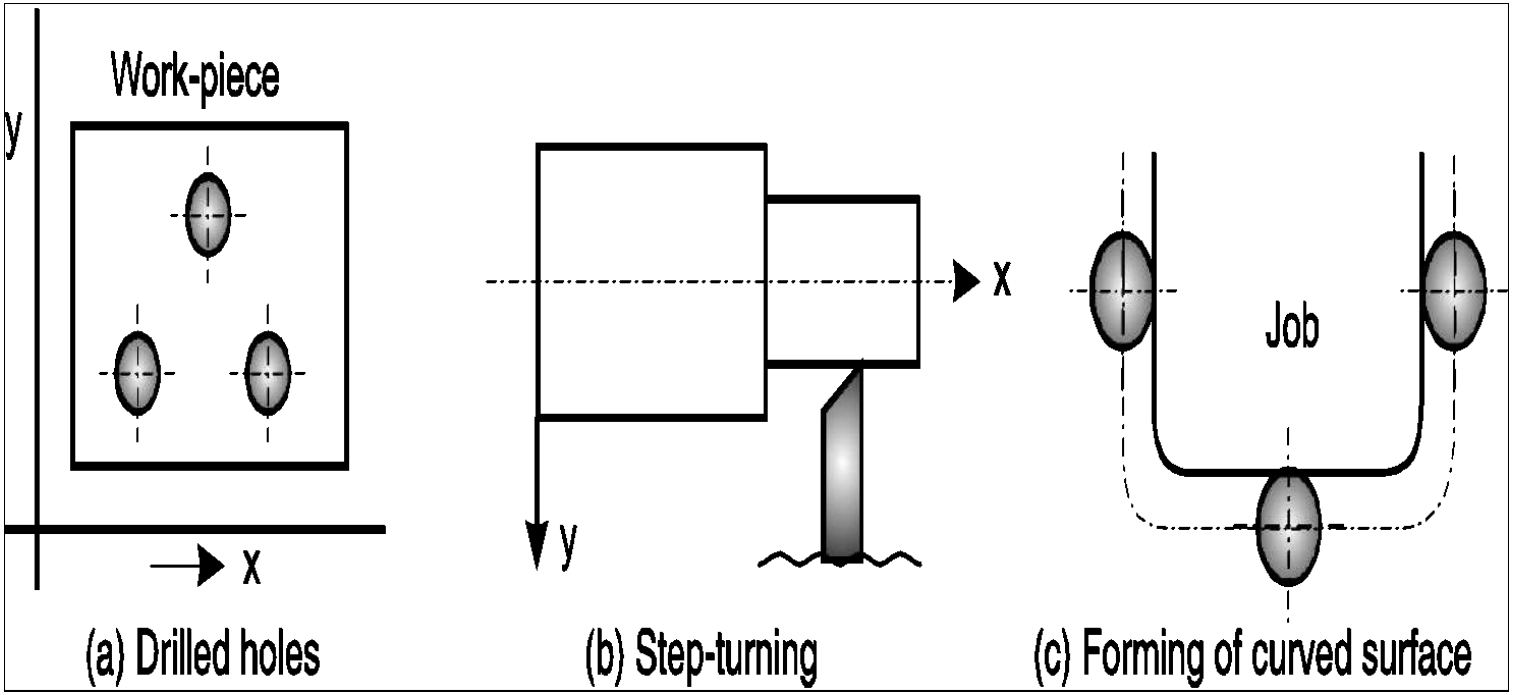
2. **Straight Cut System :**

   In this operation, the tool is moved continuously along a straight path for required cut and for required time. The example of this system is turning on the lathe. The finishing of the job depends upon the speed of the job and feed rate.

3. **Continuous Path System :**

   In this system, simultaneous movement of tool along different axes takes place to produce desired contour. This is used for curved surfaces and different profiles (as cam profile). The motion of the tool is controlled on more than one axis simultaneously and continuously.

Fig. Continuous Path System



CNC Programming

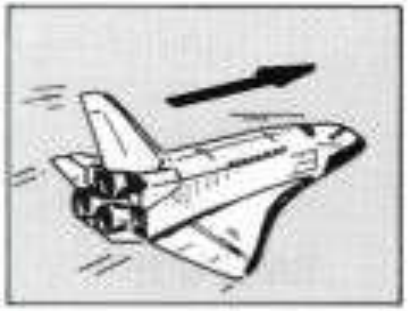
- The most common codes used when programming CNC machines tools are G-codes (preparatory functions), and M codes (miscellaneous functions).

- Other codes such as F, S, D, and T are used for machine functions such as feed, speed, cutter diameter offset, tool number, etc.

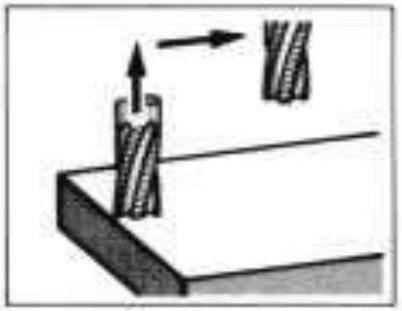
- **G-codes** are sometimes called cycle codes because they refer to some action occurring on the X, Y, and/or Z axis of a machine tool

- **M or miscellaneous codes** are used to either turn ON or OFF different functions which control certain machine tool operations

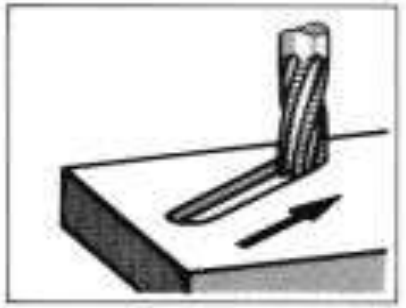
G Codes



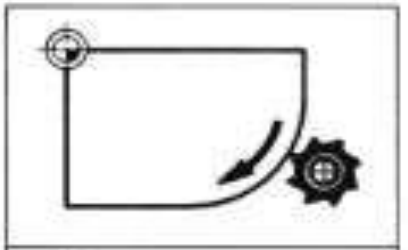
G00
RAPID TRAVERSE

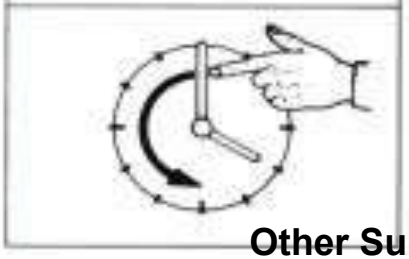


G01
LINEAR INTERPOLATION
(STRAIGHT LINE MOVEMENT)

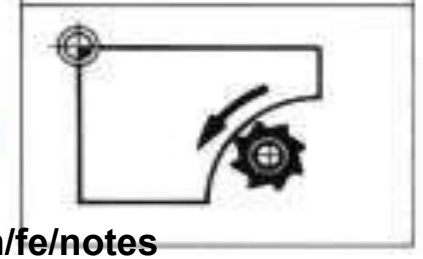


G02
CIRCULAR INTERPOLATION
(CLOCKWISE)





G03
CIRCULAR INTERPOLATION
(COUNTERCLOCKWISE)



G Codes

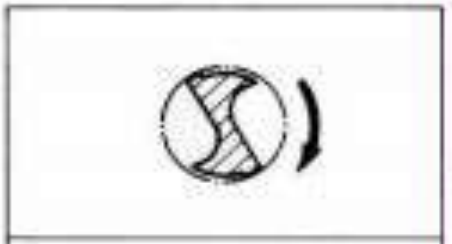
Group	Code	Function
01	G00	Rapid positioning
01	G01	Linear interpolation
01	G02	Circular interpolation clockwise (CW)
01	G03	Circular interpolation counterclockwise (CCW)
06	G20*	Inch input (in.)
06	G21*	Metric input (mm)
	G24	Radius programming (**)
00	G28	Return to reference point
00	G29	Return from reference point
	G32	Thread cutting (**)
07	G40	Cutter compensation cancel
07	G41	Cutter compensation left
07	G42	Cutter compensation right
08	G43	Tool length compensation positive (+) direction
08	G44	Tool length compensation minus (-) direction
08	G49	Tool length compensation cancel
	G84	Canned turning cycle (**)
03	G90	Absolute programming
03	G91	Incremental programming

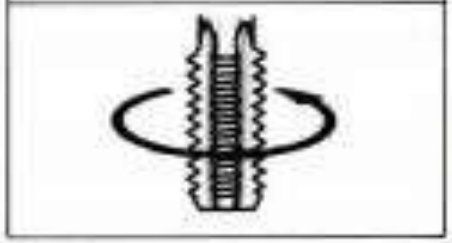
(*) - on some machines and controls, these may be G70 (inch) and G71 (metric)

(**) - refers only to CNC lathes and turning centers

M Codes

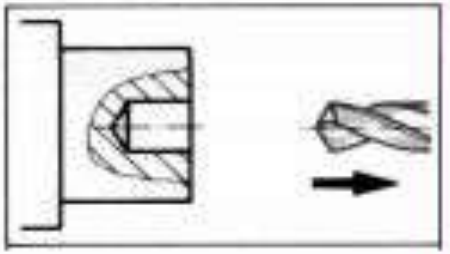
M03
DIRECTION OF ROTATION
(CLOCKWISE)

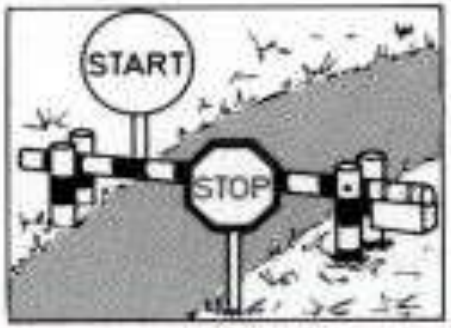




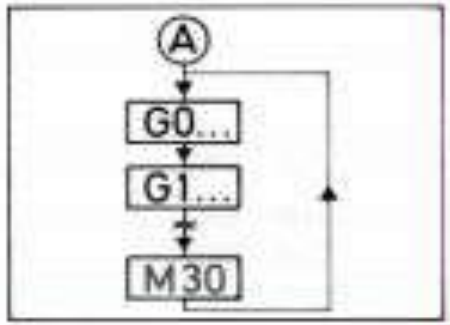
M04
DIRECTION OF ROTATION
(COUNTERCLOCKWISE)

M06
TOOL CHANGE WITH
AUTOMATIC RETRACTION





M30
END OF PROGRAM
AND
RETURN TO BEGINNING
OF PROGRAM



M Codes

Code	Function
M00	Program stop
M02	End of program
M03	Spindle start (forward CW)
M04	Spindle start (reverse CCW)
M05	Spindle stop
M06	Tool change
M08	Coolant on
M09	Coolant off
M10	Chuck - clamping (**)
M11	Chuck - unclamping (**)
M12	Tailstock spindle out (**)
M13	Tailstock spindle in (**)
M17	Toolpost rotation normal (**)
M18	Toolpost rotation reverse (**)
M30	End of tape and rewind
M98	Transfer to subprogram
M99	End of subprogram

(**) - refers only to CNC lathes and turning centers.

Internet Of Things (IoT)

- The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

- **A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an IP address and is able to transfer data over a network.**

- IoT is simply the network of interconnected things/devices which are embedded with sensors, software, network connectivity and necessary electronics that enables them to collect and exchange data making them responsive.

- More than a concept Internet of Things is essentially an architectural framework which allows integration and data exchange between the physical world and computer systems over existing network infrastructure.

Working of IoT

- An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments.

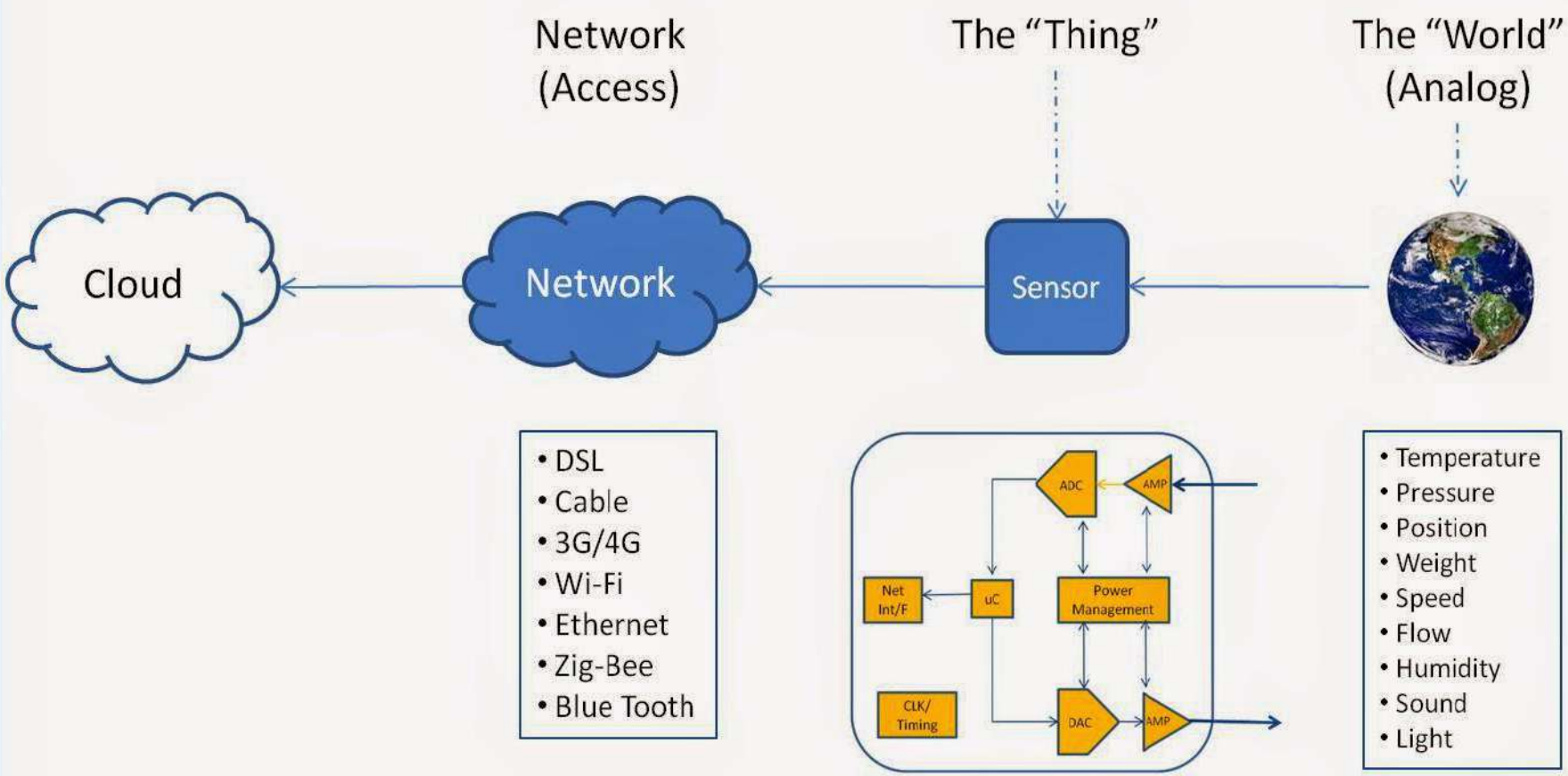
- IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally.

- Sometimes, these devices communicate with other related devices and act on the information they get from one another.

- The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

IoT

IoT: The Basics



QUESTION BANK

- What is casting? Explain with sketch sand casting.
- What is forging? State its advantages and disadvantages
- Write short notes on drawing and extrusion metal forming process.
- Explain with sketch different types of sheet metal working processes.
- What is welding? Write short notes on arc welding.
- Compare TIG and MIG welding.
- Explain with sketch shielded metal arc welding.
- Draw the block diagram of lathe machine.
- Write short notes on different parts of lathe machine.
- Explain with sketch different operation performed on lathe machine.
- Draw block diagram of sensitive drilling machine.
- Draw sketches of different operation performed on drilling machine.
- Write a short notes with figure On Horizontal milling & Vertical milling.
- Explain with sketch different operation performed on milling machine.
- Write short notes on Micromachining, Additive manufacturing,3D printing, IOT, Rapid prototyping, CNC Programming.