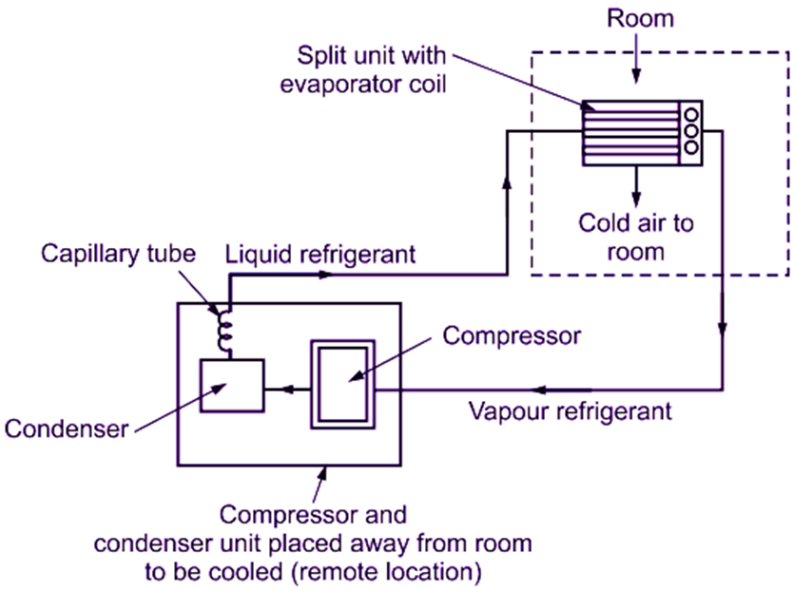
- Then it passes through the throttle valve where the refrigerant is expanded further. It is passed to the evaporator coil.
- Fresh air from the atmosphere and return air from the rooms pass through the filter.
- The filtered air passes through the evaporator. Here, the liquid refrigerant absorbs the heat from the air and is evaporated. The air is now cooled.
- The cooled air is added with adequate amount of moisture by the humidifier.
- The water/ moisture eliminator reduces the moisture content if excess.
- The heating coil may reduce or increase the coldness of the air as required. If the rooms are cooled more than required, the coil will add heat to the cold air and if the rooms are warm, coils can absorb heat from the air to make it more cooler.
- The cooled air is transferred to the rooms through the supply ducts with the help of a blower.

Split Air conditioning *(layout is needed)* *All the components and working are same as window AC. Only the diagram differs*

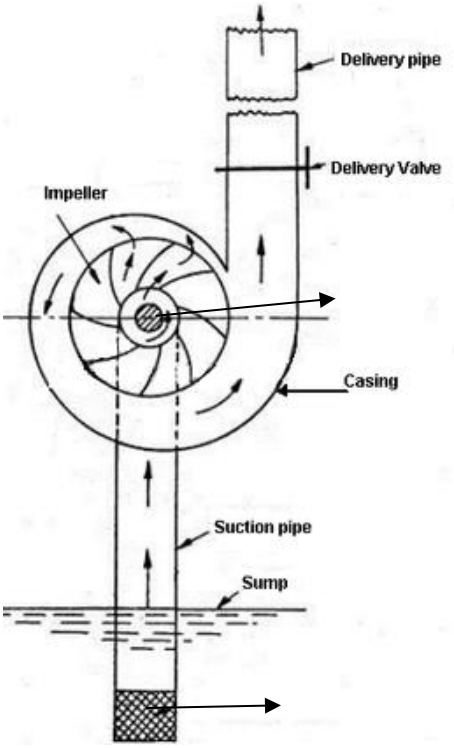


HYDRAULIC PUMPS

A hydraulic pump is a mechanical source of power that converts mechanical power into hydraulic energy (hydrostatic energy i.e. flow, pressure). It generates flow with enough power to overcome pressure induced by the load at the pump outlet. When a hydraulic pump operates, it creates a vacuum at the pump inlet, which forces liquid from the reservoir into the inlet line to the pump and by mechanical action delivers this liquid to the pump outlet and forces it into the hydraulic system.

Centrifugal pump

The centrifugal pump defines as a hydraulic machine that converts mechanical energy into hydraulic energy by means of a centrifugal force acting on the fluid. These pumps are used to raise the water or liquid from a lower level to a higher level.



Parts

a) Suction Pipe with a Foot Valve and Strainer

The suction pipe has two ends. One end is connected to the inlet of the pump (commonly called as the eye of the impeller), and the other dips into the water in a sump. A foot valve fits at the lower end of the suction pipe. The foot valve is the one-way type of valve which only opens in an upward direction. A strainer is also fitted at the end of the suction pipe to prevent the entry of foreign bodies into the suction pipe.

b) Impeller

The impeller consists of a series of backward-curved vanes. It is mounted to the shaft of an electric motor. An impeller is a rotating part of the centrifugal pump.

c) Casing :

The casing is an airtight passage surrounding the impeller. It provides a gradual increase in the area of a flow, thus decreasing the velocity of water and correspondingly increasing the pressure (ie kinetic energy is converted to pressure energy).

d) Delivery valve:

The delivery valve also has two ends. One end is connected to the outlet of the pump, and the other end delivers the water at a required height.

Working

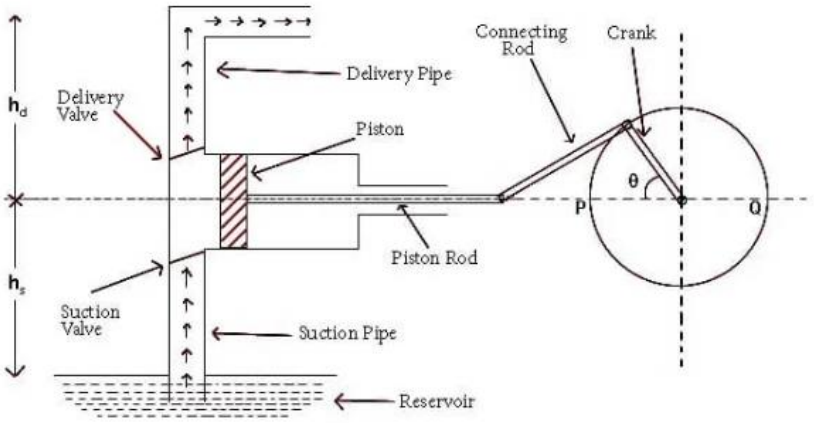
- As the electric motors start rotating, it also rotates the impeller.
- The rotation of the impeller creates suction (partial vacuum) on the suction pipe.
- Due to suction, water from the sump enters the casing through the eye of the impeller and rotates outward tangentially and radially due to centrifugal force until it leaves the impeller in the diffuser part of the casing.
- When passing through the impeller, the fluid is receiving both velocity and pressure.
- The area of the casing increases slowly in the direction of rotation, so as the water velocity decreases and the pressure increases, the pressure at the outlet of the pump is maximized.
- Now from the outlet of the pump, the water goes through the delivery pipe to its intended location under high pressure.

Priming of a centrifugal pump

- Priming of a centrifugal pump is the process of filling the liquid at the suction pipe and the impeller. Priming is done to put pump into working order by filling or charging with water.
- If the impeller is running in air, it will produce only a negligible pressure. This pressure will not suck water from its source through the suction pipe. To avoid this, pump is first filled up with water.

Reciprocating pump

→ A reciprocating pump is a mechanical device that converts hydraulic energy from mechanical energy into a fluid (pressure energy).
→ The fluid is pumped from one area to another using a piston or plunger.
→ A reciprocating pump is often known as a piston pump since it employs a piston or plunger for pumping functions.



The distance from the surfaces of the fluid to the center of the piston where the piston rod is attached is called the suction head (h_s), and the distance from the center of the piston to the outlet of the delivery pipe is called the delivery head (h_d).

Parts

1. Cylinder: This cylinder consists of a piston. The cylinders stores water before delivery to the required area. It is also used to create a vacuum for the suction of fluid.

2. Piston: The piston is present inside the cylinder. This piston moves back and forth. These pistons are used to create a vacuum & exert thrust on the fluid.

3. Piston Rod: A rod is attached to a piston and is known as a piston rod. This piston rod is further connected to the connecting rod.

4. Connecting Rod: The connection rod is connected to the piston rod at one end and the crank at the other end.

5. Crank: The rotational motion of the crank provides reciprocating motion to the piston.

6. Suction Valve: Suction valves are non-return valves, which means that only one direction of flow is available. This is situated between the entrance of the suction pipe and the cylinder. It is opened during liquid suction and closed during liquid discharge.

7. Suction Pipe: This is the pipe that contains suction. The sump or reservoir water is sucked through this pump, and this pipe carries water to the cylinder.

8. Delivery Valve: The delivery valve is fitted in the delivery pipe. It is a non-return valve. This valve opens when the fluid needs to be transported to the required area.

9. Delivery Pipe: The delivery pipe is used to deliver water from the cylinder to the desired area where water needs to be delivered.

10. Reservoir or Sump: The reservoir is present in the bottom and is used to store the fluid that has to be pumped using a reciprocating pump.

Working

- When a power source is linked to the crank, the crank will begin to rotate, and the connecting rod will be moved as well.
- The piston, which is attached to the connecting rod, will move in a straight line. When the crank rotates outwards, the piston travels to the right, creating a vacuum in the cylinder.
- This vacuum forces the suction valve to open, forcing liquid from the source into the cylinder through the suction pipe.
- The piston advances to the left as the crank moves inwards or towards the cylinder, compressing the liquid in the cylinder.
- The pressure now causes the delivery valve to open, allowing liquid to flow through the delivery line.
- The whole liquid in the cylinder is supplied through the delivery valve when the piston reaches its extreme left position.
- The crank rotates outwards again, and the piston advances to the right to generate suction, and the process is repeated.

HYDRAULIC TURBINE

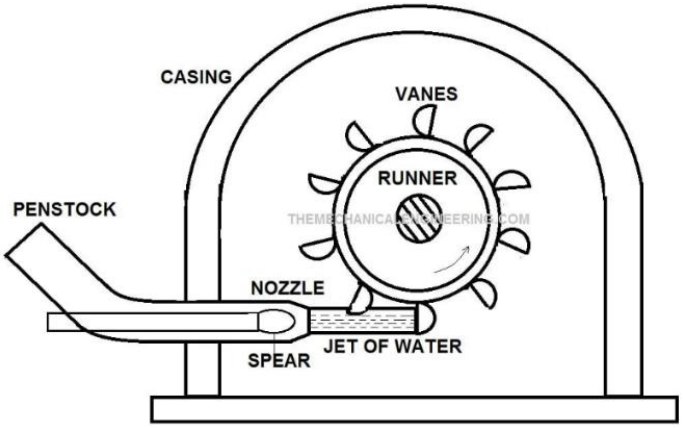
Hydraulic Turbine is the main prime over which helps to converts hydraulic energy into electrical energy by the help of a generator. When a stream of water is hit the blades of the turbine, it forces the turbine to rotate hence there is a generator fitted with the turbine so the generator has also come in rotation and produces the electrical energy.

Hydraulic turbines are classified as:

a) ***Impulse turbine:*** water possess only kinetic energy at the inlet of the turbine e.g: *Pelton turbine*
b) ***Reaction turbine: :*** water possess both kinetic and potential energy at the inlet of the turbine e.g: *Francis and Kaplan turbine*.

Pelton wheel/ Pelton turbine ***(diagram is required)***

Pelton Turbine is a Tangential flow impulse turbine in which the pressure energy of water is converted into kinetic energy to form high speed water jet and this jet strikes the wheel tangentially to make it rotate. It is also called as Pelton Wheel. Mainly, used for hydroelectric powerplant.



Construction:

Casing: The whole arrangement of runner and buckets, inlet and braking jets are covered by the Casing. Casing of Pelton turbine does not perform any hydraulic actions but prevents the splashing of water while working and also helps the water to discharge to the tail race.

Nozzle and spear assembly: The water from source is transferred through penstock to which end a nozzle is provided. Using this nozzle the high speed water jet can be formed. To control the water jet from nozzle, a movable needle spear is arranged inside the nozzle. The spear will move backward and forward in axial direction. When it is moved forward the flow will reduce or stopped and when it is moved backward the flow will increase.

Runner or Rotor and buckets: A Pelton turbine consists of a runner, which is a circular disc on the periphery of which a number of buckets are mounted with equal spacing between them. The buckets mounted are either double hemispherical or double ellipsoidal shaped. A dividing wall called splitter is provided for each bucket which separates the bucket into two equal parts.

Braking jet: Due to inertia, the runner will not stop revolving even after complete closure of inlet nozzle. To stop this, a brake nozzle is provided as shown in figure. The brake nozzle directs the jet of water on the back of buckets to stop the wheel. The jet directed by brake nozzle is called braking jet.

Working of Pelton Turbine

- The water is transferred from the high head source through a long pipe called penstock.
- Nozzle arrangement at the end of penstock helps the water to accelerate and it flows out as a high speed jet with high velocity and discharge at atmospheric pressure.
- The jet will hit the splitter of the buckets which will distribute the jet into two halves of bucket and the runner starts revolving.

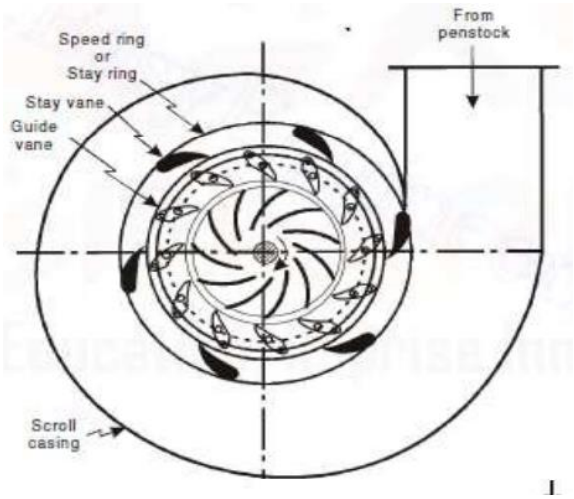
- The kinetic energy of the jet is reduced when it hits the bucket and also due to spherical shape of buckets the directed jet will change its direction and takes U-turn and falls into tail race.
- As the runner rotates, the runner will rotate
- The runner shaft which is coupled to the generator will convert this rotation/mechanical energy to electrical energy. Thus current is generated in a hydroelectric powerplant.

Francis turbine ***(diagram important)***

Francis turbine definition is a combination of both impulse and reaction turbine, where the blades rotate using both reaction and impulse force of water flowing through them producing electricity more efficiently. Francis turbine is used for the production of electricity most frequently in medium or large scale hydropower stations.

Construction:

a) Scroll Casing (Spiral Casing): In Francis Turbine, Water from the Penstock enter a scroll casing (spiral casing) that surrounds the runner



b) Speed ring (stay ring): From the scroll casing, water passes through a speed ring or stay ring which consists of a series of fixed vanes called stay vanes. The function of the speed ring is to direct the water from casing to the guide vanes.

c) Guide Vanes: Water passes through a series of guide vanes provided around the periphery of the runner. Their function is to regulate the quantity supplied to the runner and direct the water on to the runner. Also, increases the velocity of the water

d) Runner: Francis Turbine blades are specially shaped that it has thin aerofoil cross-section, so when water flows over it, low pressure will be produced on one side and high pressure will be on another side. This will result in a lift force.

e) Draft tube: A draft tube is a large pipe with an increasing cross-section area that connects the runner exit to the tailrace.

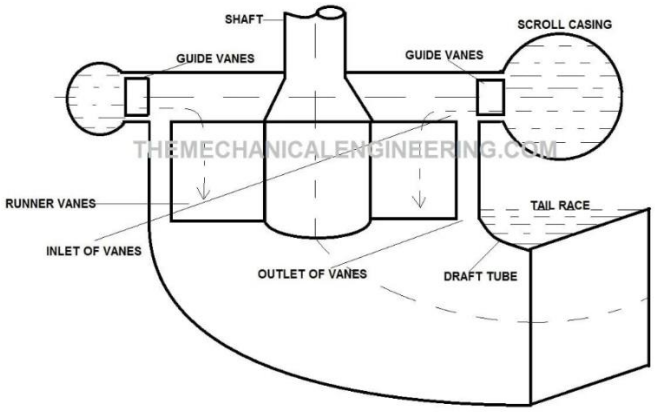
Working:

- Water enters the scroll casing from the penstock. It distributes water evenly to the runner, maintain constant velocity with the help of its gradually reducing cross-section.
- From the scroll casing, water passes through a stay ring which consists of stay vanes. From the stay ring, water passes through a series of guide vanes provided around the periphery of the runner.

- The vanes are so shaped that water enters the runner radially and leaves it axially (mixed flow turbine)
- Runner is fitted with a collection of complex-shaped blades.
- The aerofoil shape of the blades creates a low pressure area on one side and high pressure area on the other, creating a lift force on the blades.
- Both impulse force (*Forces that act for a very short time are called impulse forces*) and lift force *(A fluid flowing around an object exerts a* force *on it)* will make the runner rotate.
- From the runner, water enters into the draft tube which converts a large portion of velocity energy into useful pressure energy that is rejected from the runner.
- Finally, water moves out through the tailrace after passing from the draft tube. In this way, by the usage of Francis turbine, electricity is generated.

Kaplan Turbine *(diagram important)*

- Viktor Kaplan, an Austrian, developed this turbine in the year 1913.
- It is an axial flow turbine i.e. the falling of water on the runner or blades is along the axis. and the water also exits from the runner axially.
- A Reaction type of turbine. This means that it utilizes the Kinetic Energy and Pressure Energy of the water.
- A low head turbine (10 m to 30 m).
- It requires a large quantity of water
- It has a high specific speed (600-1000)
- The vanes of this turbine are not fixed to the hub, it means the angles can be adjusted based on the requirement.
- Vanes number ranges from 4 to 8.



Construction:

1) Runner blades: The blades are the key components of the turbine. The Kaplan turbine blade looks like a propeller. Other When the water strikes these blades, they start rotatory motion, which further rotates the shaft.

2) Hub: Hub includes in the essential components of the Kaplan turbine. The blades mountain on the hub of the turbine. It controls the rotation of blades. It connects with the central turbine shaft.

3) Shaft: The one end of the turbine shaft is linked with the turbine runner, while the other end is linked with the generator coil. As the runner rotates due to the rotation of the blades, the shaft also rotates, which further transmits its rotation to the generator coil. As the generator coil rotates, it produces electricity.

4) Guide Vane: Guide vanes rotate at a specific angle to regulate the water flow. If the power requirement is more, it opens more so that a large volume of water can strike the rotor blades. As the power requirements reduce, it opens less so that a low amount of water can strike the blades. The guide vanes increase the efficiency of the turbine.

5) Runner: The runner or impeller is a rotating component of the turbine. The axial water flow acting on the blades causes the rotation of the impeller, which further rotates the shaft.

6) Scroll or Volute Casing: The entire turbine mechanism is surrounded by a housing called a scroll casing. The scroll casing reduces the cross-sectional area.

8) Draft Tube: In the case of a Kaplan turbine, the atmospheric pressure is higher than the pressure at the runner outlet area. Therefore, the fluid from the turbine outlet can't discharge directly into the tailrace. Due to this reason, a tube having a progressively rising area uses to discharge the fluid from the outlet into the tailrace. This increasing area tube is known as a draft tube. The draft pipe attaches the outlet of the runner to the tailrace and drains the water from the turbine. The primary function of the draft tube is to decrease the flow rate and minimize the loss of K.E. at the exit. They reduce the water speed by raising the water surface.

Working

- First of all, the water introduces into the volute/scroll casing from the pen-stock.
- From scroll casing, the water through the guide vanes falls on the runner by turning 90 degrees and thus making it parallel to the runner (axial flow).
- As the waterfalls axially, the blades rotate due to the reaction force developed by the water.
- After passing through the impeller blades, the water reaches the draft tube, where the kinetic and pressure energies of the water reduce.
- This draft tube converts the kinetic energy or speed into pressure energy and increases the pressure of water.
- When the water pressure increases according to the requirements, the water delivers into the tailrace.
- The increased pressure of the water rotates the turbine.
- A generator is coupled with the turbine shaft. The rotation of the turbine further rotates the generator coil.

According to Faraday's 1st law, "when a conductor rotates in a magnetic field then electricity produces," and in hydroelectric powerplants, electricity produces by using the same phenomena.

Turbine efficiencies

- Hydraulic efficiency:

$$\eta_h = \frac{power\ delivered\ to\ runner}{power\ supplied\ at\ inlet\ of\ turbine} = \frac{R.P.}{W.P.}$$

- Mechanical efficiency:

$$\eta_m = \frac{power\ at\ the\ shaft\ of\ turbine}{power\ delivered\ to\ runner} = \frac{S.P.}{R.P.}$$

- Volumetric efficiency:

$$\eta_v = \frac{volume\ of\ water\ actually\ striking\ the\ runner}{volume\ of\ water\ supplied\ to\ the\ turbine}$$

- Overall efficiency:

$$\eta_o = \frac{S.P.}{W.P.}$$

$$= \frac{S.P.}{R.P.} \times \frac{R.P.}{W.P.}$$

$$\therefore \eta_o = \eta_h \times \eta_m$$

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R.P- Runner power

W.P- Water power

S.P- Shaft power

$$\eta_H = \frac{\text{Power produced by the runner}}{\rho\, Q\, g\, H}$$

where Q is the volume flow rate and H is the net or effective head. where Q is the volume flow rate and H is the net or effective head.

$$\eta_0 = \frac{\text{Power available at the turbine shaft}}{\rho\, QgH}$$

Power Output of the hydraulic turbine

$$P = Q * \rho * g * H * \eta$$

Where

P = electric power in kVA

Q = flow rate in the pipe (m3/s) ρ = density (kg/m3) g = Acceleration of gravity (m/s²)

H = waterfall height (m) η = global efficiency ratio

Pump output power (Water Horse Power (WHP)) $P = \frac{Q \times H \times g \times \rho}{100 \times \eta}$	Pump efficiency η $\eta = \frac{\rho \times Q \times g \times H}{P}$

METHODS OF POWER TRANSMISSION

Mechanical power transmission refers to the transfer of mechanical energy (physical motion) from one component to another in machines. Most machines need some form of mechanical power transmission.

i) Belt drive

It consists of two pulleys over which an endless belt it passed over them. The mechanical power or rotary motion is transmitted from the driving pulley to the driven pulley because of the frictional grip that exists between the belt and the pulley surface.

- *The one that drives is called the driving system and*
- *The other which is driven is called driven system.*

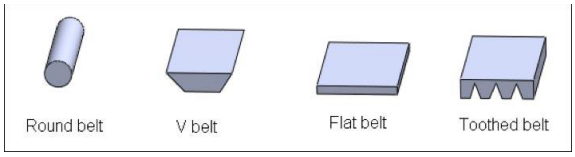
Types of belt

a) Flat belt: This belt has a rectangular cross-section. These belts are capable of transmitting power over long distances within 5 to 10 meters between pulley centres. The efficiency of this drive is around 98% and produce little noise. Flat belt transmits power by the help of friction which gets produced within the belt and the pulley. The rotation of the pulley is found to be in the same direction in the flat belt.

b) ***V-belt:*** V belts are referred to as those kinds of belts which are found to be in the trapezoidal cross-section. These belts are mostly used whenever the distance of the shaft is considered less than 2 meters and is also used for a moderate speed and high power. In these types of belt there is a possibility of multiple drives.

c) ***Round belt:*** Circular belt is referred to as that in which there is a circular cross-section. These are the belts which are used at places where there is more than 5-meter shaft distance. Circular belts are used mostly for high transmission of power and are also used at places where there is smaller initial tension required and absence of vibration and noise is present.

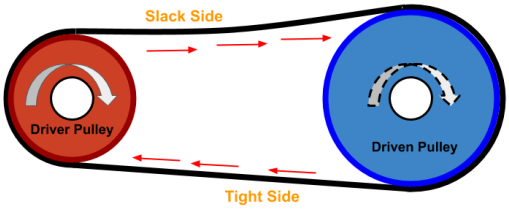
d) Timing belt (toothed belt): A toothed belt, also known as a timing belt or synchronous belt, is a type of flexible belt with teeth (or cogs) on its inner surface that mesh with corresponding teeth on a pulley. This design allows for positive power transmission *(i.e power transmission without slippage),* preventing slippage between the belt and pulley.



Types of belt drive ***(diagram important)***

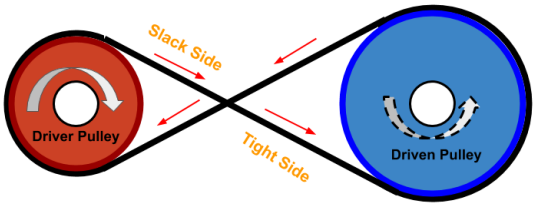
1. Open Belt Drive

The direction of rotation is found to be same as the driving and the driven pulley. The shafts seem to be arranged in the parallel directions. In case the shafts are found having more distance within the driver and the driving pulley then there must be the upper side, which can be the slack side and the below side, the tight side.



2. Crossed Belt Drive

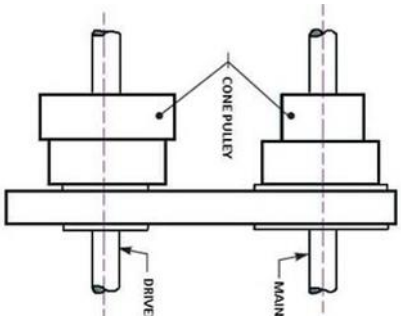
Crossed belt drive also known to be closed belt drive and is referred to as that drive which has transmitted more power but there is a problem that it cannot run that faster. This is the reason which creates rubbing between belts and leads to wear and tear, so it should run at low speed to reduce it. In this type of belt drive, the shafts are found to rotate in the opposite direction.



3. Stepped (Cone) Pulley Drive

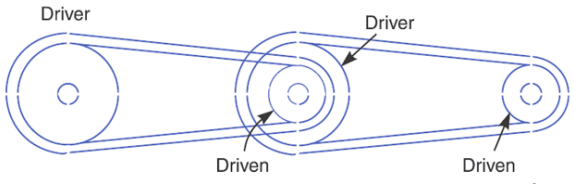
Stepped cone pulley is also referred to as speed cone. There are more pulleys which are attached to the different diameter wherein one is attached adjacent to another. Stepped cone pulleys are used where

there is a need to change *gear* or speed of driven shaft, or change frequently like in the case of a machine lathe, milling etc.



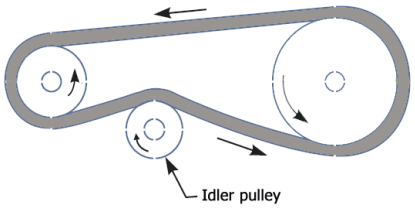
4. Compound belt drive

A compound belt drive consists of more than two shafts with multiple pulleys keyed to at least one of the shafts. The driving pulley transfers power from one shaft to another through multiple shafts. This setup improves the speed ratio without requiring a larger driven pulley or too much extra space.



5. Belt drive with idler pulley

The idler pulley is placed on the slack side of the belt. They improve the belt drive's performance as they reduce vibration by supporting the belt. Idler pulleys can increase the wrap angle for smaller pulleys, ultimately increasing the surface area between the drive belt and the pulley.



Applications of Belt Drive

- A belt drive is used for transferring the power.
- The belt drive is used in the Mill industry.
- The belt drive is used in the Conveyor.
- Belt drives are used in mills.

Advantages of Belt Drives

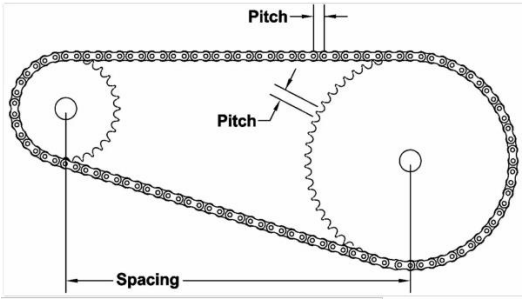
(i) They are simple and economical.
(ii) They can transmit power over a medium distance.
(iii) They give smooth operation (Noise and vibrations are damped out)
(iv) They can operate at high speeds of rotation.
(v) They are lubricant free and their maintenance cost is relatively low.

Disadvantages of Belt Drives

(i) Their considerable overall size, usually several times larger than toothed gearing.
(ii) Slip occurs in the belt drives.
(iii) The necessity of belt tensioning devices.
(iv) The necessity to keep oil from getting on the belt.
(v) The relatively short service life in high speed drives.
(vi) Heat build-up occurs. Speed is limited to usually 35 meters per second. Power transmission is limited to 370 kilowatts.
(vii) Operating temperatures are usually restricted to –35 to 85°C.
(viii) Stretching of belt after some time

ii) Chain drive

Chain drive is a way to transfer mechanical power from one place to another. Chain drives are widely used in vehicles such as bicycles and motorcycles to transfer power to the wheels. It is also used in different types of machines. Most often, power is communicated by a roller chain, known as a drive chain or transmission chain, that passes over a sprocket gear, with the gear teeth intersecting holes in the chain's links.



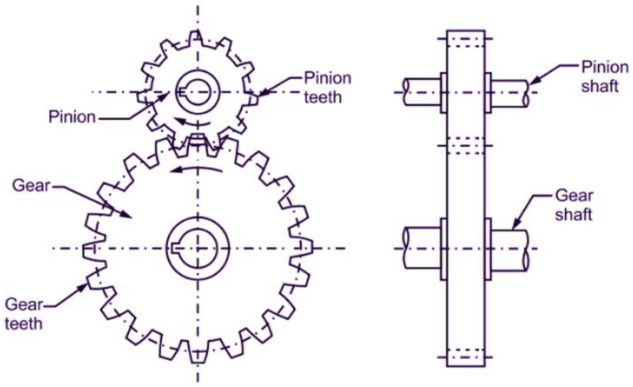
Advantages	***Disadvantages***
▪ No slip occurs ▪ Can carry heavy loads ▪ More durable ▪ Easy replacement of the chain ▪ More durable	▪ High cost ▪ Chain can get loosened, should be tighted when needed. ▪ Require proper housing

Applications

- Rigging and moving heavy materials
- Hydraulic lift truck fork operation
- Overhead Hoist
- Operating Belt Conveyor
- Motocycles, bicycles, machine tools etc.

iii) Gear drive

Gear drive is used, when centre to centre distance between driver and driven shafts is very small. Gears are defined as, "toothed wheels, which can transmit power and motion from one shaft to another shaft by means of successive engagement of teeth. "



It is important to note that, both the gears, which are engaged, always rotate in opposite direction. Gear drive consists of two wheels. The smaller wheel is called as pinion and the larger wheel is called as gear. In gear drive, slip is absent. Therefore, it gives exact and uniform velocity ratio. Due to this ability of maximum power transmission and exact velocity ratio, gear drive is called as perfect positive drive.

Advantages of Gear Drive	***Disadvantages of Gear Drive***
1. Exact velocity ratio. 2. High efficiency. 3. Compact layout. 4. Ability of transmitting large power. 5. Reliable service.	1. Manufacturing of gears requires special tools and equipment. This leads to high production cost. 2. Complicated manufacturing process. 3. Gear drive requires precise alignment of shafts. 4. Costly lubrication system is required for smooth operation and longer life of gear teeth. 5. Any error induced in gear during the process of teeth cutting leads to noisy operation with severe vibrations.

Applications of Gear Drive

1. Gear box of vehicle
2. Machine tools
3. Dial indicator
4. Gear mechanism of wrist watches
5. Differential mechanism of automobile
6. Cement mixing unit.

Types of gear

a) ***Spur gear:*** The spur gear is the most common and simplest type of gear. It is generally used for the transmission of rotary motion between parallel shafts. The spur gear is the best option for gears except when speed, loads, and ratios direct towards other options. They have straight teeth and are mounted on parallel shafts.

b) ***Helical gear:*** Helical gears offer a refinement over spur gears. The teeth of a helical gear are not parallel to the axis of rotation but are set at a helix angle. Helical gears can be meshed in a parallel or crossed orientation.

c) ***Bevel gears:*** Bevel gears have teeth cut on a cone instead of a cylinder blank. they are used in pairs to transmit rotary motion and torque where the bevel gear shaft are at right angles (90 degrees) to each

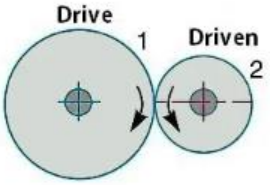
other. When two bevel gear has their axes at right angles and is equal sizes, they are called miter gears. Bevel gear transmits power between two intersecting shafts at any angle or non-intersecting shaft.

d) ***Worm gear:*** A gear that has one tooth is called a worm wheel. The tooth in the form of a screw thread is called a worm screw. The worm wheel is a helical gear with teeth inclined so that they can engage with the thread-like worm. This wheel transmits torque and rotary motion through a right angle. The worm can easily turn the gear, but the gear cannot turn the worm. This is because the angle on the worm is so shallow that the gear tries to spin it. Worm mechanisms are very quiet running.

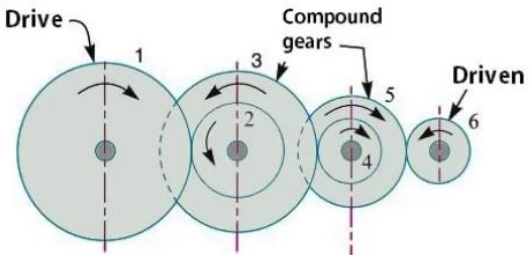
e) ***Rack and pinion:*** A rack and pinion is a pair of gears that convert rotational motion into linear motion and vice versa. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack". Rotational motion applied to the pinion will cause the rack to move to the side, up to the limit of its travel. The diameter of the gear determines the speed that the rack moves as the pinion turns.

Types of gear drive ***(diagrams important)***

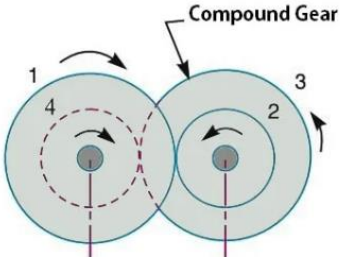
i. ***Simple gear train:*** A simple gear train consists of only one gear on each shaft. The gear 1 is transmitting the motion to the gear 2 so the gear 1 called the driver and the gear 2 is called the driven or a follower. When the driving gear is driving the driven gear the rotational direction of the two gears will be opposite in direction.



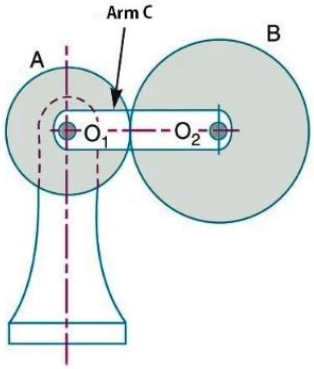
ii. ***Compound gear train:*** If there are two gears on the same shaft then it will be the compound gear train. The compound gear train is used where the distance between the two shafts has to be bridged by the intermediate gears and to maintain the speed ratio.



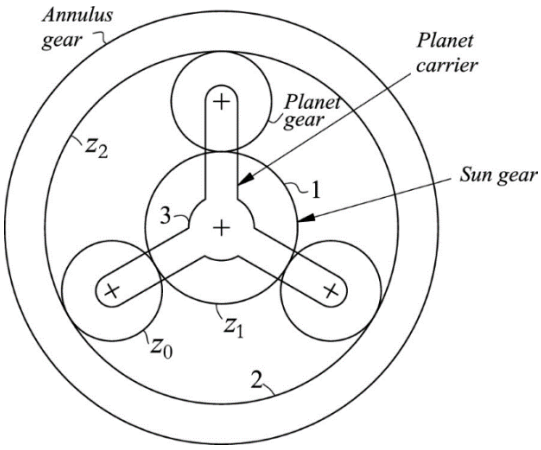
iii. ***Reverted gear train:*** A reverted gear train is also quite similar to the compound gear train, but when the driveshaft and the driven shaft are co-axial then it is called as the reverted gear train. In the reverted gear train the motion of the drive gear (first) and the driven gear (last), are in the same direction.



iv. ***Epicyclic gear train:*** When one shaft needs to be moved relative to the other shaft, then the application of the gears is possible. The Gear A is having the fixed shaft O_1 and the gear B is having the shaft O_2 which needs to be rotated relative to the shaft O_1. So that the shaft O_1 and shaft O_2 will be connected by the arm C. So the rotating shaft will be on its path. Here the gear can drive the gear or vice versa.



v. ***Planetary gear train:*** Epicyclic gearing also called as planetary gearing. It is a gear system that consists of one or more outer gear (planet gear) rotating about a central gear (sun gear). The planet gear is mounted on a moveable arm (carrier) which itself may rotate relative to the sun gear. Epicyclic gearing systems may also incorporate the use of an outer ring gear or annulus, which meshes with the planet gears.



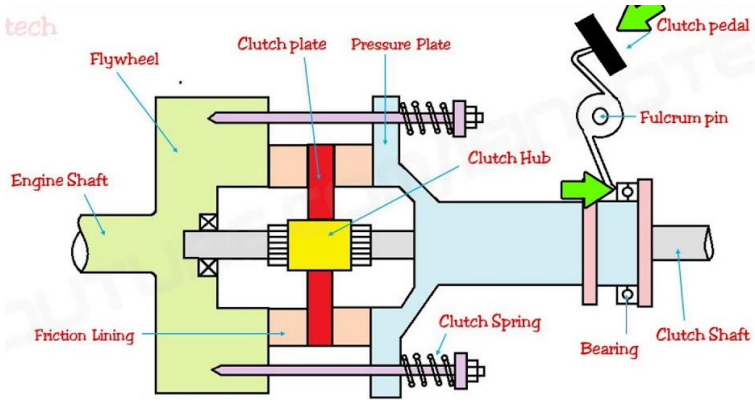
CLUTCH

A clutch is a mechanical device that engages and disengages the power transmission from the driving shaft to the driven shaft. The device features two-shaft, one is connected to the engine or power unit (the driving member) while the other shaft provides the power output that does the work.

Functions of clutch:

- The clutch helps the engine to run at a stationary position.
- It can be used to reduce engine speed.
- It enables easy changing of gears.
- Smooth vehicle control is achieved

Single plate clutch ***(diagram is important)***



Construction:

1. Clutch Plate: The clutch plate is the main component of the clutch. A single plate clutch has only one clutch plate. It is a thin disk type of metal plate with a frictionless surface on both sides. These abrasive surfaces are called friction lining. These friction lining must be made of such material that it provides torque (engines rotational force) transmission without slip. The co-efficiency of friction of materials should be high. The clutch plate is assembled between the flywheel and the pressure plate.

2. Pressure Plate: The main function of a pressure plate is to maintain proper contact between the flywheel and the clutch plate surfaces via springs. Pressure plates are usually made of cast iron.

3. Springs: Springs are used to move the flywheel plate toward the flywheel plate and to establish a proper connection between the clutch plate and the flywheel. It also prevents the slipping of contact surfaces.

4. Flywheel: The flywheel is connected to the engine output. When the clutch is in a busy position, the flywheel comes into contact with the clutch plate, and the torque is transmitted by friction.

5. Clutch Spring: To keep the clutch in engaged position, the springs are arranged circumferentially around the shaft which provide axial force for proper engagement.

6. Friction Lining: Friction Lining is to be placed on the inside surface of flywheel and the outer surface of clutch plate for the better engagement without the formation of slip.

Working of Single Plate Clutch:

- ***When the clutch is in engaged position***
  The single plate clutch assembly in engaged position means that, clutch pedal is not pressed by the driver. This condition is referred as clutch pedal position-up. When the pedal position is up, the axial force offered by clutch springs is pressed against the flywheel (i.e. towards flywheel) with clutch plate being sandwiched between pressure plate and flywheel. Therefore, drive is engaged and power is transmitted from the flywheel to the clutch plate due to friction existing between their

contacting surfaces. Further, the power is transmitted from clutch plate to clutch shaft through mechanical splines (used to transfer torque).

- ***When clutch needs to be disengaged:***
  For disengaging the clutch, the clutch pedal is pressed by the driver. This condition is referred as clutch pedal position pressed - down. When the clutch pedal is pressed down, release lever pulls the pressure plate away from clutch plate against the axial force offered by clutch springs and thereby, compressing clutch springs. This loosens the contact between clutch plate and flywheel. Therefore, drive gets disengaged and power is not transmitted to clutch plate and hence, clutch shaft the clutch shaft speed gradually decreases, and eventually, it stops rotating.

Advantages	***Disadvantages***
1. Single Plate Clutch is widely used because of its ability to completely disengage the drive. 2. Single Plate Clutch is simple in construction. 3. Single Plate Clutch is inexpensive and requires less maintenance. 4. Single Plate Clutch is easy to operate because pedal movement is less. 5. Less chances of failure.	1. Torque transmission capacity of Single Plate Clutch is less. 2. Single Plate Clutch is less compact as compare to multi-plate clutch so that it is not used in small vehicles.

Application:

1. Single Plate Clutch is used in Truck , Jeep, etc.
2. Farm machineries like cultivators.
3. Construction equipments like bulldozers.

Reaction turbine equations

Head and efficiency of reaction turbines

Effective head/ net head (H)

$H = H_g - H_f$, *where* H_g *is the gross head race head &* H_f *is the head loss due to friction in the penstock*

Water power (WP): power supplied to the turbine by water entering the turbine.

$$RP = \rho g Q H \text{ (equation is same for pelton wheel)}$$

Runner power (RP): power developed by the runner of the turbine.

$$RP = WP - \textit{hydraulic losses in the turbine runner}$$

Runner power is called as bucket power(BP) in pelton wheel (same equation)

Shaft power (SP) is the net output power available at the generator, *SP= BP-mechanical losses*

Equations for pelton wheel

Effective head (H) for the turbine is the head under which the turbine operates.

$$H = H_g - h_f - h$$

H_g is the gross/total/race head and is the difference between water level in the reservoir and water level in tailrace, h_f is the loss of head due to friction in the penstock and h is the height of turbine nozzle above tail race.

$$Actual\ velocity, \boldsymbol{V = C_v\sqrt{2gH}}$$

$$Theoritical\ velocity, \boldsymbol{V_{th} = \sqrt{2gH}}$$

Head and power of centrifugal pump

Head

a) Suction head (h_s) is the vertical height of the centreline of the pump above liquid level in the sump

b) Delivery head (h_d) is the vertical height of the level of liquid in the delivery tank above centreline of pump.

c) Static head (H_s) is the vertical height of liquid levels in the delivery tank above that of the sump.

$$\boldsymbol{H_s = h_s + h_d}$$

d) Manometer head (H_m) is the height against which the pump has to work. It is the sum of static head and the head spend for overcoming friction in suction and delivery pipes

$$\boldsymbol{H_m = h_s + h_d + h_{fs} + h_{fd} + \frac{V_d^2}{2g}}$$

Where h_{fs} and h_{fd} are loss of head due to friction in suction and delivery pipes. V_d is flow velocity in delivery pipe.

Manometric head is the sum of suction gauge and delivery gauge of the pump plus the vertical difference between the two gauges

$$\boldsymbol{H_m = h_{gs} + h_{gd} + z}$$

z -level difference between the two gauges in meters

e) Virtual head (H_v) is the head imparted to the liquid by the impeller. It is the sum of manometric head and hydraulic losses in the impeller.

$$H_v = H_m + losses\ in\ impeller$$

Power and efficiency of pump

a) *Water power (WP):* hydraulic power output from the pump impeller

$$\boldsymbol{water\ power = w \times H_m = \rho g Q H_m}$$

b) Shaft power (SP): power input to the pump from the prime mover (motor) running the pump

c) Volumetric efficiency(η_v) is the ratio of actual discharge from the pump to the flow rate entering the impeller.

$$\eta_v = \frac{Q}{Q + q}$$

Q-actual discharge and q is the leakage from the impeller

d) Manometric efficiency(H_m)

$$\eta_m = \frac{H_m}{H_m + losses\ in\ impeller}$$

e) Mechanical efficiency (η_{me})

$$\eta_{me} = \frac{workdone\ on\ the\ impeller}{shaft\ power\ of\ prime\ mover}$$

f) Overall efficiency (η_o)

$$\eta_o = \frac{WP}{SP} = \eta_m \times \eta_{me}$$

Equations for reciprocating pump

a) Discharge:

Volume of liquid sucked in during suction stroke=AL

Theoretical discharge through single acting pump

$$\boldsymbol{Q_{th} = volume\ per\ stroke \times no.of\ strokes\ per\ second}$$

$$= \boldsymbol{AL} \times \left(\frac{\boldsymbol{N}}{\boldsymbol{60}}\right) = \frac{\boldsymbol{ALN}}{\boldsymbol{60}}$$

$coefficient\ o\ discharge, C_d = \frac{Q_{th}}{Q}$, actual discharge Q

Slip is the difference between theoretical actual discharge of the pump it may sometimes be expressed as percentage

$$S = \frac{Q_{th} - Q}{Q_{th}}$$

$$weight\ of\ water\ delivered\ per\ second, W = \rho g Q = \frac{\rho g A L N}{60}$$

$$work\ done\ per\ second = W(h_s + h_d) = \frac{\rho g A L N}{60} \times (h_s \times h_d)$$

MODULE 3

Syllabus: *Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications. Metal Joining Processes: List types of welding, Description with sketches of Arc Welding, Soldering and Brazing and their applications Basic Machining operations: Turning, Drilling, Milling and Grinding. Description about working with block diagram of: Lathe, Drilling machine, Milling machine, CNC Machine. Principle of CAD/CAM, Rapid and Additive manufacturing.*

Classification of manufacturing process

There are four basic manufacturing processes for producing desired shape of a product. These are casting, machining, joining (welding, mechanical fasteners etc.), and deformation processes.

a) Primary process: metal in molten form or powder form is made into the nearly required shape of the final product by creating cohesion among the particles. It is the primary manufacturing process.

b) Machining process: provide desired shape with good accuracy and precision but tend to waste material in the generation of removed portions.

c) ***Joining processes:*** two or more metal parts are joined together to make intermediate or final product. eg. welding, soldering, brazing etc.

d) ***Deformation processes:*** the original shape of a solid is converted to another shape maintaining the cohesion among particles. No metal removal involved. eg. Forging, rolling, extrusion, sheet metal working, etc

e) ***Surface finishing:*** provide required cleaning, surface finish and protective coating to final product, without changing the dimensions of the part.

f) ***Property modification process:*** the material property of the product is changed to achieve the desired characteristics without changing its dimensions. Some common processes are heat treatment and surface treatment processes like stress relieving, annealing, tempering, hardening, normalizing etc.

CASTING

It is a manufacturing process in which molten metal is poured in a mould or cavity and is allowed to solidify. Mould has the shape of the product to be made. Molten metal on solidification gets the shape of the mould.

Mould: negative print of the product to be cast (cavity whose geometry determines the shape of the cast part).

Moulding: process of making mould of desired shape using sand, pattern and core so that the molten metal can be poured into it to produce casting

Pattern: the model or replica of the component to be made by casting. It has the shape and size (with some allowance) of the final component. Wood is the commonly used . metals like cast iron, brass, and aluminium alloys are also used for making patterns due to their durability, dimensional accuracy and better surface finish. Plastics are also used due to its light weight, surface finish and ease of manufacture

Casting is classified into two;

1) Sand Casting

2) Metal Mould Casting

Steps in casting

1. Pattern Making:

The pattern is the replica of the casting to be produced. Replica means the shape of the pattern is same as the shape of the casting to be produced.

2. Mold and Core making:

After creating a pattern with any of the material mentioned above, we need to create sand mould.

For creating a sand mould, the properties of green sand has to be known.

Core making: In order to create hollow components in casting process, core is to be placed in the casting cavity and when the molten metal surrounds the core, a hollow space is produced.

3. Pouring and Solidification:

After the creation of pattern, core as well as mould, the next step is to pour the molten metal into the sand molding.

When the molten metal is poured, it will not move to each and every corner. Therefore, chills are provided at the corners to do the solidification fastly.

2. Fettling:

Fettling is nothing but, breaking of the mould after production of a component so as to take it out from the sand mould.

5.Inspection:

After production of component, it is inspected under the guidance of quality engineers and further it is sent to the machining shop where the surface finish of the component is to be done.

Advantages of Casting:	**Disadvantages of Casting:**
• Casting processes can create any complex structures economically. • Short lead time compared to others and hence, ideal for short production runs. • Low-cost tooling • The size of an object doesn't matter for casting. • *Wider material choice*	• Because of shrinkage in the casting, the dimensional accuracy might be at risk. So, the designers must take care of providing the allowance to the product(Pattern) before pouring the molten metal. • Low strength • It requires Secondary machining operations in order to improve the surface finish. • Generally limited to metals of the lower melting point. • Not suitable for low-volume production.

Lead time: amount of time that passes from the start of a process until its conclusion

Importance of Casting Process:

- This process is widely used to manufacture complex parts.

- All major parts like milling machine bed, the bed of lathe machine, IC engine components, etc. are made by this casting process.
- It produces the best quality sand casting products at the lowest possible cost compared to the machining process.
- High Production rate.

SAND CASTING

Sand casting is a manufacturing process in which liquid metal is poured into a sand mold, which contains a hollow cavity of the desired shape and then allowed to solidify.

Terminologies in casting

1. **Flask:** A metal or wooden frame, without top or bottom, in which the mould is formed. There are two types of flasks:

   a) Drag: lower moulding flask

   b) Cope: upper moulding flask
2. **Pattern:** It is the replica of the final object to be made. The mould cavity is made with help of a pattern.
3. **Parting line:** This is the dividing line between the two moulding flasks that make up the mould.
4. **Moulding sand:** Also known as foundry sand, this sand is commonly used for making moulds. Natural sand located on the bed and banks of rivers gives a larger source, although high-quality silica sand is also mined. Types of moulding sand:

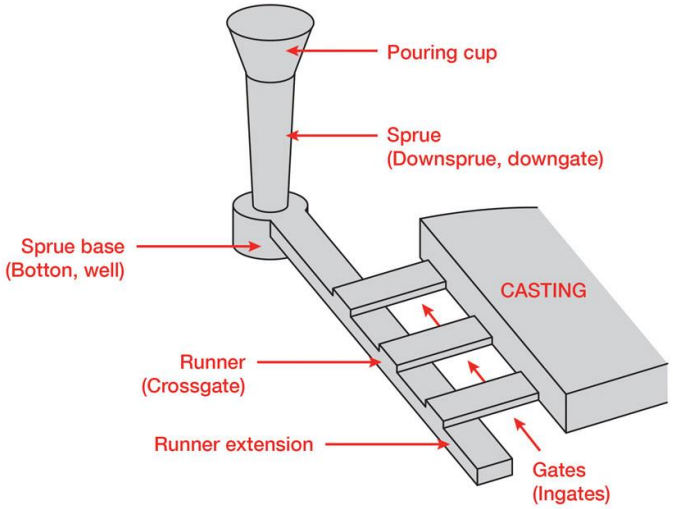
   a) Facing sand :It forms the face of the mould. The facing sand is used directly next to the patterned surface and comes into direct contact with the molten metal when the molten metal is poured into the mould. It has high strength and refractivity *(ability to withstand the heat from the molten metal)* as it comes in contact with molten metal. It is made of clay, silica sand and water.

   b) Backing sand: Also called floor sand, used to back up the facing sand. It is an old and frequently used moulding sand is used for backing purpose. It is sometimes called black sand because of the addition of coal dust and burning due to in contact with the molten metal.

   c) Parting Sand: The parting sand is used to avoids sticking of facing sand to the pattern. And also it allows in easy removal of cope and drag. This parting serves the same purpose as dust. It is pure clay free silica sand.

5. **Chaplets:** These are used to support the core to take care of their own weight and overcome metallostatic forces.
6. **Vent:** Small opening in the mould to facilitate the escape of air and gases.

Gating system (diagram is important):

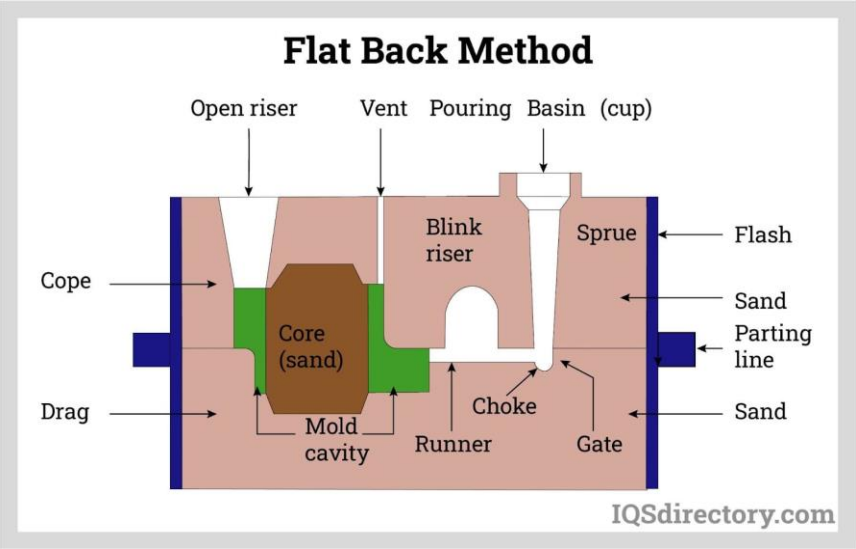


The passage provided in the mould through which molten metal will flow into the mould cavity is known as the gating system. It is provided by scooping out sand in the drag box to cut necessary channels.

- ***Pouring basin:*** is made at the top of the mould for pouring the molten metal at the required rate into the mould cavity. It also prevents slag from entering the mould cavity.
- ***Sprue:*** vertical passage made through the cope for connecting pouring basin with the gate
- ***Runner:*** for connecting the sprue and gate.
- ***Choke:*** the minimum area of gating system which control the flow of molten metal into mould cavity.
- ***Gates/ Ingates:*** Gate is the passage through which molten metal flows from the sprue base to the mould cavity. It is the passage for connecting the base of the runner with the mould cavity.
- ***Riser:*** passage made in the cope to permit molten metal to rise up after filling the mould cavity.
- ***Pattern:*** model or replica of the component to be made by casting. Types of patterns are; One piece pattern, Split pattern, Loose piece pattern, Match plate pattern ,Cope and Drag pattern.

- ***Core:*** Core is a prepared solid mass of dry sand, in order to introduce into the mould cavity, to form a hole." Cores are kept in the mould after the pattern is removed. It is used to obtain the desired hole or recess in the casting which otherwise could not be obtained by normal moulding process.

Sand casting process (should draw diagram):



1. Drag is placed on the moulding board with upside down and drag half (lower part) of pattern is placed inside the drag. Sprinkle some parting sand on the pattern and the moulding board.

2. Drag is filled with moulding sand to a depth of 20-25mm. rest of the portion will be filled with backing sand and properly rammed. Excess sand above top level of drag is removed using strike rod.

3. Drag is turned over and placed on another board.

4. Cope half (upper part) of pattern is kept over drag half of pattern and cope is placed

over the drag.

5. Runner, riser pins and sprue pins are placed at appropriate places and cope is filled

with moulding sand and rammed properly. Excess sand at top is removed.

6. Runner, riser pins and sprue pins are removed and vent holes are made and pouring

basin is cut at the top of the sprue. *(Small holes, called vents, are made using vent wires in the sand mould to allow the exit of gases and steam during casting.)*

7. Cope is carefully turned over to a board and pattern halves are removed. The patterns are loosened a bit by rapping these handles gently before lifting them. This minimizes the damage to sand moulds.

8. Gate is prepared on the top surface of the drag and repairs if any and cleaning of mould cavity is carried out.

9. In case, any cores are used to make holes in the casting, this is time for placing the cores in the mould cavity. Of course, the cores are supported properly by means of core prints or other devices like chaplets etc. Lack of adequate support for cores may result in their displacement from correct position when the liquid metal is poured in

10. Core is kept carefully in position and Cope is kept back over drag and clamped.

11. Molten metal is poured into the pouring basin.

12. After sufficient time is allowed for metal solidification, casting is taken out by

breaking the mould.

13. Unwanted projections in the casting are removed by metal removal processes and

casting is cleaned.

FORGING

Forging is a manufacturing process involving the shaping of metal using localized compressive forces. The blows are delivered with a hammer (often a power hammer) or a die. Forging is often classified according to the temperature at which it is performed: cold forging (a type of cold working), warm forging, or hot forging (a type of hot working). For the latter two, the metal is heated, usually in a forge. It is employed for parts that require high strength and better mechanical properties.

Advantages	***Disadvantages***
1. It can be able to withstand fluctuating stress caused by sudden shock loading. 2. Practically there is no waste of metals. 3. Reduces machining time for finishing operations of the products. 4. A high rate of production is possible. **5.** It maintains uniform and same quality all over parts**.** **6.** It gives a smooth surface finish.	1. High tool cost. 2. High tool maintenance 3. Limitation in size and shape. 4. The heat treatment process increases the cost of the product. 5. Brittle materials like cast iron cannot be forged. 6. The complex shape cannot be produced by forging. 7. The rapid oxidation of the metal surfaces at high temperatures wears the dies.

Applications of Forging Process:

1. Connecting rod	2. Crankshaft	3. Camshaft	4. Spanner	5. Alloy wheel
6. Differential gears	7. Drive shafts	8. Clutch hubs	9. Universal joints	10. Hand Tools

CLASSIFICATION OF FORGING

a. According to the forging equipment

- Hand forging
- Drop forging
- Press forging
- Machine forging

i. Hand forging

- Hand forging is the oldest type of metal working process and has influenced the formation of other materials through the age.
- Smith forging was formerly the process where the blacksmith wielding a hammer against a piece of hot metal placed upon a rigid anvil.
- The modern process is the same except that the crafts-person uses a mechanical hammer and manipulators to move heavy pieces.
- Hand forging is performed in the black smithy shop. The job is heated at the forging temperature in the hearth and it is then brought on the anvil using a tong.
- It is then forged using hand hammers and other hand-forging tools for imparting specific shape.

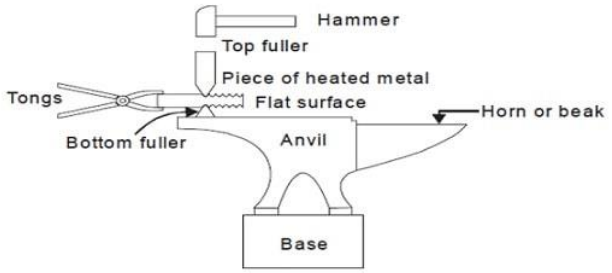


Fig. 14.16 Hand forging

ii. Drop forging

→ Drop forging is a process that uses a pair of impression dies and a heavy hammer to form and compress metal bars or billets into complex shapes.

→ The impression or die cavity is the desired shape of the final forging.

→ The equipment used in the drop forging process is known as a power or drop hammer.

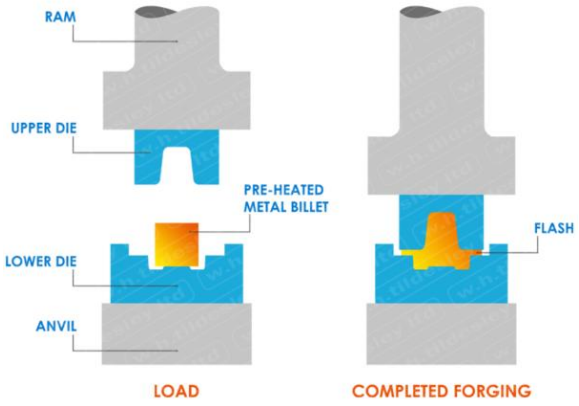
→ Drop hammers are typically mechanical where the weight and upper die are lifted by a belt or chain and dropped.

→ Power hammers are powered by air or hydraulics and are typically used for heavier production.

→ The lower half of the forging die is fixed in position on the anvil and the upper is fixed onto the ram that moves up and down.

→ Material is heated to the required temperature and then placed into the lower forging die in its plain or preformed condition.

→ The material is then hammered until it completely fills the die cavity. The process can also be called impression die forging.



iii. Press forging

Press forging is a method of forming a piece of metal into a specific shape by applying gradual pressure on a shaped die holding the metal. In closed-die press forging, the metal is completely enclosed in a die and pressure is applied on the die.

Compared to open-die press forging, closed-die is an overall more efficient method with lower chance of error.

With press forging, the metal is shaped in a uniform way from the surface to the center. This means the impressions created are cleaner and the end product is generally stronger.

Initial setup costs are also higher with press forging, but the method becomes more cost effective as volume increases.

Compared to drop forging, press forging has the advantage of being more cost effective for higher volume runs, and also results in a stronger workpiece. It also retains the strength benefits of forging compared to casting.

d) Machine forging

This process makes use of forging machines, also known as up setters, for the application of force. In this process also the shaping of the product is done by using two halves of a die which contains the impression of the required product. Some of the examples are bolt heads, rivets, small shafts etc.

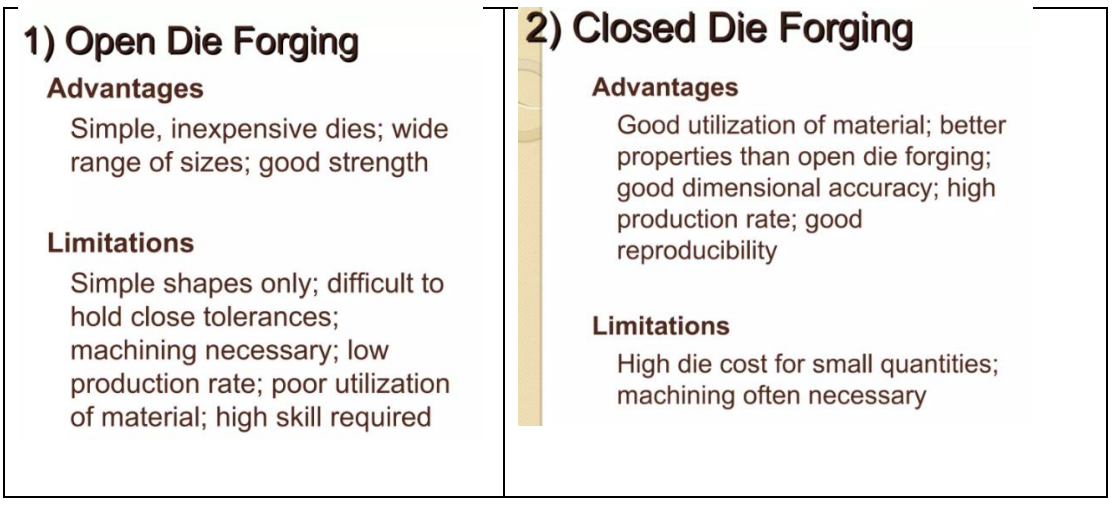
a. According to arrangement of die/ process

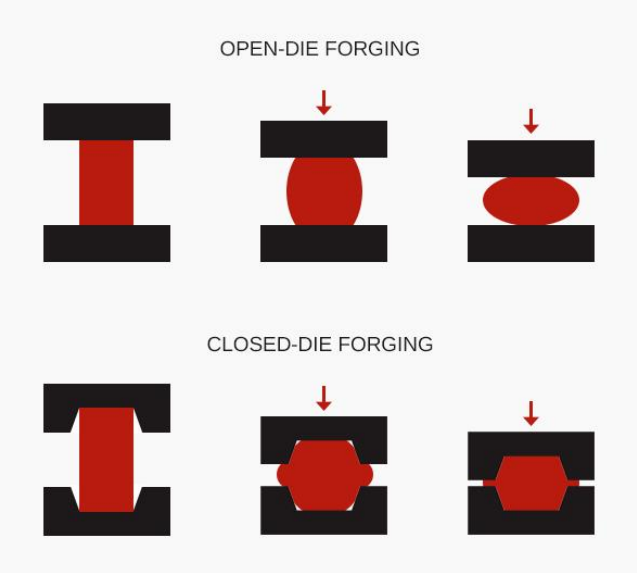
i. Open die forging (should draw diagram if asked for 5 marks or more

- Also, called as free forging or smith forging.
- The heated workpiece is compressed between two flat dies, allowing it to flow sideways without any restriction
- The lower die is stationary and the upper die is movable which compresses the workpiece.
- Mainly used for large objects and small quantities.

ii. Closed die forging (should draw diagram if asked for 5 marks or more):

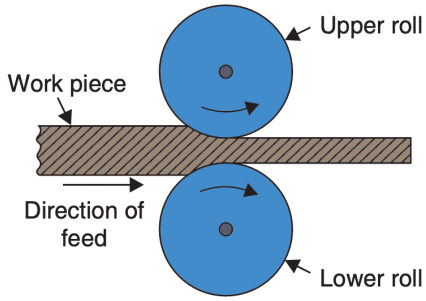
- The workpiece is deformed between two die halves which carry the impressions of the desired final shape.
- The die will be the negative image of the required final product.
- The final product will be the shape and size of the required final product, so further machining is not required.
- It uses carefully machined matching die blocks to produce forgings to close dimensional tolerances.
- Normally used for smaller components
- In closed die forging, flash is produced. (*flash- when the die comes together for the finishing step, the excess metal squirts out of the cavity as a thin ribbon of metal*).
- So, flash has to be trimmed off.





ROLLING

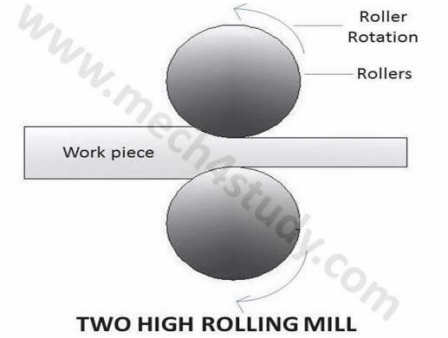
- The rolling process is a metal forming process, in which the material is passed between one or more pairs of rollers in order to reduce and to maintain the uniform thickness.
- This process is mainly focused on the cross-section of the ingot (block of metal typically rectangular and flat) or the metal which is forming.
- Now, the rolling processes are mainly focused on the increasing length and the decreasing thickness without changing the width of the workpiece.
- There are 2 types of rolling process:
    - Hot rolling
    - Cold rolling
- If the strip is rolled after heating the strip ***above the re-crystallization temperature*** then it is termed as ***Hot rolled*** and if that done in ***room temperature*** then it is termed as the ***Cold rolled***. In this process, the force is much more required than the hot working process to pass the metal from the rollers and this process offers good surface finish. *(recrystallization temperature is the temperature just below the melting point of the metal)*
- Rolling is a process that is widely used and has very high production.



Types of rolling mills *(diagrams are required)*

Two High Rolling Mill:

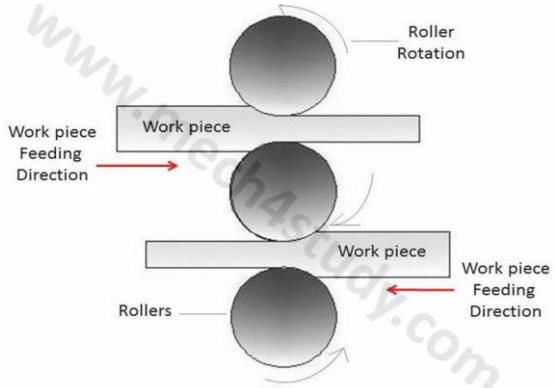
- This mill consist two rollers.
- Both the rollers rotate in opposite direction for desire movement of work piece.
- Work piece is feed between the rollers which apply a compressive force and tends to plastically deform work piece and convert it into desire shape.
- This machine can further classified into two types.
- The first one is ***two high non reversible machine*** in which the rollers can rotate in only one direction (Either clockwise or anticlockwise) and thus work piece can feed only in one direction (Either left to right or right to left).
- The other one is ***two high reversible machine*** in which both the rollers can be rotate in both directions.



Three High Rolling Mill:

- This type of rolling mill consist three rollers arrange parallel to each other.

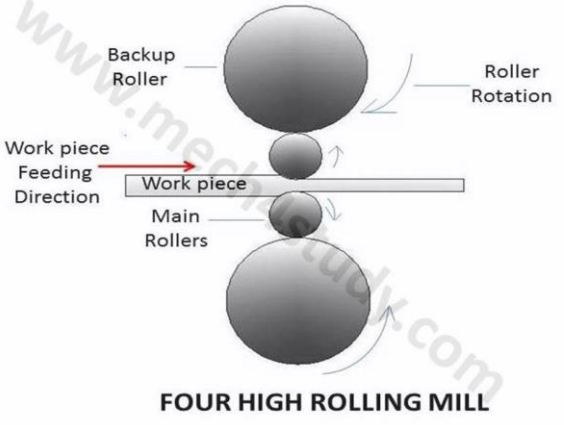
- In this machine the middle roller rotate in opposite direction of other two rollers.
- This machine is used to reduce two times thickness in one pass.
- In this machine, the work piece is feed between bottom and middle roller in one direction and top and middle rollers in opposite direction.
- This machine can handle two work pieces in single run.



THREE HIGH ROLLING MILL

Four High Rolling Mill:

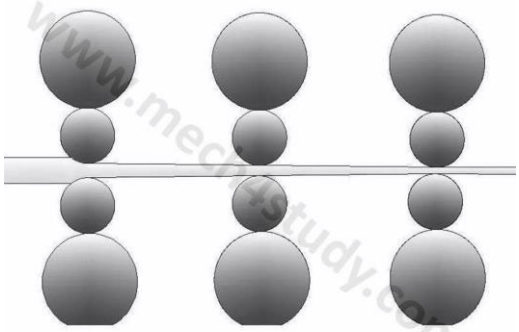
- These machine consist four rollers (two small and two big). These rollers are arranged as shown in figure.
- Small rollers are in direct contact with work piece and rotate in opposite direction.
- Big rollers works as backup rolls and are used to prevent the deflection of the smaller rollers and they also rotates in opposite direction with each other and also with contact roller.
- This machine is used for cold rolling where high rigidity required.



FOUR HIGH ROLLING MILL

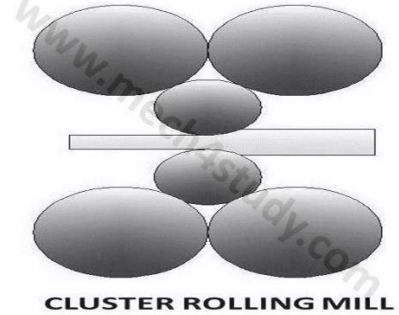
Tandem Rolling Mill:

- Tandem rolling is also known as continuous rolling in which two or more set of four high rolling mill arranged in a series in which each set is called stand.
- These stands are arranged so they can roll the work piece in decreasing cross section.
- It is used for rolling thick work piece in single pass.



Cluster Rolling Mill:

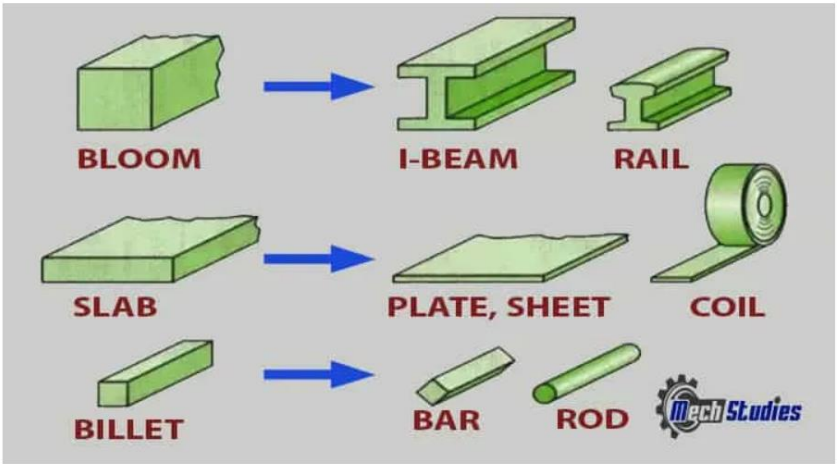
- In this type of rolling mill, each of working roller is backup by two or more of larger backup roller.
- This machine is used for rolling hard material.
- These backed up rolls give more pressure to the basic rolls to heavily press the strip.



Application:

- Rolling is used for making hollow seamless tubes, rods etc.
- Large cross sections are produced by rolling process.
- It is use for mass production of threaded parts like screw, bolts etc.
- Gears can be cut on gear blank by rolling process.
- Construction material, roofing panels, partition beams, railroads, etc. are rolling product.
- It is used in automotive industries for manufacture various parts.

- Rings of turbines, bearing and other machines are rolling product.
- Steel sheets, plates are made by rolling process.



EXTRUSION *(diagram is required)*

- ✓ Extrusion is a simple compressive metal forming process.
- ✓ In this process, piston or plunger is used to apply compressive force on a heated work piece.
- ✓ These process can be summarized as follow.
- ✓ First billet or ingot (metal work piece of standard size) is produced.
- ✓ This billet is heated in hot extrusion or remains at room temperature (cold extrusion) and placed into a extrusion press (Extrusion press is like a piston cylinder device in which metal is placed in cylinder and pushed by a piston. One side of cylinder is fitted with die).
- ✓ Now a compressive force is applied to this part by a plunger fitted into the press which pushes the billet towards die.
- ✓ The die is small opening of required cross section.
- ✓ This high compressive force allow the work metal to flow through die and convert into desire shape.
- ✓ Now the extruded part remove from press and is heat treated for better mechanical properties.

Types of extrusion

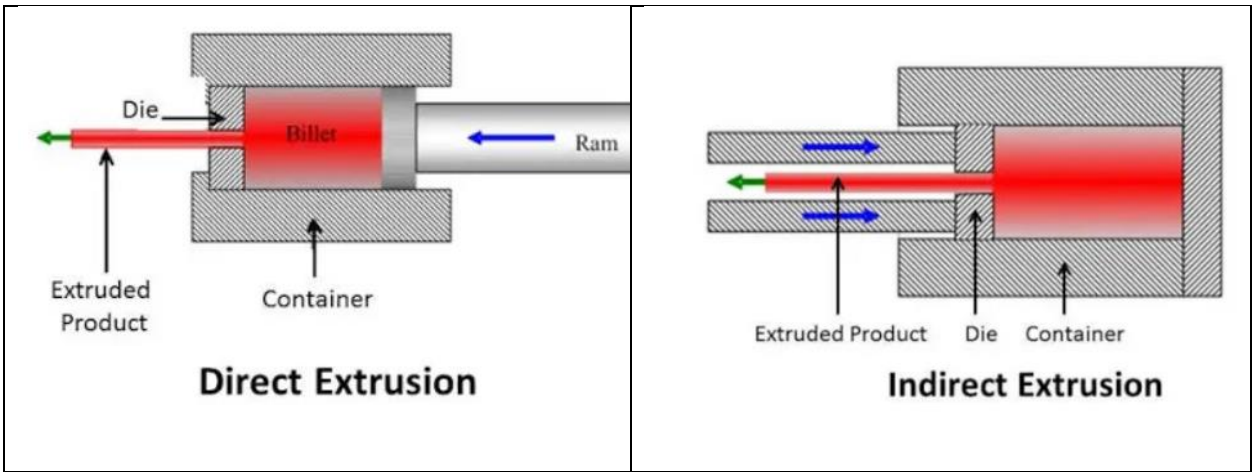
- **According to the direction of flow of metal *(diagrams required)***

a) ***Direct Extrusion:***

- In this type of extrusion process, metal is forced to flow in the direction of feed of punch.
- The punch moves toward die during extrusion.
- This process required higher force due to higher friction between billet and container.

b) Indirect Extrusion:

- In this process, metal is flow toward opposite direction of plunger movement.
- The die is fitted at opposite side of punch movement.
- In this process, the metal is allowed to flow through annular space between punch and container.



- **According to the temperature**

a) **Cold extrusion :**

→ If the extrusion process takes place below crystallization temperature or room temperature, the process is known as cold extrusion.

→ Aluminum cans, cylinder, collapsible tubes etc. are example of this process.

a) **Hot extrusion:**

- If the extrusion process takes place above recrystallization temperature which is about 50-60% of its melting temperature, the process is known as hot extrusion.

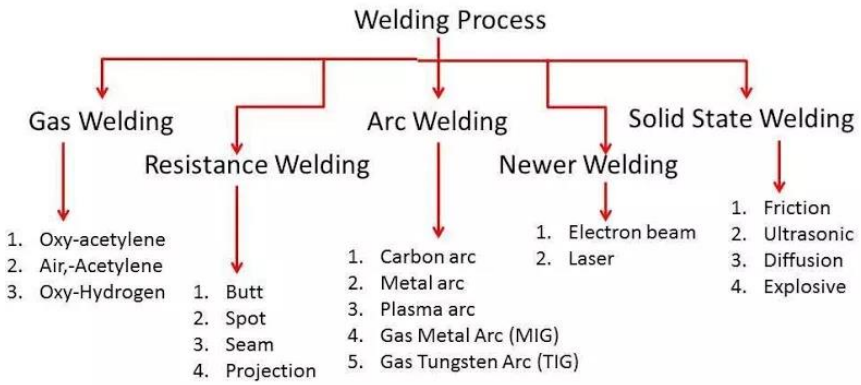
Applications

- Extrusion is widely used in production of tubes and hollow pipes.
- Aluminum extrusion is used in structure work in many industries.
- This process is used to produce frames, doors, window etc. in automotive industries.
- Extrusion is widely used to produce plastic objects.

WELDING

It is a process in which two metal pieces similar (or) dissimilar may be joined by heating them to a temperature high enough to fuse the metals with (or) without the application of pressure and with (or) without the aid of filler material. *(Filler metals are used to fill the space between two close-fitting materials in welding, soldering, or brazing. These alloys or unalloyed metals when heated, melt to flow into the gaps between two close-fitting materials to create a weld, soldered, or brazed joint.)*

TYPES OF WELDING

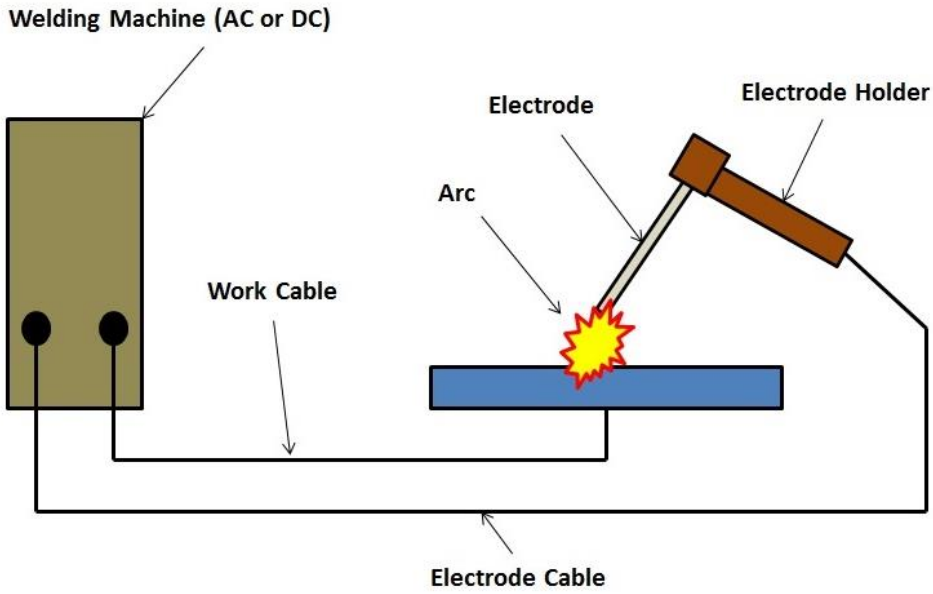


ARC WELDING *(diagram is required)*

The process of joining metal to metal with the help of an electric arc is called arc welding. In this welding process, the arc is used to create intense heat and this heat is used join the metals together. The arc is brought in between two metal pieces and due to the heat generated, the metals melt and when it cools a strong welded joint is formed.

The power source used in arc welding is electricity (electric current). The electric current used may be either direct (DC) or alternating (AC). The welding region is protected by some shielding gas, vapours or slag. The shielding gas protects the weld area from atmospheric contamination. It can be manual, semi-automatic, or fully automated. It uses consumable or non-consumable types of electrodes for the welding purpose.

Working *(diagram is required)*



Working :

- The work lead is connected to the positive terminal of a AC/DC welding machine.
- The electrode lead is connected to the negative terminal.
- Flux coated electrode material is used as the filler metal.
- The clamp at the other side of the work lead is connected to the workpiece.
- The edges of the parts which are to be melted are cleaned using a wire brush.
- The tip of the electrode touches the parent metal.
- After touching, the electrode tip is lifted to make a gap of about 3mm.
- This creates an electric arc between the workpiece and the electrode.
- When the voltage applied to two spatially separated electrodes is gradually increased, the air insulation finally breaks and current flows between the electrodes, emitting bright light and high heat at the same time.

- The generated arc-shaped light is called an electric arc or arc.
- Arc welding is welding using the heat of an arc as a heat source.
- The output current of the arc is about 5 to 1,000 A and the output voltage is about 8 to 40 V.
- The temperature of the arc is about 5,000°C to 20,000°C.
- The melting temperature of iron is about 1,500°C.
- Consequently, the base material and electrode are heated to a high temperature and fuse together.
- Because the metals react chemically to oxygen and nitrogen in the air when heated to high temperatures by the arc, a protective shielding gas or slag is used to minimize the contact of the molten metal with the air.
- Once cooled, the molten metals solidify to form a metallurgical bond.

ADVANTAGES OF WELDING

- A good weld is as strong as the base metal.
- General welding equipment is not very costly.
- *Portable welding equipments are available.*
- *Welding permits considerable freedom in design.*
- A large number of metals/alloys both similar and dissimilar can be joined by welding.
- *Welding can join workpieces through spots, as continuous pressure tight seams, end-to-end and in a number of other configurations.*
- *Welding can be mechanized.*

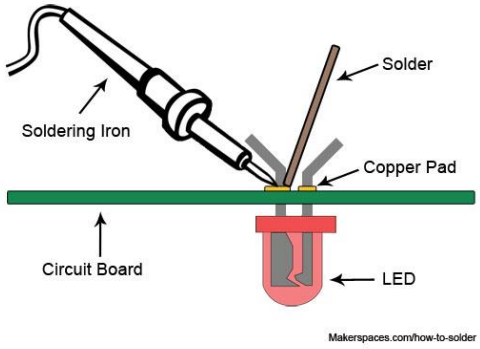
DISADVANTAGES 0F WELDING

- Welding gives out harmful radiations (light), fumes and spatter.
- *Welding results in residual stresses and distortion of the work-pieces.*
- *Edge preparation of the workpieces is generally required before welding them.*
- *A skilled welder is a must to produce a good welding job.*
- *Welding heat produces metallurgical changes. The structure of* the welded joint is not same as that of the parent metal.
- *A welded joint, for many reasons, needs stress-relief heat-treatment.*

Applications

- For Automotive industries
- Aircraft and space craft industries
- Fabrication of pressure vessels and steel structures
- For Railway Tracks
- For laying of pipelines
- Transport tankers
- Welding of tubes and pipes
- General applications like microwave oven
- Home applications like doors and door frames

SOLDERING



- Soldering is a joining process used to join different types of metals together by melting solder.
- Solder is a metal alloy usually made of tin and lead which is melted using a hot iron.
- The iron is heated to temperatures above 600 degrees fahrenheit which then cools to create a strong electrical bond.
- The parts to be joined are first cleaned and are coated with flux. *(Flux is **a chemical cleaning agent used in the soldering process**. Its uses include the soldering of electronic components onto circuit boards. The purpose of flux is to prepare surfaces for soldering by removing any oxides and impurities. Using flux improves the strength of the soldering joints)*
- The soldering iron is then heated to a high temperature.

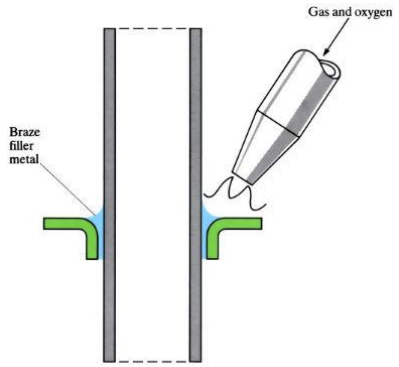
- The joints are placed in a clamp
- The solder wire will be placed near the soldering iron.
- Due to the high temperature of the iron, solder will melt and a few drops are applied all over the joint.
- Soldered joints are easy to separate and hence not useful for permanent work.
- Here the base metal is not melted.
- Soft soldering includes the soldering with solders, where the liquidus temperature (lowest temperature at which an alloy is completely liquid) is below 450°C.
- With hard soldering, however, the liquidus temperature of the solders is between 450°C and 900°C. Usually, hard soldered connections are mechanically stronger than soft soldered connections

Advantages: ▪ Lower energy than brazing or fusion welding ▪ Variety of heating methods available ▪ Good electrical and thermal conductivity in joint ▪ Easy repair and rework Disadvantages: ▪ Low joint strength unless reinforced by mechanically means ▪ Possible weakening or melting of joint in elevated temperature service	**Soldering Applications** • Plumbing, electronics, and metalwork • Commonly used in repairs & joining of dissimilar metals • Plumbing: Soldering provides reasonably permanent but reversible connections between copper pipes in plumbing systems • Electronics: soldering connects electrical wiring and electroni components to printed circuit boards (PCBs). • Metalwork: Jewelry repair, sheet metal objects such as food cans, roof flashing, rain gutters. • Used to seal & repair automobile radiators. • Small mechanical parts are often soldered or brazed as well. • Soldering is also used to join copper foil in stained glass work

BRAZING

- Brazing is a process of joining two pieces of metal in which a non-ferrous alloy is introduced in a liquid state between the pieces of metal to joining allowed to solidify.
- The melting temperature of the filler material is about 600°c, but lower than the melting temperature of the parent metal.

- The filler metal is distributed between the surface by capillary action. Metals to be joined are not melted, only the filler metal is melted.
- Brazing is basically the same as soldering, but it gives a much stronger joint than soldering.
- The principal difference is the use of harder filler material, commercially known as a speller, which fuses at some temperature above red heat, but below the melting temperature of the parts to be joined.



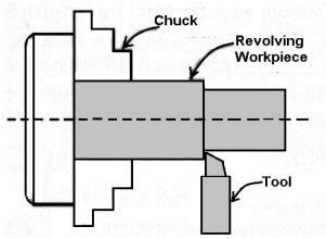
Advantages of Brazing	***Disadvantages of Brazing***
• Dissimilar metals and parts having a thin section can be easy. • Brazing may avoid the metallurgical damage to the base metal. • The strong joint can be obtained by brazing. • Properly brazed joints are pressure-tight. • It is an economical and quick process. • Less heating is required than for welding.	• Reduction of joint strength compared to a welded joint due to the soft filler metals used. • The strength of the brazed joint is less than that of base metal but is more likely to be higher than filler metal. • The brazed joints can be destroyed under high service temperatures. • Brazed joints need high-metal cleaning when done in an industrial setting. • The joint colour is usually different from the base metal, creating an aesthetic disadvantage.

Applications of Brazing

It is used in vacuum interrupters.	It is used in transport applications.
Used in constructions.	It is helpful in medical equipment.
Used in art and jewellery.	

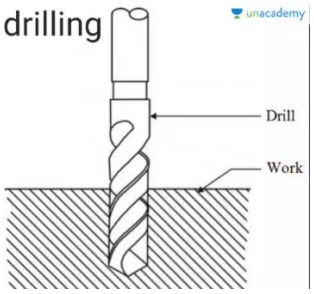
BASIC MACHINING OPERATIONS

iii. Turning



Turning is the most common lathe machining operation. During the turning process, **a cutting tool removes material from the outer diameter of a rotating workpiece**. The main objective of turning is to reduce the workpiece diameter to the desired dimension. There are two types of turning operations, rough and finish.

iv. Drilling



Drilling is a cutting process where a drill bit is spun to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips (swarf) from the hole as it is drilled.

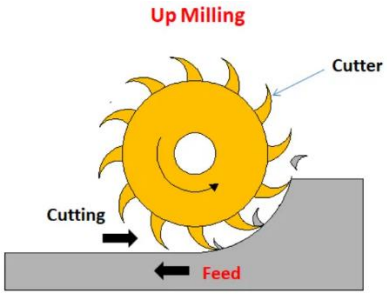
v. Milling

Milling is a cutting process that uses a milling cutter to remove material from the surface of a workpiece. The milling cutter is a rotating cutting tool, often with several cutting edges. In contrast to drilling, in which the tool is advanced along its axis of rotation, during milling the milling cutter is normally moved perpendicular to its axis so that the cutting takes place on the circumference of the milling cutter.

There are 2 types of milling:

a) Up milling (diagram is required)

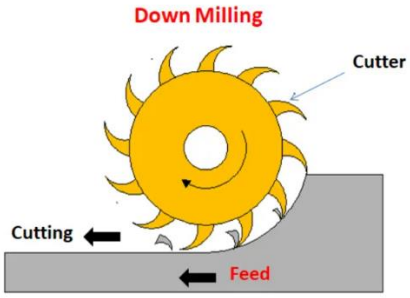
- The up milling is also called as conventional milling or Climb up milling in which the cutter and feed moves in opposite direction i.e the rotary cutter moves against the feed.
- The cutter rotates in anti-clockwise direction while the direction of feed is from right to left.
- So, due to this opposite motion the width of the cutting chips gradually increases from minimum to maximum.
- There is massive friction between the cutter and workpiece which results in generating quite large amount of heat



Feed and cutting are in opposite direction

b) Down milling (diagram is required)

- In case of down milling, the cutter rotates in the same direction as that of the feed.
- In down milling there is less friction involved between the cutter and the workpiece as both i.e. cutter and feed are moving in the same direction.
- This small amount of friction results in generation of minimum heat.
- Here, the thickness of the chip varies from maximum to minimum during the process.



Feed and cutting are in same direction

vi. Grinding

12. A grinding is metal cutting operation which is performed by means of a rotating abrasive wheel that acts as a tool.
13. These are mostly used to finish workpieces which must show a high surface quality, accuracy of shape and dimension.
14. Mostly, it is finishing operation because it removes material in very small size of chips 0.25 – 0.5 mm.

DIFFERENCE BETWEEN SOLDERING AND BRAZING

Soldering is a metal-joining process where the melting temperature of the filler metal is relatively low.	Brazing is a metal-joining process where the melting temperature of the filler metal is usually above 450˚C.
The most common type of filler metal used in soldering is a 60:40 tin: lead alloy.	Brass alloys are commonly used in brazing.
Soldering occurs at temperatures around 400˚C.	Brazing occurs at temperatures above 450˚C.
Soldering is a softer metal-joining process where the metals parts are not held very tightly.	Brazing creates a tight fit between the metal parts joined.

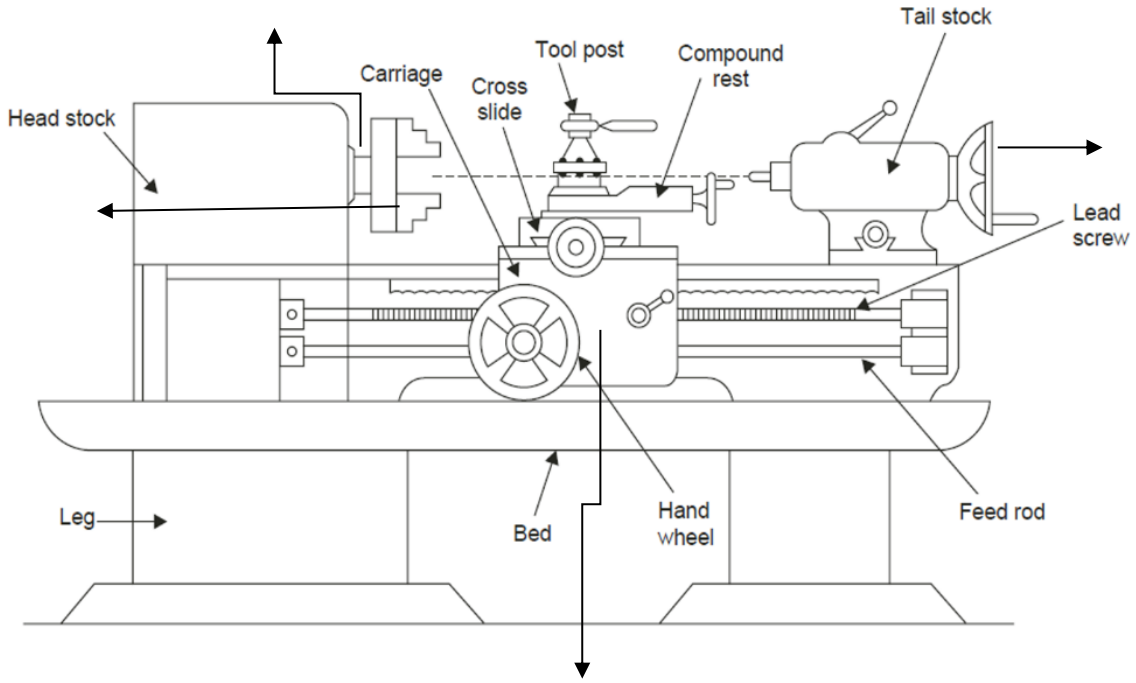
LATHE ***(diagram should be drawn)***

- A lathe is a machine, which removes the metal from a piece of work to the required shape and size.
- Lathe is one of the most important machine tools in the metal working industry. A lathe operates on the principle of a rotating workpiece and a fixed cutting tool.
- The cutting tool is feed into the workpiece, which rotates about its axis causing the workpiece to be formed to the desired shape.

Types of Lathe Machines:

- Speed Lathe Machine
- Engine Lathe Machine
- Bench Lathe Machine
- Toolroom Lathe Machine
- Capstan and Turret Lathe Machine
- Special-purpose Lathe Machine
- Automatic Lathe Machine

Parts of a lathe machine ***(Construction with diagram. Points with the tick has to be written):***



✓ **Bed**

- A bed is the main body of the machine.
- All the main components are bolted on it.
- It is usually made of cast iron due to its high compressive strength.
- It is made by the casting process and is bolted to the floor space.

✓ **Guideways**

- Guideways take care of the movement of tailstock and carriage on the bed.

✓ **Headstock**

- Headstocks are the main body parts that are placed on the left side of the bed.
- It serves as a holding device for gear chains, spindles, driving pulleys, etc.
- The mechanism of the headstock is driven by an electric motor that rotates the spindle.
- It is also made of cast iron.

✓ **Spindle**

- It is the main part of the lathe which holds and rotates the chuck.
- It is made from good quality alloy steel and it is heat treated.
- Threads, tapers, etc. are made at one end of the spindle to which holding devices can be attached.

✓ **Carriage**

- It is located between headstock and tailstock.
- It is used to hold and move the tool post along the bed either towards or away from the headstock.
- It slides on the guideways.
- It is also made of cast iron.
- It has six main parts:
    - Saddle
    - Cross slide
    - Compound Rest
    - Compound slide
    - Tool Post
    - Apron

✓ ***Saddle***

- It is an 'H' shaped casting mounted on lathe ways, supports the cross slide that provides movement to the tool post.

✓ ***Cross Slide***

- A cross slide is a part of the carriage that allows the movement of a tool post at a right angle to the bed guideways during machining.
- The cross slide is moved by the feed screw.

✓ ***Compound Rest***

- A compound rest is a part that connects the cross slide and the compound slide.
- The compound rest is mounted on top of the cross slide.
- It has a circular base on which the graduations in degrees are made.
- Its power is not fed but it is operated by hand.
- A certain depth of cut can be set by rotating the feed screw of the compound rest.
- After setting it as required, the compound slide is solidly locked with the base.

✓ ***Compound Slide***

✓ A compound slide is attached to the compound rest by the dovetail joint.

✓ Compound slides are used to cut angles or tapers that cannot be cut by rotating the headstock.

✓ ***Tool Post***

- It is bolted to the carriage on top of the compound slide.
- It is used to hold the tools at the correct position with rigidity.

✓ ***Apron***

- An apron is situated on the carriage.
- It consists of all controlling and moving mechanisms of carriage.
- The apron is fastened to the saddle with feed mechanisms that provide automatic feed to the carriage.
- The apron hand wheel can be rotated to move the carriage by hand along with the bed of the lathe.

✓ **Tailstock**

- Tailstock is a casting located on the right side of the bed.
- Its function is to support the loose end of the workpiece or a job while machining.
- It can slide on the bed guideways and can be clamped in any position.
- The tailstock has the following purposes:

1. To support the loose ends of long jobs for carrying out lathe operations.
2. To hold the cutting tools such as drill chucks, drills, reamers, etc.
3. Turning of outer taper by an offsetting method.

✓ **Chuck**

- It is an important tool, which is used to hold and rotate the workpiece.
- The smallest piece of workpiece can be hold in a chuck.

Faceplate

- The faceplate is fixed to the lathe spindle and can be job mounted to perform the turning operation.

Center

- Center is a part of lathe machine which is used to support long jobs in between headstock and tailstock to carry out a lathe operation.
- A center that fits into the headstock spindle and rotates with the workpiece is called a live center.
- The center which is used in the tailstock spindle and which does not rotate is called the dead center.

✓ **Feed Shaft**

- It is made from good quality alloy steel.
- It spans the entire length of the bed and is fitted under the lead screw.
- It has a "keyway" from which motions can be given to the carriage for the feed mechanism.
- When the power feed is attached, it provides cross movement to the tool.

✓ **Lead Screw**

- It is used for thread cutting.
- Lead screw is situated at the bottom side of the bed which is used to move the carriage automatically during thread cutting.
- It is made from good quality alloy and is made of acme threads.

✓ **Legs**

- Legs are used to carry all the loads of the machine.
- They are bolted on the floor which prevents vibration.

Chips Pan

- Chips pan is placed lower side of the bed.
- The main function of it is to carry all chips removed by the workpiece.

Hand Wheel

- This is the wheel that is operated by hand to move a cross slide, carriage, tailstock, and other parts that contain a hand wheel.

Speed Controller

- The speed controller is located on the headstock which controls the speed of the spindle

Sleeve

- Sleeve fits inside tailstock which can be moved back and forth to fit or remove dead center.

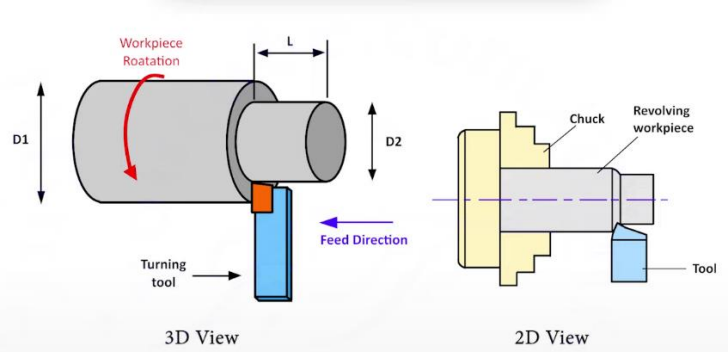
Various operations done on a lathe machine *(diagrams are required either 2D or 3D)*

i. Turning

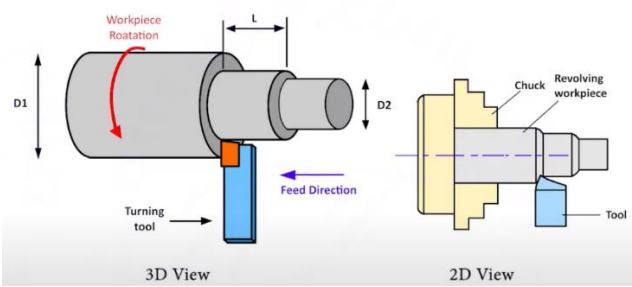
It is the removal of material from the outside diameter of a cylindrical job to obtain one or more finished diameter. Usually, there are three types of turning which are given below :

(a) Plain or straight or parallel turning.
(b) Stepped turning.
(c) Taper turning.

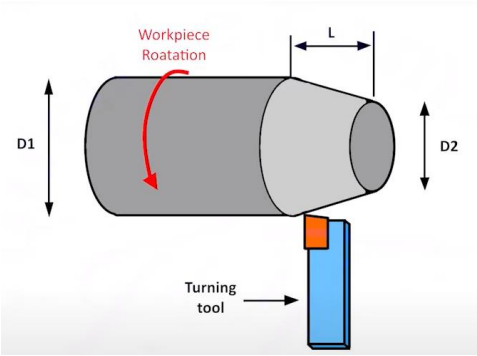
- In plain turning machining is done in this way that after removal of material, finished diameter at both the ends of length remains equal.



- Turning operation where the entire length is divided in steps of different diameter but each step individually finished by using plain turning is known as stepped/ shoulder turning.

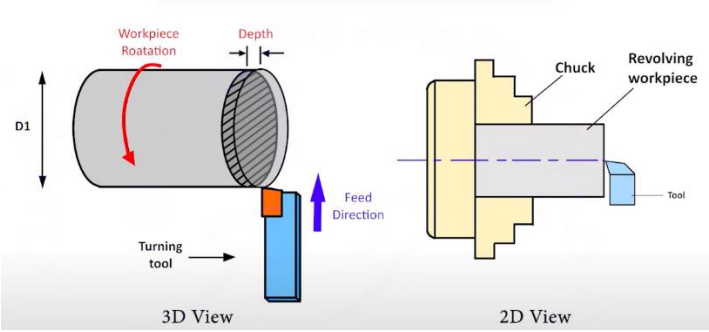


- Taper turning is the operation in which the material is removed from the job to produce a conical shape.



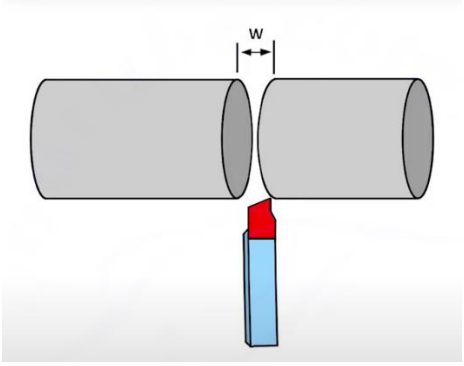
ii. ***Facing***

- It is the machining of the ends of a workpiece to make the ends smooth or for reducing the length. For this operation, the cutting tool is fed perpendicular to the lathe or workpiece axis by means of cross slide.



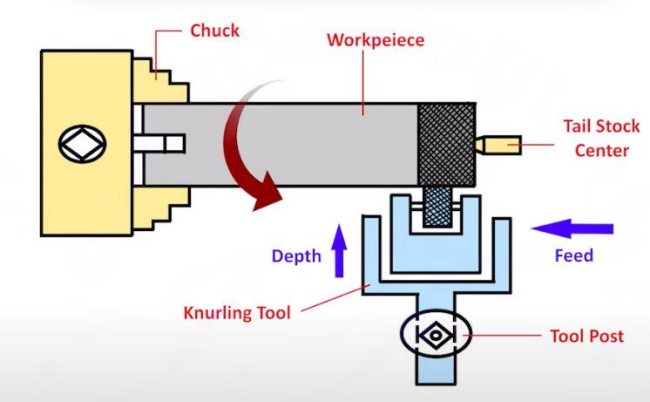
iii. ***Parting Off***

- This operation involves cutting the work-metal into two parts by using parting off tool. Feed to the cutting tool is given in same manner as in case of facing operation.



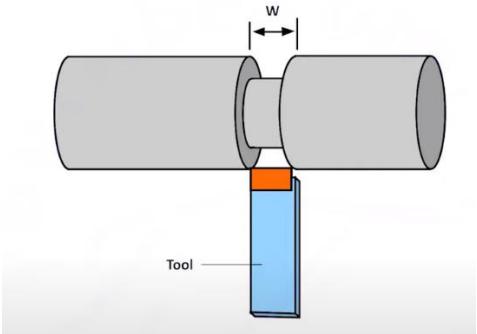
iv. **Knurling`**

It is the process of producing rough surface of embossing diamond shaped pattern on a smooth surface of a cylindrical workpiece. Knurling provides an effective gripping surface on a job to prevent it from slipping when operated by hand.



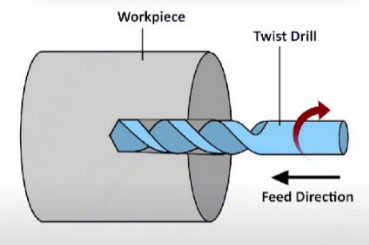
v. **Grooving**

This operation is also denoted as necking. Usually, grooves are cut on a cylindrical surface in narrow shape by means of grooving tool i.e diameter will be reduced for a narrow width. The cutting edge of grooving tool is kept narrow.



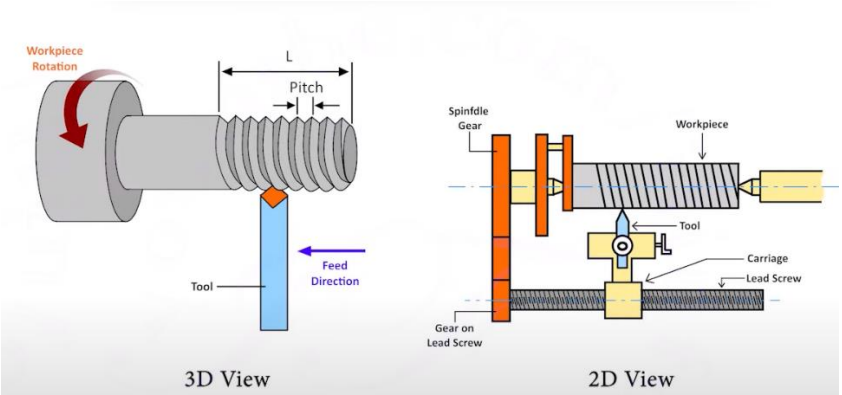
vi. **Drilling**

For making a standard size of hole in a workpiece by means of drill is known as drilling operation. For this operation, drill is held in tail stock spindle.



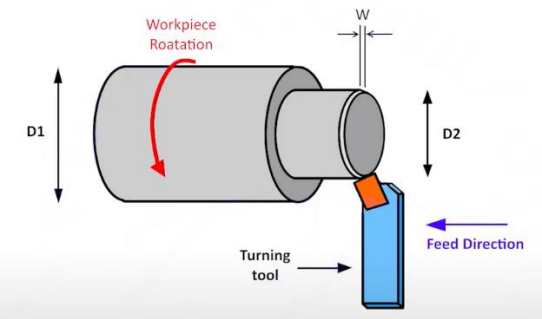
vii. Thread cutting

Thread cutting on the lathe is a process that produces a helical grooves or threads of uniform section on the workpiece. This is performed by taking successive cuts with a threading tool bit the same shape as the thread form required.



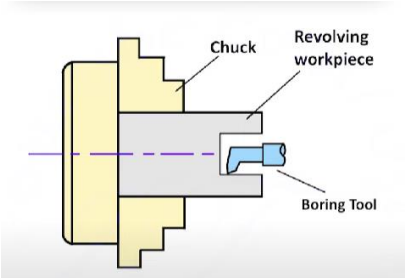
viii. Chamfering operation:

It is the operation of getting a bevelled surface at the edge of a cylindrical workpiece. This operation is done in case of bolt ends and shaft ends. Chamfering helps to avoid damage to the sharp edges and protect the operation getting hurt during other operations. Chamfering on bolt helps to screw the nut easily



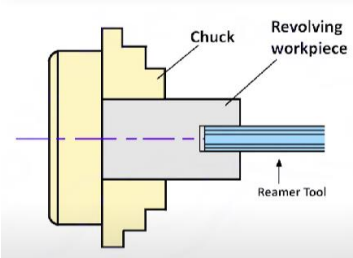
ix. **Boring**

Boring is the operation of enlarging a drilled hole by means of a boring tool. The boring tool is fitted on a boring bar which is held in tail stock spindle.



x. **Reaming**

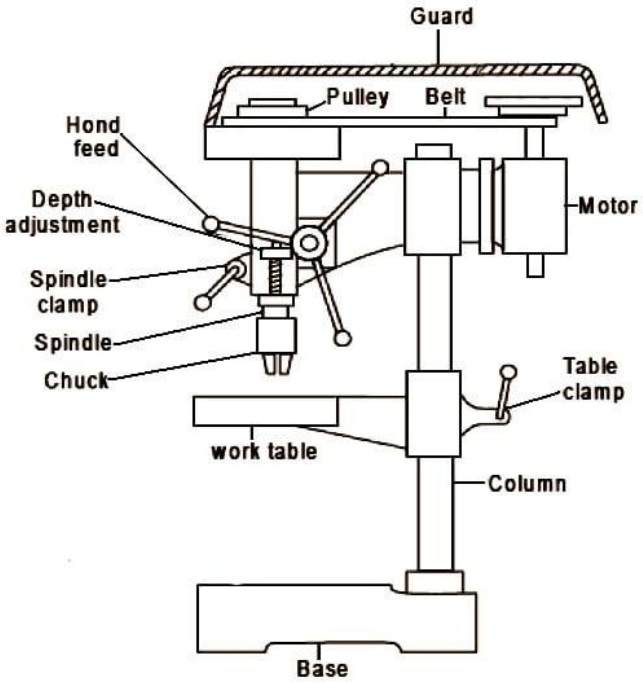
It is the operation of finishing a drilled hole to an accurate dimension with the help of reamer as a tool. The reamer is held on the tail stock spindle.



Drilling Machine (diagram required)

- A drilling machine is a type of machine in which the holes are being made on the workpiece by making use of a rotating tool called drill bit or the twist drill.
- Drilling is basically a technology of creating holes.
- Drilling operations can also be performed on Lathe machines.

- In the lathe machine, the workpiece rotates and the drilling tool is held stationary in the tailstock.



1. Bed:

The bed is the main part of the machine on which the whole machine is being mounted. The bed is made up of cast iron, so it has high compressive strength and good wear resistance.

2. Pillar:

It is exactly placed at the center of the base which can act as a support for rotating the Swivel table and holding the power transmission system.

3. Swivel Table:

The table is the place where the workpiece is being mounted. The table is attached to the column and it can be rotated around the column and can have an upward and downward moment. A table can be adjusted at any angle as per the requirement.

4. Motor:

The motor is present at the top of the column. The inside motor shaft is there which is connected to a stepped pulley so that we can increase or decrease the speed of the rotation of the motor.

5. Stepped pulley:

Two steeped pulleys are present on either side of the column at the top. Out of these two, one pulley will be in an upward direction while the other pulley is inverted.

Always both the pulleys will be there in the opposite direction. The basic function of the stepped pulley is to control the speed of the rotation of the motor.

6. Spindle:

Spindle arrangement is present at top of the column opposite to the arrangement of the motor.

The top of the spindle is attached to one of the stepped pulleys. The bottom of the spindle is connected to the chuck.

7. Chuck:

Chuck is present at the bottom of the spindle. The basic function of the chuck is to hold the cutting tool firmly.

8. Drill bit:

A drill bit is an actual cutting tool that is used to create a hole in the workpiece.

9. Hand Wheel:

The basic function of the handwheel is to adjust the spindle position as per the requirement.

10. Power Transmission system:

It consists of motor, stepped pulley, V-belt, and the Spindle.

Working of drilling machine

- When the power is given to the motor, the spindle rotates, and thereby the stepped pulley attached to it also rotates.
- On the other end, one more stepped pulley is attached and that is inverted to increase or decrease the speed of the rotational motion.
- Now, a V-belt is placed in between the stepped pulleys so as to drive the power transmission.
- Here a V-belt is used instead of a flat belt, in order to increase the power efficiency.
- Now the drill bit also rotates which was placed in the chuck and which was in connection with the spindle.
- As the Pulleys rotates, the spindle also rotates which can rotate the drill bit.
- Now, by the rotation of hand-wheel, the spindle moves up and down in the vertical direction in order to give the necessary amount of feed to the work and this drill bit is used to make the holes on the component placed in the machine vice.

Various operations done on a drilling machine

i) Drilling Operation:

The operation of making holes on the surface of the workpiece by the use of drill bit is called Drilling Operation.

ii) Boring Operation:

The operation of enlarging an existing hole is called the Boring Operation. The existing hole was created by the drilling operation.

iii) Reaming Operation:

The operation of sizing and finishing an existing hole with the help of a reamer is called Reaming Operation. Reamer is a multipoint cutting tool having several cutting edges to finish the surface.

iv) Tapping Operation:

It is the operation of creating internal threads by means of a cutting tool called Tap and the operation is called Tapping Operation.

v) Spot Facing Operation:

This is an operation of removing the chips from the surface of the hole such that proper seating of bolts takes place and this removal can be done through end mill cutter using a drilling machine.

vi) Trepanning Operation:

Without drilling, a Trepanning operation is used for producing a large-size hole of more than 50mm in diameter. This Trepanning operation cannot be used for blind holes.

vii) Honing Operation:

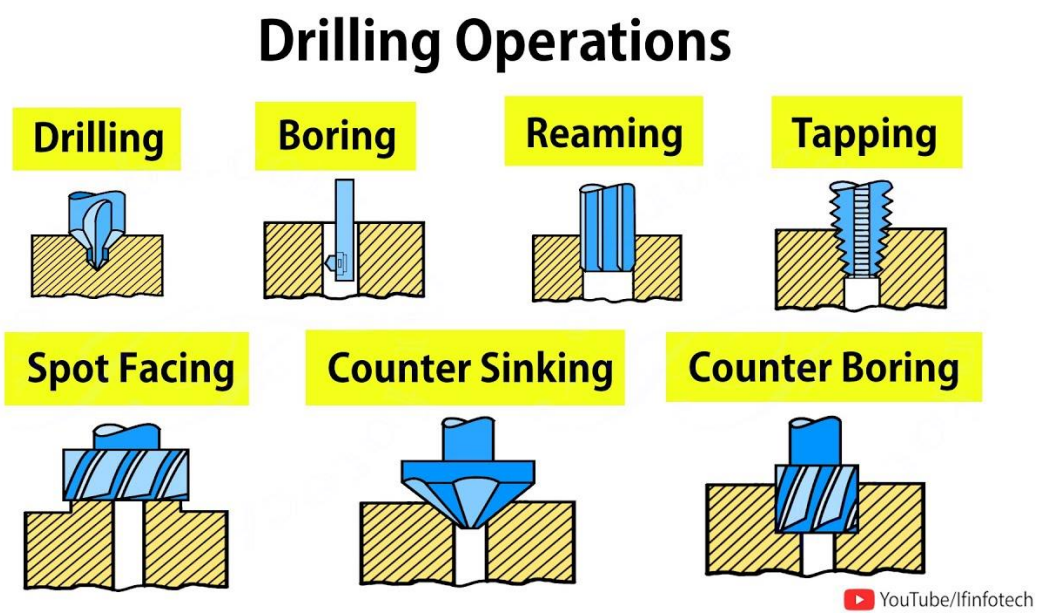
In this operation, the tool will rotate and reciprocate about its axis for producing very smooth holes. This honing operation is mainly used for finishing the holes in the IC Engine cylinder.

viii) Counterboring Operation:

The Counter boring operation is used to enlarge a particular portion of the hole.

ix) Countersinking Operation:

The Countersinking operation is used to enlarge the end of the hole to give it a conical shape for a shorter distance.



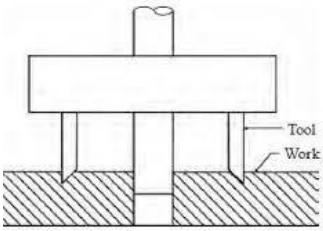


Fig 2.24 Trepanning

Advantages of Drilling Machine:	**Disadvantages of Drilling Machine:**
• It requires less labour. • High precision and accuracy will be maintained by the operator in Bench Drilling Machine whereas, in the case of Automatic drilling machine, high accuracy is maintained by the machine itself. • It is easy to operate • The maintenance is low.	• As it makes rough holes during the drilling operation. Therefore, a medium surface finish can be expected but not a high surface finish. • A small size workpiece that can fit on the worktable is machined whereas large size components cannot be machined. • If there is an improper clamping between the drill and the workpiece, there will be a probability of breaking the drill bit.

Applications of Drilling Machine:

- Surface mining
- Counter boring
- Countersinking
- Underground mining
- Tapping etc.

Milling machine

Milling Machine is used for Machining flat surfaces, Slotting, Contoured surfaces. It is also useful for making complex and irregular areas, revolution surface, eear cutting, machining external and internal threads. Machining helical surfaces of various cross-sections and many more.

Types of milling machine

1. **Horizontal Milling Machine**

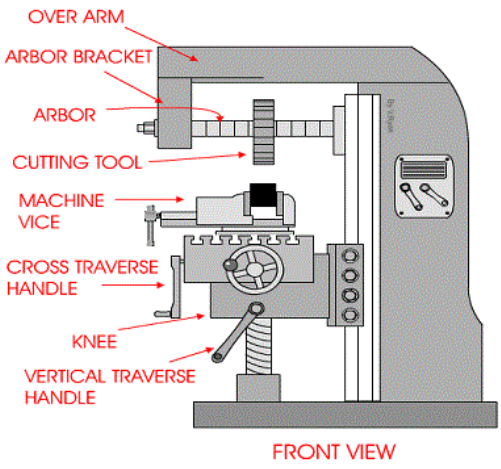
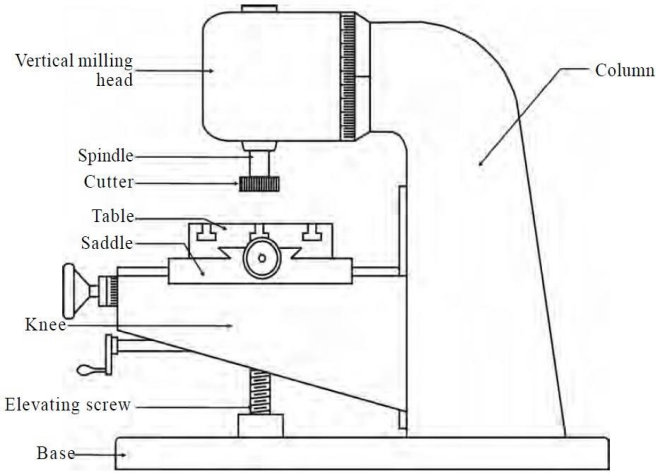
- In horizontal milling machine the axis of rotation of the spindle is horizontal to the table. And due the axis of spindle horizontal, it is called as horizontal milling machine.

-

2. **Vertical Milling Machine**

- The milling machine in which the spindle axis is perpendicular to the table is called vertical milling machine.

Parts of milling machine ***(construction with diagram, parts will be the same for both horizontal and vertical milling machine, only the diagrams vary. Draw the type of milling machine which is mentioned in the question. If not mentioned you can draw either one)***

Horizontal milling machine	*Vertical milling machine*
	

#1. Base:

The base is the part upon which the whole machine parts are being mounted. It is a type of foundation for the machine.

The base is mostly made up of cast iron, so it has good strength and rigidity. It also helps in the absorption of shocks. Cutting fluid can also be stored in the base.

#2. Column:

The main supporting frame which consists of all the driving mechanisms and the motor is called the column.

The driving mechanism usually consists of a cone pulley mechanism in which the v-belt is being used to connect it to the motor.

Further by using this driving mechanism the speed of the machine can control as per our requirement.

#3. Knee:

The knee shape is quite similar to that of the human body knee. This is an important part of this machine that supports the other parts like the saddle and table.

It is attached to the column and has guideways by which it can move up and down with the help of the elevating screw for adjusting its height.

#4. Saddle:

The saddle is present on the top of the knee which further carries the table. Its basic function is to support the table.

A saddle can slide on the guideways which are exactly at 90 degrees to the column face. Saddle moves cross wise(in or out) on guideways provided on the knee.

#5. Table:

The table is present on the top of the saddle. The table consists of T-slots or sometimes fixtures are used for holding up the workpiece on the table. A table can travel longitudinally in a horizontal plane.

#6. Over-arm:

It is also called the over-hanging arm. Overarm is present at the top of the column. The basic function of the over-arm is to support the arbor and spindle.

#7. Spindle or Arbor:

The top portion of the column contains the spindle. The spindle is also an important part of the machine as it is the part where the multipoint cutter is attached.

Power required for the rotation of the spindle is obtained from the motor through the belt, gear, and clutch assembly.

Operations done on a milling machine

1. Face Milling

This operation makes flat surfaces at the face of workpiece. This machining operation is done on the surfaces which are perpendicular to the axis of the cutter. The operation is performed by the face milling cutter mounted on stub arbor of the machine.

2. Side Milling

It is the machining process which produces flat vertical surface at the sides of a workpiece. This operation is performed by using side milling cutter.

3. Plain Milling

It is a Process of milling flat surfaces keeping the axis of the cutter parallel to the surface being milled. It is also called surface milling or slab milling. A plain milling cutter is used for the plain milling.

4. Gear Milling

It is the milling process which is used to cut gears on the workpiece. This operation is done by using formed milling cutters called involute gear cutters.

5. Helical Milling

This milling operation is done to produce objects having helical design such as helical gears, twisted drills etc. it is done on the periphery of the cylindrical workpiece.

6. Cam Milling

It is a machining process which is used to make cams. The cams are used to open and close of the valves in the internal combustion engines.

7. Milling Key Ways, Grooves and Slots

This milling operation is used to produce key ways, grooves and slots on the workpiece.

8. Straddle Milling

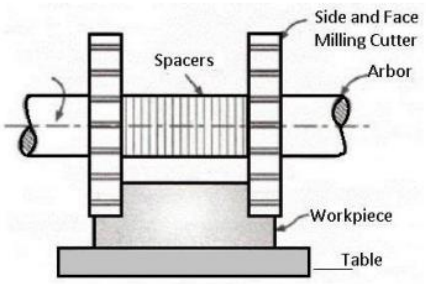
Straddle milling is an operation of a milling machine in which flat vertical surfaces are made on both sides of the workpiece using two side milling cutters tied on the same arbor.

9. Angular Milling

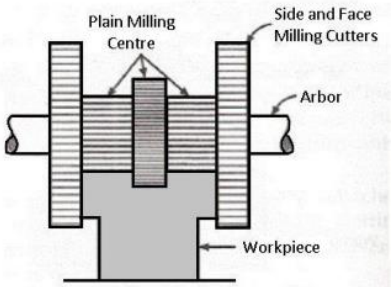
Angular milling is an operation of a milling machine in which the angular surface is formed on the workpiece at an angle other than the right angle along the axis of the spindle of the milling machine.

10. Gang milling

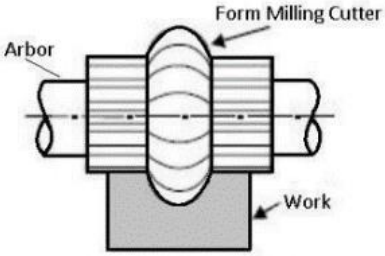
A gang milling is a type of milling operation in which several surfaces are machined on the workpiece, using one diameter or different diameter cutters together on the machine arbor.



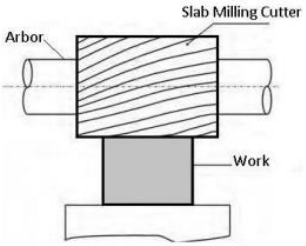
Straddle Milling Operation



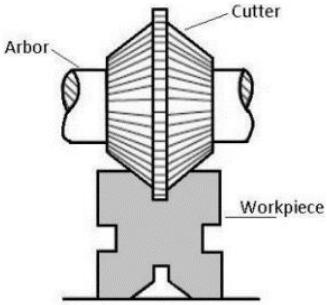
Gang Milling Operation



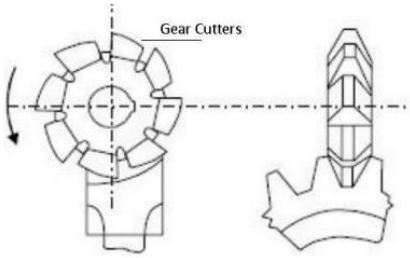
Form Milling Operation



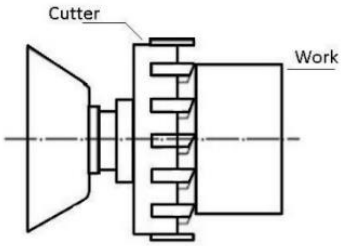
Plain Milling Operation



Angular Milling



Gear Cutting Milling Operation



Face Milling Operation

Working of milling machine

- Milling machine employed in the metal removing operation in which the work is rigidly clamped on the table of the machine and the revolving cutter which has multiple teeth is mounted on the arbor.
- The cutter revolves at high speed and the work is fed slowly past the cutter.
- The work can be fed in a vertical, longitudinal, or cross direction depending upon the type of milling machine being used.
- As the work proceeds, the cutter-teeth removes the metal from the surface of the job(workpiece) to produce the desired shape.

Advantages	Disadvantages
In Milling, the rate of metal removal is very high as the cutter rotates at a high speed and has multiple cutting edges. Better surface finish: Increased Productivity: High Accuracy Milling can be used for machining flat surfaces, irregular surfaces, contoured surfaces, slotting, gear cutting, and many more.	High Flank wear High crater wear Breaking of carbide High Chatter Chip clogging:

CNC machine

- Computer Numerical Control – A computer and CAM software are used to automate, control, and observe the motions of a machine using digital data.
- The machine might be a robot, router, lathe, grinder, welder, sheet metal stamping machine, laser or waterjet cutter, or any number of other devices.
- In order to move and control the machine axes and carry out the preprogrammed movements, the CNC controller collaborates with a number of motors and drive components.
- The advanced feedback system that continuously analyzes and modifies the cutter's speed and position is often present on industrial equipment.

Parts of CNC Machine *(diagram is required):*

1. Input Device

These are the device that is used to input part programs in a CNC machine. There are three commonly used input devices, & these are punch tape readers, magnetic tape readers, and computers .

2. Machine Control Unit (MCU)

The machine control unit is called the heart of the CNC machine. It performs all the control functions of the CNC machine, there are various tasks performed by MCU that are

- It reads the coded instructions given in it.
- Machine control unit decodes the coded instruction.
- This axis implements interpolation (linear, circular and helical) to generate motion commands.
- Machine control unit feeds the axis motion command to the amplifier circuit to drive the axis mechanism.
- It takes a feedback signal of position and speed for each drive axis.
- It implements the auxiliary control functions such as coolant or spindle on/off and tool change.

3. Machine Tools

A CNC machine tool always has a slidings table & a spindle to control position and speed. The machine tables are controlled in the X and Y-axis direction, & the spindle is controlled in the Z-axis direction.

4. Driving System

The driving system of the CNC machine consists of an amplifier circuit, drive motors, and ball lead screws. The MCU feeds the signals (i.e., position and speed) of each axis into the amplifier circuit.

The control signals are then amplified (amplified) to activate the drive motors. And actuated drive motors rotate the ball lead screw to position the machine table.

5. Feedback System

The system consists of transducers that act as sensors. It is also called a measurement system. It consists of position and motion transducers that continuously monitor the position and speed of the cutting tool located at any given moment.

The MCU receives signals from these transducers, and it uses the difference between reference signals and response signals to generate control signals to correct position and motion errors.

1. ***Display Unit***

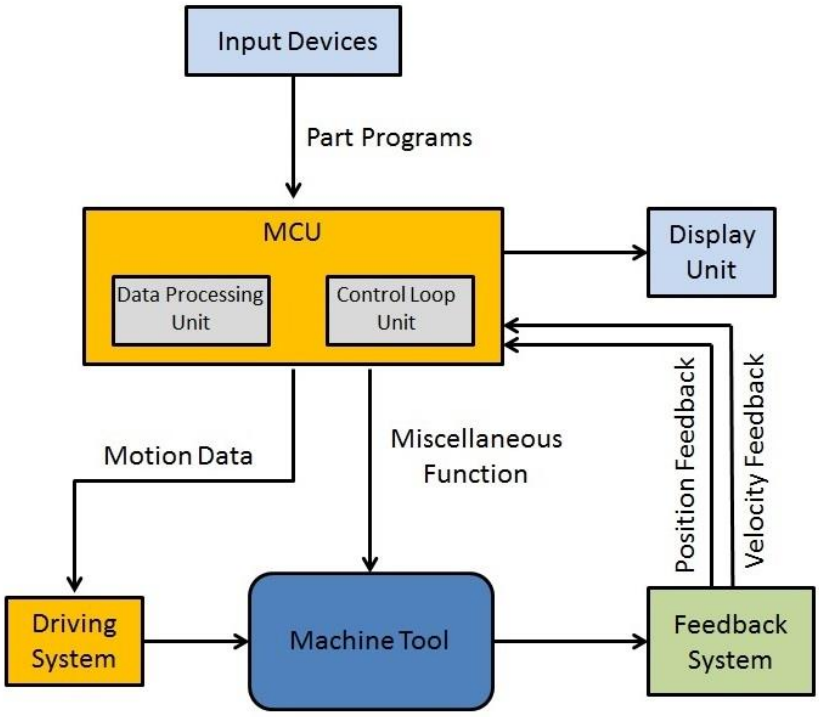
A monitor is used to display programs, commands, and other useful data of the CNC machine.

2. ***Bed***

On CNC machines, these parts bear all the weight of the machine; this means that all other components are mounted on it. The bed component is made of hardened materials such as cast iron because the tool turret passes over them in CNC lathe machines.

3. ***Control Panel***

Control panels are also one of the important parts of CNC machines that are used to set or feed programs for the operation to be performed on the workpieces. It is also called the brains of the CNC machine.



Advantages	Disadvantages
• Highest accuracy and precision than any other manual machine. • It can be run for 24 hours. • Same products will have same accuracy all the time. • Id can be operated by a semi skilled worker • Reduce delay time. • Complex shapes can be made in short period of time. • Eliminates the need to create prototypes or models and saves time and money. • Fewer workers are required to operate CNC and save labour costs.	• The cost of these machines is very high as compared to manually operated machines. • CNC machine parts are expensive. • Maintenance costs are higher for CNC machines. • The machine requires expensive equipment to operate. • Require skilled labourers

Working of CNC

- First, the part program is entered into the MCU of the CNC.
- The MCU processes all the data and according to the program prepared, it prepares all the motion commands and gives them to the driving system.
- The drive system acts as motion commands sent by the MCU. The drive system manages the motion and velocity of the machine tool.
- The feedback system records the position and velocity measurements of the machine tool and gives a feedback signal to the MCU.
- In the MCU, the feedback signals are compared with reference signals and if errors occur, it corrects it and sends new signals to the machine tool to be corrected.
- The display unit is used to see all the programs, commands, and other data. It works like the eye of the machine.

Principle of CAD/CAM

CAD/CAM refers to the integration of Computer-aided design (CAD) and Computer-aided manufacturing (CAM). Both of these require powerful computers. *CAD* software helps designers and draftsmen; *CAM* "reduces manpower costs" in the manufacturing process.

Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant

parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions.

Computer-aided manufacturing (CAM) uses geometrical design data to control automated machinery. CAM systems are associated with computer numerical control (CNC) or direct numerical control (DNC) systems. These systems differ from older forms of numerical control (NC) in that geometrical data are encoded mechanically. Since both CAD and CAM use computer-based methods for encoding geometrical data, it is possible for the processes of design and manufacture to be highly integrated. Computer-aided design and manufacturing systems are commonly referred to as CAD/CAM.

Additive Manufacturing (AM)

- Additive manufacturing (AM) or additive layer manufacturing (ALM) is the industrial production name for 3D printing, a computer controlled process that creates three dimensional objects by depositing materials, usually in layers.
- 3D printable models may be created with a computer-aided design (CAD) package, via a 3D scanner, or by a plain digital camera and photogrammetry software.
- 3D printed models created with CAD result in relatively fewer errors than other methods.
- Errors in 3D printable models can be identified and corrected before printing.
- The manual modelling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting.
- 3D scanning is a process of collecting digital data on the shape and appearance of a real object, creating a digital model based on it.
- CAD models can be saved in the *stereolithography file format (STL),* a CAD file format for additive manufacturing that stores data.

Rapid manufacturing/ Rapid Prototyping

Rapid Prototyping

Rapid prototyping is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. The process of prototyping involves quick building up of a prototype or working model for the purpose of testing the various design features, ideas, concepts, functionality, output and performance.

- Rapid prototyping opens new opportunities for innovation
- Time Savings
- Easier Visualization
- Detect design flaws before the manufacture of tooling
- Rapid prototyping allows designers to realize their concepts beyond virtual visualization
- Rapidly create tooling to manufacture physical prototypes

Methodology of Rapid Prototyping

The basic methodology for all current rapid prototyping techniques can be summarized as follows:

- 1.A CAD model is constructed, then converted to STL format. The resolution can be set to minimize stair stepping.
- 2.The RP machine processes the .STL file by creating sliced layers of the model.
- 3.The first layer of the physical model is created. The model is then lowered by the thickness of the next layer, and the process is repeated until completion of the model.
- 4.The model and any supports are removed. The surface of the model is then finished and cleaned.