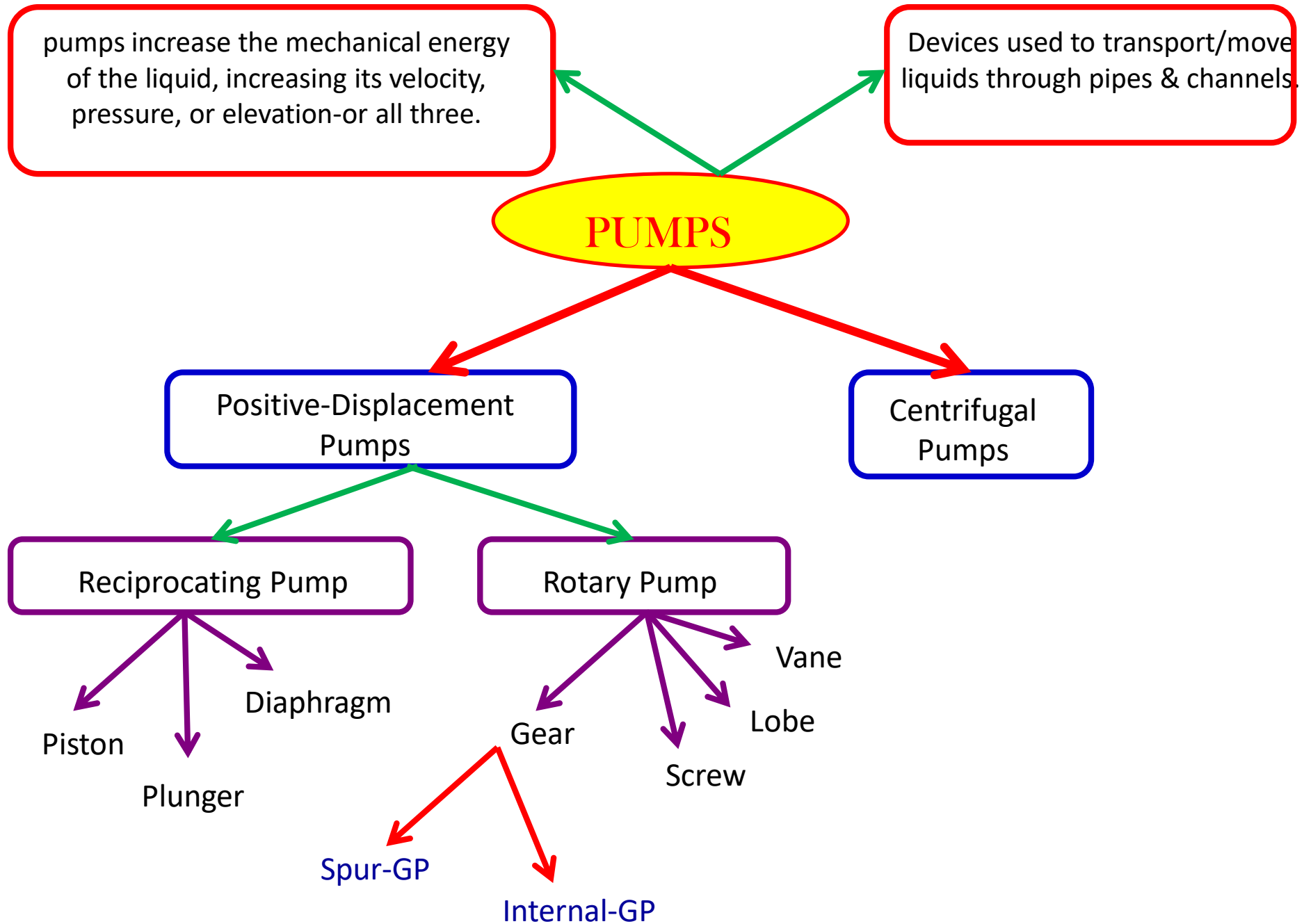


Process equipment

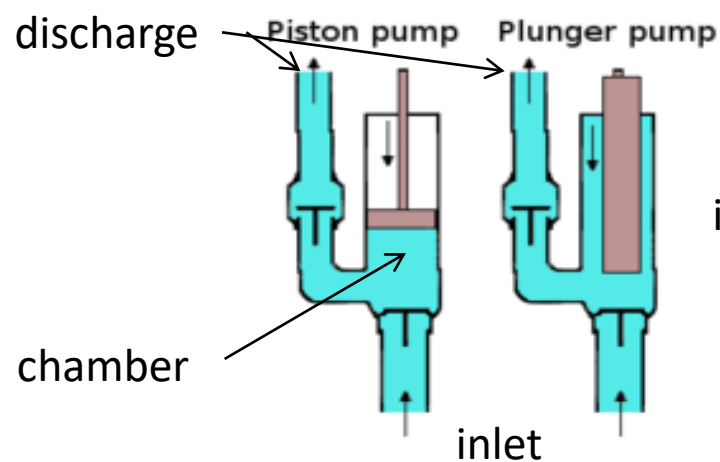
Process equipment

- Classify Pumps & Compressors
- Pumps
- Compressor
- Belt & belt conveyers

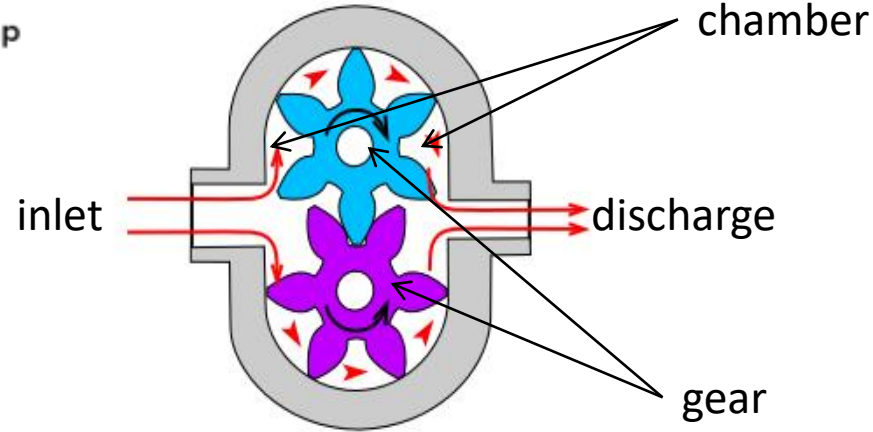


Positive-Displacement Pumps

- 2 subclasses: **reciprocating pumps** & **rotary pumps**.
- **Reciprocating pumps**: the chamber is stationary cylinder that contains a piston or plunger.
- **Rotary pumps**: the chambers moves from inlet to discharge and back to the inlet.



Reciprocating pumps

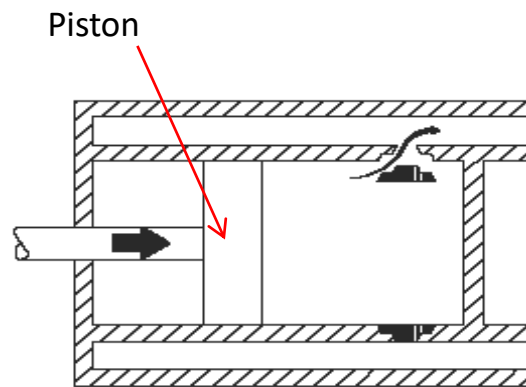
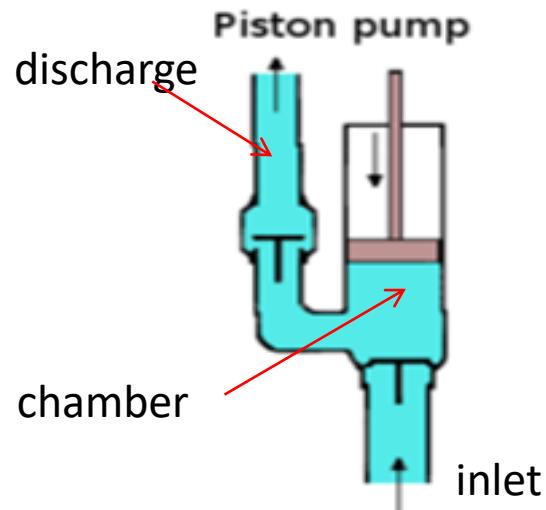


Rotary pump

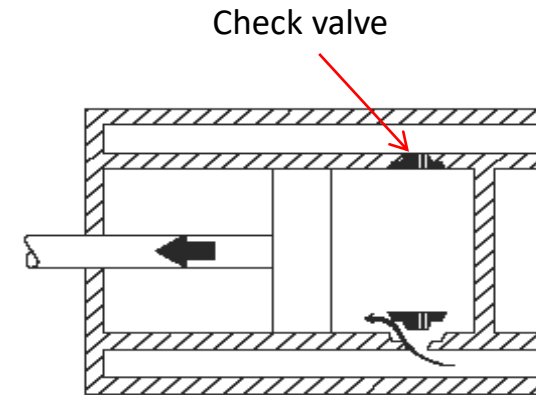
Positive-Displacement Pumps:

Reciprocating Pumps

- Piston pump:
 - liquid is drawn through an inlet check valve into the cylinder by the withdrawal of a piston.
 - then the liquid is forced out through a discharge on the return stroke.



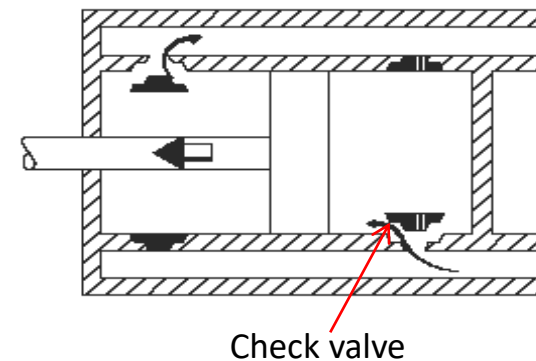
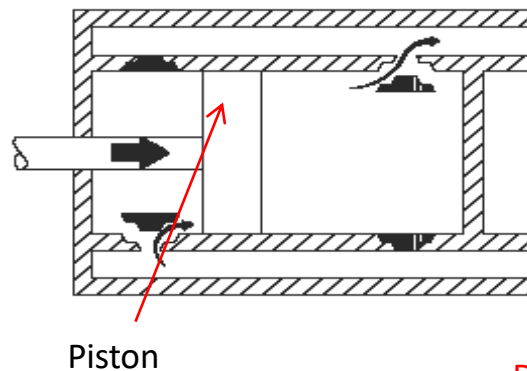
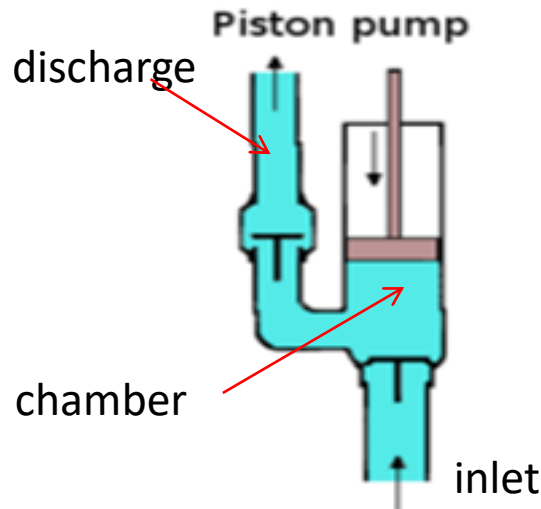
Single-acting



Positive-Displacement Pumps:

Reciprocating Pumps

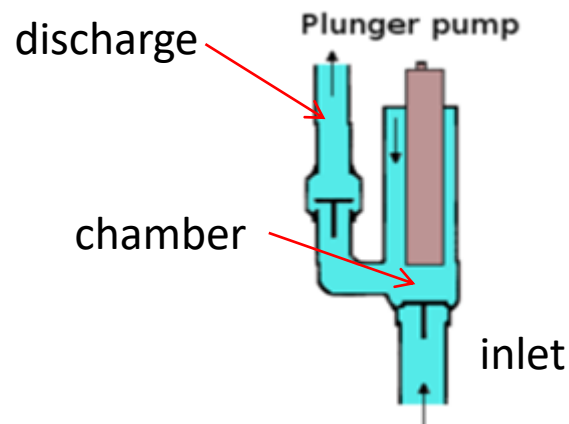
- most piston pumps are **double-acting** with liquid admitted alternately on each side of the piston so that one part of the cylinder is being filled while the other is being emptied.
- the piston may be motor-driven through reducing gear or a steam cylinder may be used to drive the piston rod directly.
- max. discharge pressure for commercial piston pumps is about 50 atm.



Positive-Displacement Pumps:

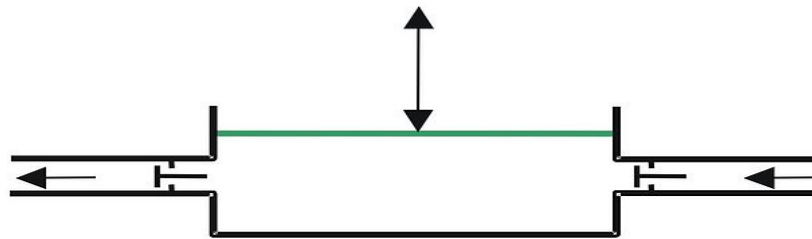
Reciprocating Pumps

- Plunger pump:
 - are used for higher pressures.
 - instead of using pistons and piston rings, they make use of finely machined plungers of very small clearances in order to seal the liquid to be pumped.
 - the plungers are highly polished and made relatively long so that only very little liquid can escape through the clearances.
 - at the limit of its stroke, the plunger fills nearly all the space in the cylinder.
 - are **single-acting** and usually are motor driven.
 - they can discharge against a pressure of 1500 atm or more.



Positive-Displacement Pumps: Reciprocating Pumps

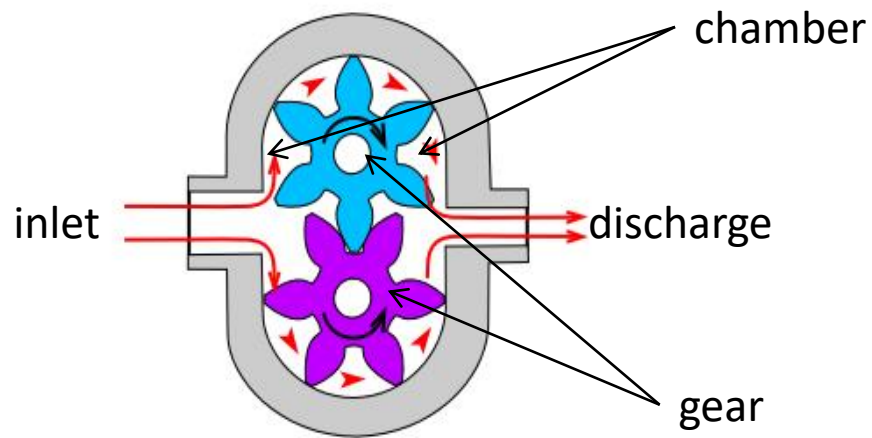
- Diaphragm pump:
 - the reciprocating member is a flexible diaphragm of metal, plastic & rubber.
 - diaphragm pumps handle small to moderate amounts of liquid, up to about 100 gal/min, can develop pressures in excess of 100 atm.



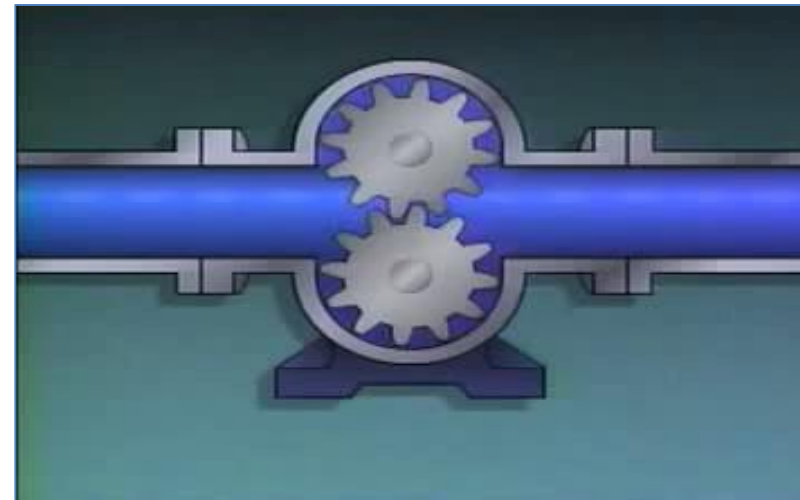
Positive-Displacement Pumps:

Rotary Pumps

- Unlike reciprocating pumps, rotary pumps **contain no check valves**.
- Minimize leakage from the discharge space back to the suction space; they also limit the operating speed.
- Rotary pumps operate best on clean, **moderately viscous fluids** such as light lubricating oil.
- Discharge pressures up to 200 atm or more can be attained.



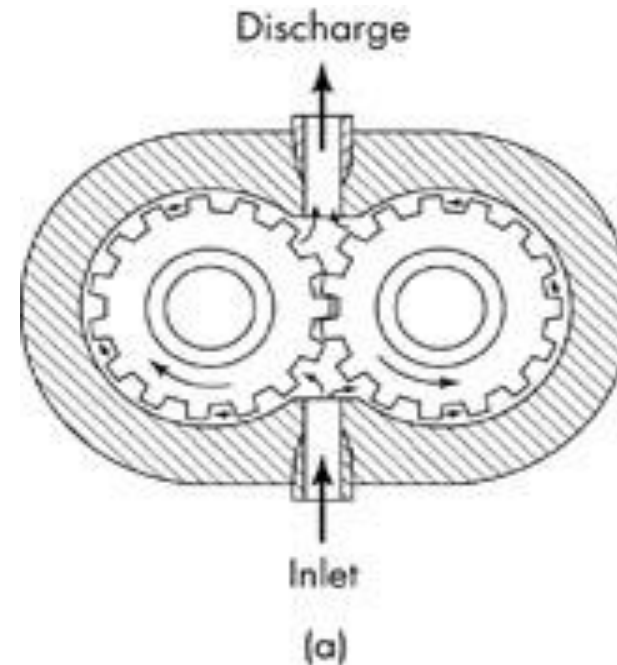
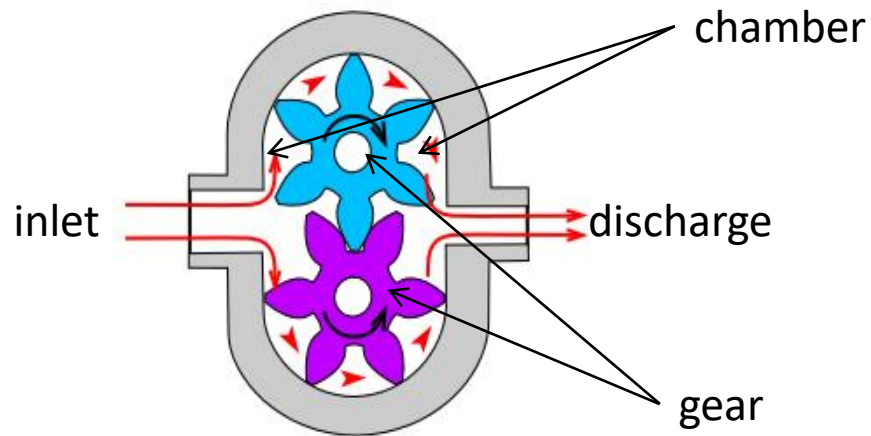
Rotary pump



Positive-Displacement Pumps:

Rotary Pumps

- Spur-gear pump OR External Gear Pump
- **Intermeshing gears** rotate with close clearance inside the casing.
- Liquid entering the suction line at the bottom of the casing is caught in the spaces between the teeth & the casing & is carried around to the top of the casing & forced out the discharge.
- liquid cannot short-circuit back to the suction because of the close meshing of the gears in the center of the pump.



Spur-gear pump

Positive-Displacement Pumps:

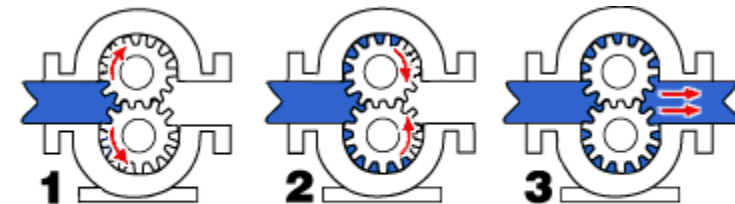
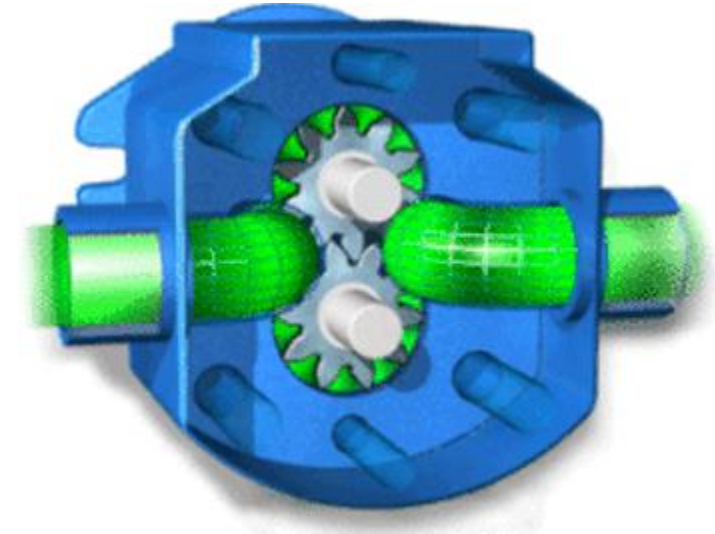
Rotary Pumps

How External Gear Pumps Work

- External gear pumps are similar in pumping action to internal gear pumps in that two gears come into and out of mesh to produce flow. However, the external gear pump uses two identical gears rotating against each other -- one gear is driven by a motor and it in turn drives the other gear. Each gear is supported by a shaft with bearings on both sides of the gear.
- Because the gears are supported on both sides, external gear pumps are quiet-running and are routinely used for high-pressure applications such as hydraulic applications.

With no overhung bearing loads, the rotor shaft can't deflect and cause premature wear.

1. As the gears come out of mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the gear teeth as they rotate.
2. Liquid travels around the interior of the casing in the pockets between the teeth and the casing -- it does not pass between the gears.
3. Finally, the meshing of the gears forces liquid through the outlet port under pressure.



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Positive-Displacement Pumps:

Rotary Pumps: External gear

- **Advantages**

- High speed
- High pressure
- No overhung bearing loads
- Relatively quiet operation
- Design accommodates wide variety of materials

- **Disadvantages**

- Four bushings in liquid area
- No solids allowed
- Fixed End Clearances

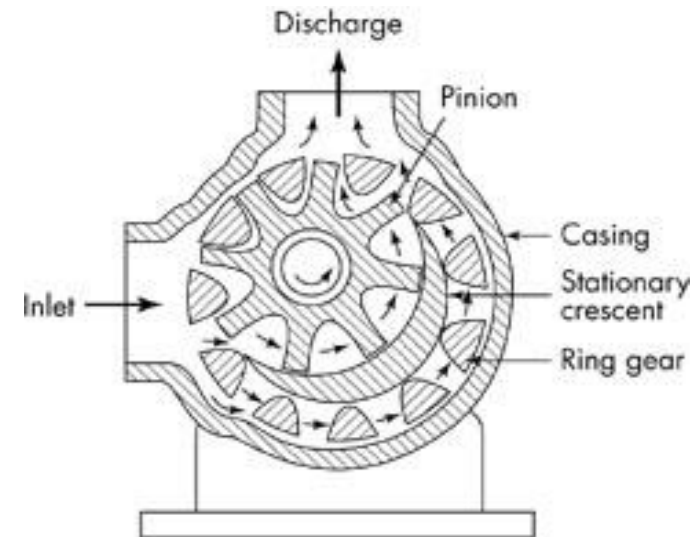
- **Applications**

- Common external gear pump applications include, but are not limited to:
 - Various fuel oils and lube oils
 - Chemical additive and polymer metering
 - Chemical mixing and blending (double pump)
 - Industrial and mobile hydraulic applications (log splitters, lifts, etc.)
 - Acids and caustic (stainless steel or composite construction)
 - Low volume transfer or application

Positive-Displacement Pumps:

Rotary Pumps

- Internal-gear pump
 - A **spur gear or pinion** meshes with a ring gear with internal teeth.
 - Both gears are inside the casing.
 - The **ring gear** is coaxial with the inside of the casing, but the pinion, which is externally driven, is mounted eccentrically with respect to the center of the casing.
 - A **stationary metal crescent** fills the space **between the two gears**.
 - Liquid is carried from inlet to discharge by both gears, in the spaces between the gear teeth and the crescent.



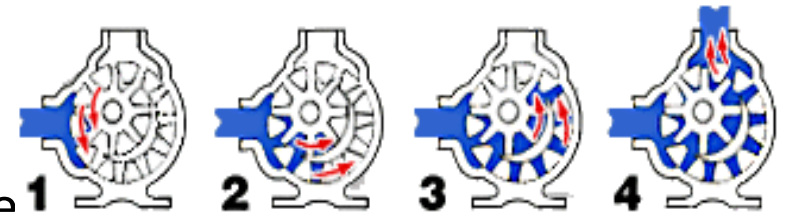
Internal-gear pump

Positive-Displacement Pumps:

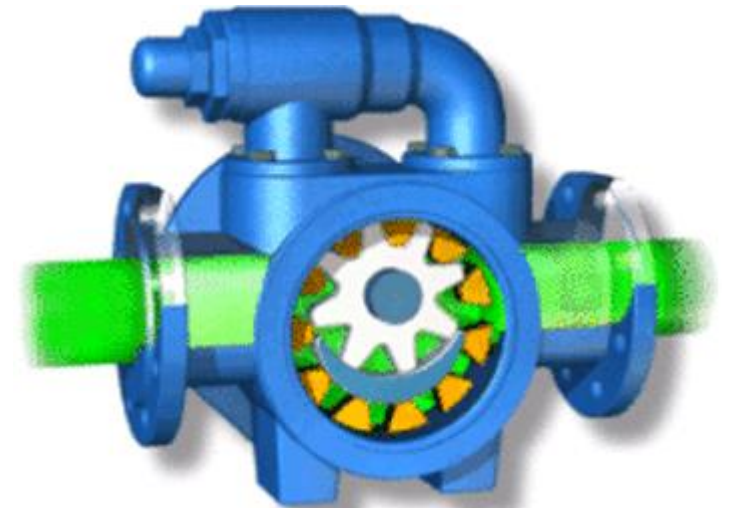
Rotary Pumps

How Internal Gear Pumps Work

1. Liquid enters the suction port between the rotor (large exterior gear) and idler (small interior gear) teeth. The arrows indicate the direction of the pump and liquid.
2. Liquid travels through the pump between the teeth of the "gear-within-a-gear" principle. The crescent shape divides the liquid and acts as a seal between the suction and discharge ports.
3. The pump head is now nearly flooded, just prior to forcing the liquid out of the discharge port. Intermeshing gears of the idler and rotor form locked pockets for the liquid which assures volume control.
4. Rotor and idler teeth mesh completely to form a seal equidistant from the discharge and suction ports. This seal forces the liquid out of the discharge port.



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Positive-Displacement Pumps:

Rotary Pumps: Internal-gear pump

Advantages

- Only two moving parts
- Only one stuffing box
- Non-pulsating discharge
- Excellent for high-viscosity liquids
- Constant and even discharge regardless of pressure conditions
- Operates well in either direction
- Can be made to operate with one direction of flow with either rotation
- Low NPSH required
- Single adjustable end clearance
- Easy to maintain
- Flexible design offers application customization

Disadvantages

- Usually requires moderate speeds
- Medium pressure limitations
- One bearing runs in the product pumped
- Overhung load on shaft bearing

Positive-Displacement Pumps:

Rotary Pumps: Internal-gear pump

Applications

- Common internal gear pump applications include, but are not limited to:
 - All varieties of fuel oil and lube oil
 - Resins and Polymers
 - Alcohols and solvents
 - Asphalt, Bitumen, and Tar
 - Polyurethane foam (Isocyanate and polyol)
 - Food products such as corn syrup, chocolate, and peanut butter
 - Paint, inks, and pigments
 - Soaps and surfactants
 - Glycol

Positive-Displacement Pumps:

Rotary Pumps

How Lobe Pumps Work

- Lobe pumps are similar to external gear pumps in operation in that fluid flows around the interior of the casing. Unlike external gear pumps, however, the lobes do not make contact.
- Lobe contact is prevented by external timing gears located in the gearbox. Pump shaft support bearings are located in the gearbox, and since the bearings are out of the pumped liquid, pressure is limited by bearing location and shaft deflection.

1. As the lobes come out of mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the lobes as they rotate.
2. Liquid travels around the interior of the casing in the pockets between the lobes and the casing -- it does not pass between the lobes.
3. Finally, the meshing of the lobes forces liquid through the outlet port under pressure.



Positive-Displacement Pumps:

Rotary Pumps: Lobe pumps

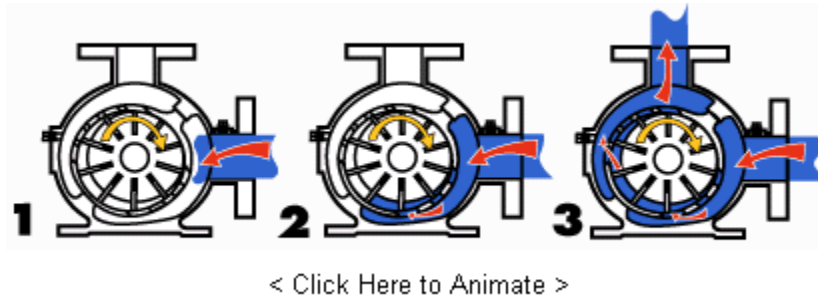
- Advantages
 - Pass medium solids
 - No metal-to-metal contact
 - Superior CIP/SIP capabilities
 - Long term dry run (with lubrication to seals)
 - Non-pulsating discharge
- Disadvantages
 - Requires timing gears
 - Requires two seals
 - Reduced lift with thin liquids
- Applications
 - Common rotary lobe pump applications include, but are not limited to:
 - Polymers
 - Paper coatings
 - Soaps and surfactants
 - Paints and dyes
 - Rubber and adhesives
 - Pharmaceuticals
 - Food applications

Positive-Displacement Pumps:

Rotary Pumps

How Vane Pumps Work

- Despite the different configurations, most vane pumps operate under the same general principle described below.



1. A slotted rotor is eccentrically supported in a cycloidal cam. The rotor is located close to the wall of the cam so a crescent-shaped cavity is formed. The rotor is sealed into the cam by two sideplates. Vanes or blades fit within the slots of the impeller. As the rotor rotates (yellow arrow) and fluid enters the pump, centrifugal force, hydraulic pressure, and/or pushrods push the vanes to the walls of the housing. The tight seal among the vanes, rotor, cam, and sideplate is the key to the good suction characteristics common to the vane pumping principle.
2. The housing and cam force fluid into the pumping chamber through holes in the cam (small red arrow on the bottom of the pump). Fluid enters the pockets created by the vanes, rotor, cam, and sideplate.
3. As the rotor continues around, the vanes sweep the fluid to the opposite side of the crescent where it is squeezed through discharge holes of the cam as the vane approaches the point of the crescent (small red arrow on the side of the pump). Fluid then exits the discharge port.

Positive-Displacement Pumps:

Rotary Pumps: Vane gear

- **Advantages**

- Handles thin liquids at relatively higher pressures
- Compensates for wear through vane extension
- Sometimes preferred for solvents, LPG
- Can run dry for short periods
- Can have one seal or stuffing box
- Develops good vacuum

- **Disadvantages**

- Can have two stuffing boxes
- Complex housing and many parts
- Not suitable for high pressures
- Not suitable for high viscosity
- Not good with abrasives

- **Applications**

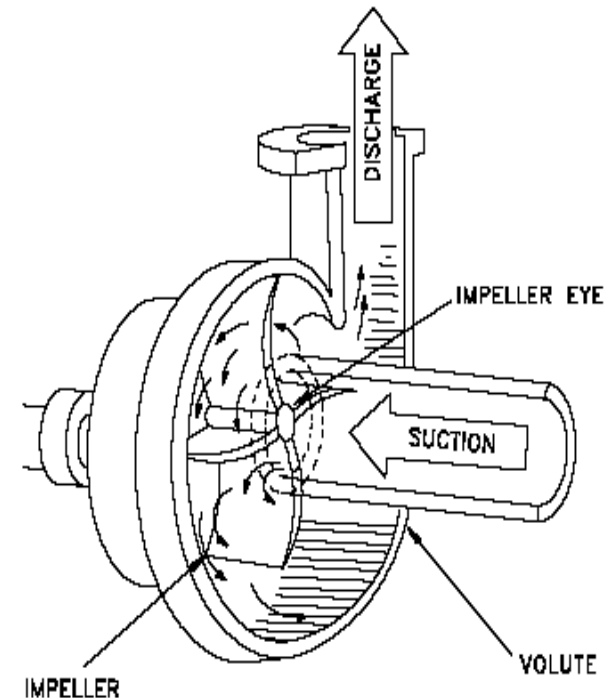
- Common Vane pump applications include, but are not limited to:
 - Aerosol and Propellants
 - Aviation Service - Fuel Transfer, Deicing
 - Auto Industry - Fuels, Lubes, Refrigeration Coolants
 - Bulk Transfer of LPG and NH₃
 - LPG Cylinder Filling
 - Alcohols
 - Refrigeration - Freons, Ammonia
 - Solvents
 - Aqueous solutions

Difference between Rotary and Centrifugal Pump

- Rotary pumps operate in a circular motion and displace a constant amount of liquid with each revolution of the pump shaft. In general, this is accomplished by pumping elements (e.g., gears, lobes, vanes, screws) moving in such a way as to expand volumes to allow liquid to enter the pump. These volumes are then contained by the pump geometry until the pumping elements move in such a way as to reduce the volumes and force liquid out of the pump. Flow from rotary PD pumps is relatively unaffected by differential pressure and is smooth and continuous. Rotary PD pumps have very tight internal clearances which minimize the amount of liquid that slips back from discharge to suction side of the pump. Because of this, they are very efficient. These pumps work well with a wide range of viscosities, particularly high viscosities.
- Centrifugal pumps differ from rotary pumps in that they rely on kinetic energy rather than mechanical means to move liquid. Liquid enters the pump at the center of a rotating impeller and gains energy as it moves to the outer diameter of the impeller. Liquid is forced out of the pump by the energy it obtains from the rotating impeller. Centrifugal pumps can transfer large volumes of liquid but efficiency and flow decrease rapidly as pressure and/or viscosity increases.

Centrifugal pumps

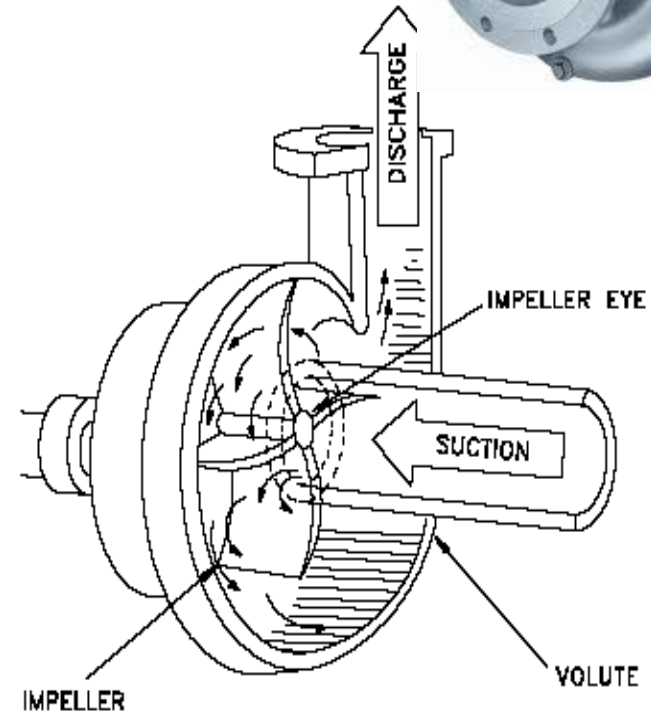
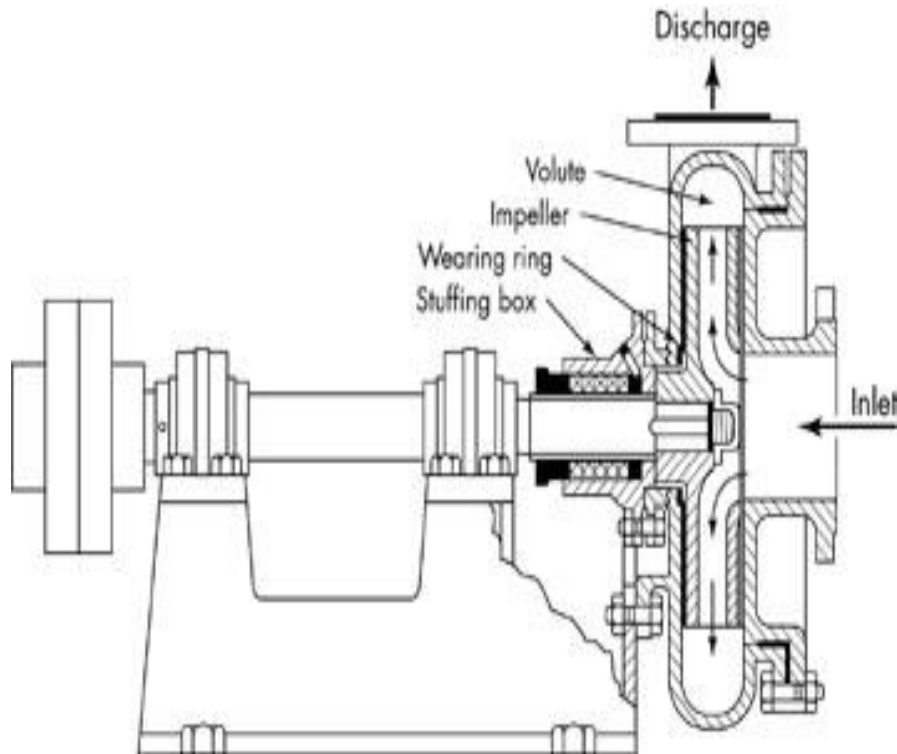
- The second major class of pumps, where mechanical energy of the liquid is increased **by centrifugal action**.
- The liquid enters through a suction connection concentric with the axis of a high-speed rotary element called the **impeller** which carries radial vanes integrally cast in it.
- Liquid flows outward in the spaces between the vanes and leaves the impeller in greater velocity with respect to the ground than at the entrance to the impeller.
 - ▶ In a properly functioning pump, the space between the vanes is completely filled with liquid flowing without cavitation.
 - ▶ The liquid leaving the outer periphery of the impeller is collected in a **spiral casing** called the **volute** and leaves the pump through a tangential discharge connection.
 - ▶ In the volute, the velocity head of the liquid from the impeller is converted to pressure head.



Centrifugal pumps

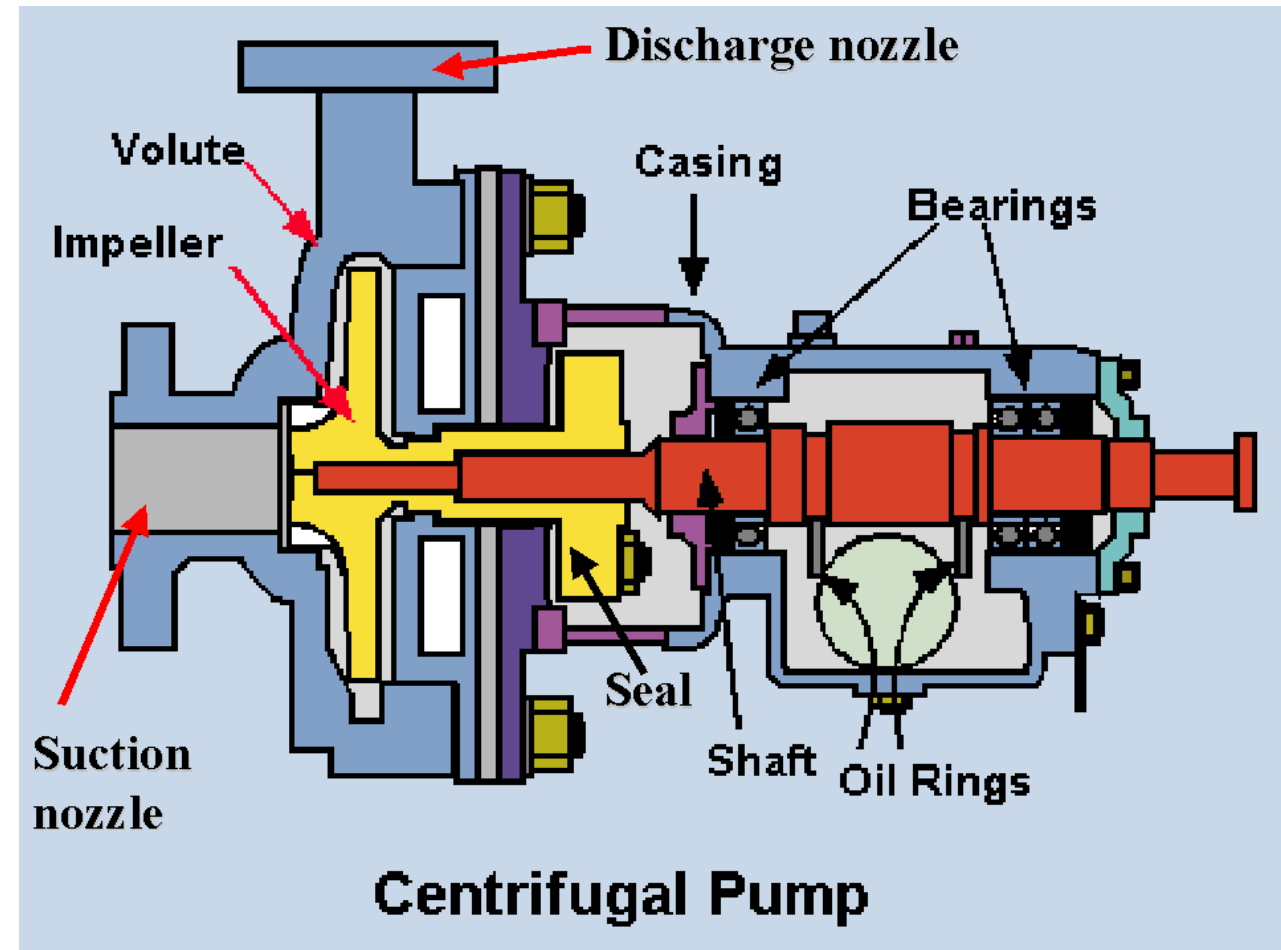
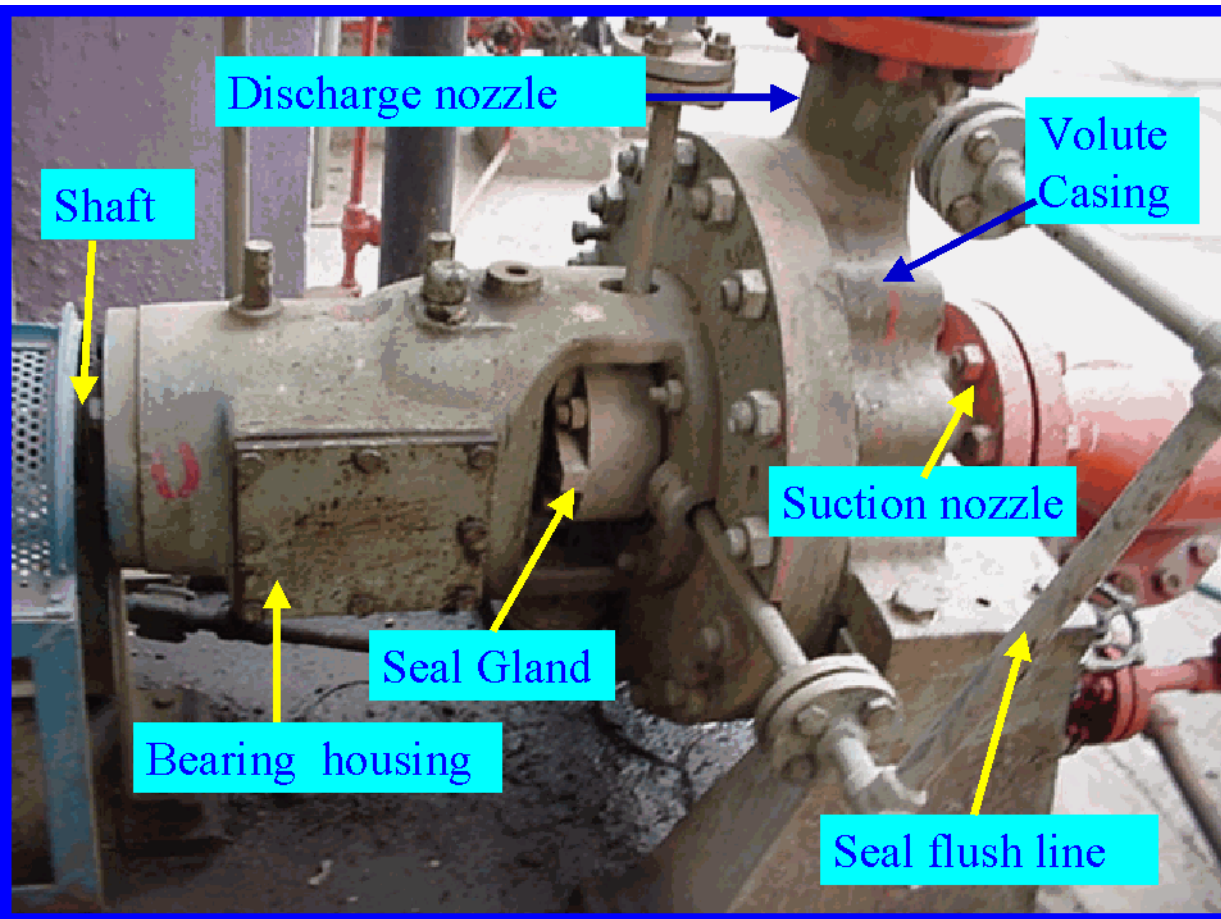
- The power is applied to the fluid by the impeller and is transmitted to the impeller by the torque of the driveshaft, which usually is driven by direct-connected motor at constant speed, commonly at 1750 or 3450 r/min.
- Centrifugal pumps constitute the most common type of pumping machinery in ordinary plant practice.
- A common type uses a double-suction impeller, which accepts liquid from both sides.

Centrifugal pumps



Single-suction centrifugal pump

Centrifugal pumps



What's the difference between a pump and a compressor?

- Sometimes the words "pump" and "compressor" are used interchangeably, but there is a difference:
- **A pump is a machine that moves a fluid (either liquid or gas) from one place to another.**
- **A compressor is a machine that squeezes a gas into a smaller volume and (often) pumps it somewhere else at the same time.**
- While pumps can work on either liquids or gases, compressors generally work only on gases. That's because liquids are very difficult to compress.
- The atoms and molecules from which liquids are made are so tightly packed that you can't really squeeze them any closer together (an important piece of science that's put to very good use in hydraulic machines).
- Pressure washers, which make a powerful jet of water for cleaning things, are an exception: they work by squeezing liquids to higher pressures and speeds. Coffee machines also squeeze water to high pressure to make stronger and tastier drinks.

COMPRESSORS

Introduction to compressors

- An air compressor is a mechanical device that increases the pressure of air by reducing volume.
- Air is compressible, the compressor reduces the volume of air and induces pressure in the air
- An air compressor converts electrical energy into kinetic energy in the form of the air
- The compressed air is stored in the air receiver and can be used for cleaning under pressure, generating torque and develop force using actuators
- This source is free of cost, safe, flexible and convenient
- Air compressor has very few parts hence maintenance is very low

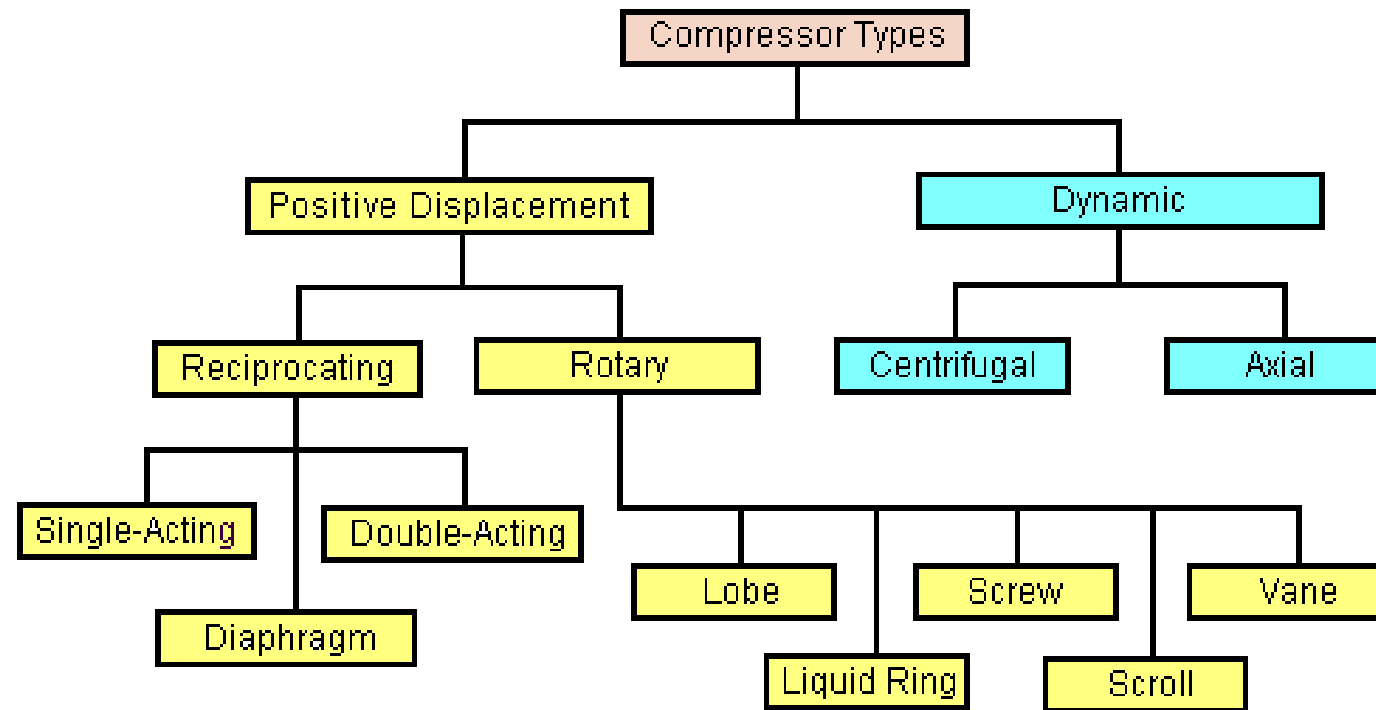
Air compressor

- Pneumatics: A system which uses compressed air is called pneumatics.
- It deals with the study of behavior & application of compressed air
- A basic pneumatic system consist of a source of compressed air, control valves, pipelines & pipe fittings and pneumatic accessories like filter, regulator and lubricator

Application of compressed air

- For operating pneumatic tools such as drills, screw drivers, hammers, chisels
- For pneumatic cranes
- For pneumatic brakes of automobiles, railways and presses
- For agricultural accessories such as dusters and sprayers
- For drive of CNC machine tools
- For pneumatic conveying of materials
- For pneumatic gauging, inspection and low cost automation systems

Classification of air compressor



Classification of air compressor

- Air compressors are classified according to method of energy transfer and pressure generation i.e. positive displacement and dynamic compressors
- Positive displacement compressors work on the principle of increasing the pressure of air by reducing the volume of air in an enclosed chamber
- Dynamic compressors works on the principle of imparting the energy by rotating vanes of impeller on air flowing through casing that increases pressure in air

Compressors

Positive-displacement compressors

- Rotary positive-displacement compressors can be used for discharge pressures up to about 6 atm.
- These devices include **sliding-vane, screw-type, and liquid piston compressors.**
- For high to very high discharge pressures & modest flow rates, reciprocating compressor are the most common type.
- These machines operate mechanically in the same way as reciprocating pumps, with the differences that leak prevention is more difficult and temperature rise is important.
- The cylinder walls & cylinder heads are cored for cooling jackets using water refrigerant .
- Reciprocating compressors are usually motor-driven & nearly always double acting.

Compressors

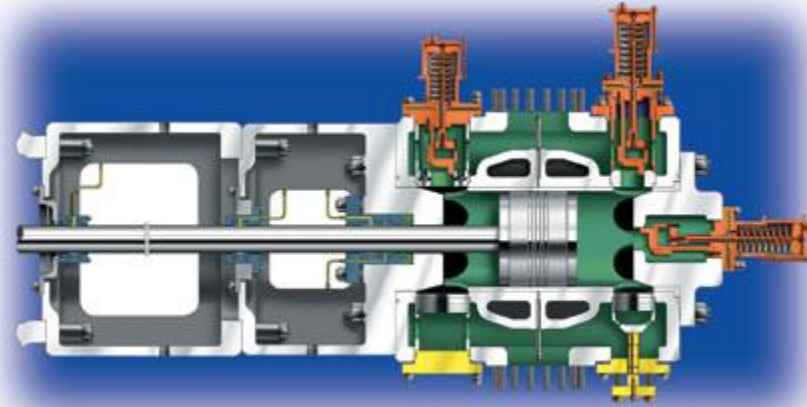
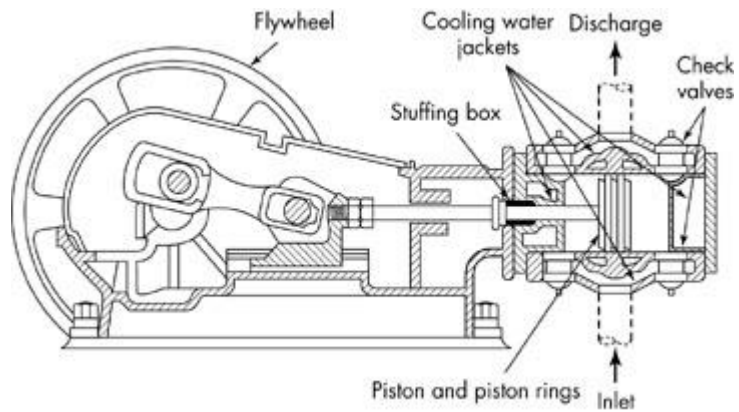


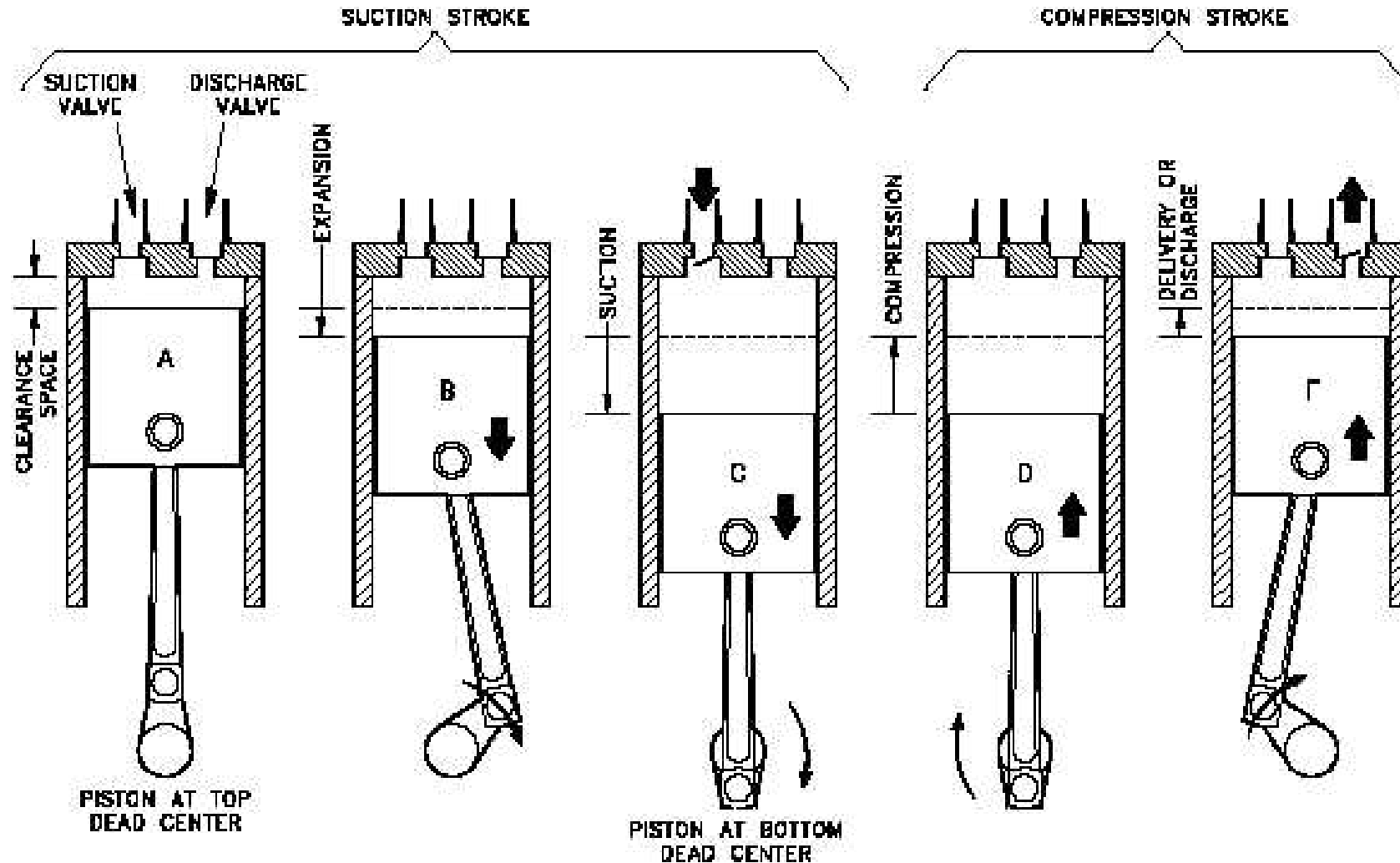
Figure 1. Reciprocating Compressor Cylinder Assembly

Reciprocating compressor

Reciprocating Air compressors

- Reciprocating air compressors are positive displacement type of air compressors.
- These are piston & diaphragm type, vane type, gear type, screw type compressors.
- The principle of operation is same but according to stages the delivery pressure is different in each compressor.
- A reciprocating air compressor consist of a piston which is enclosed within a cylinder and equipped with suction and discharge valve
- The piston receives power from electric motor or IC engine.
- The compression of air is done by first drawing a volume of air into the cylinder through suction valve during suction stroke of piston and then compressed and discharged through delivery valve during delivery stroke

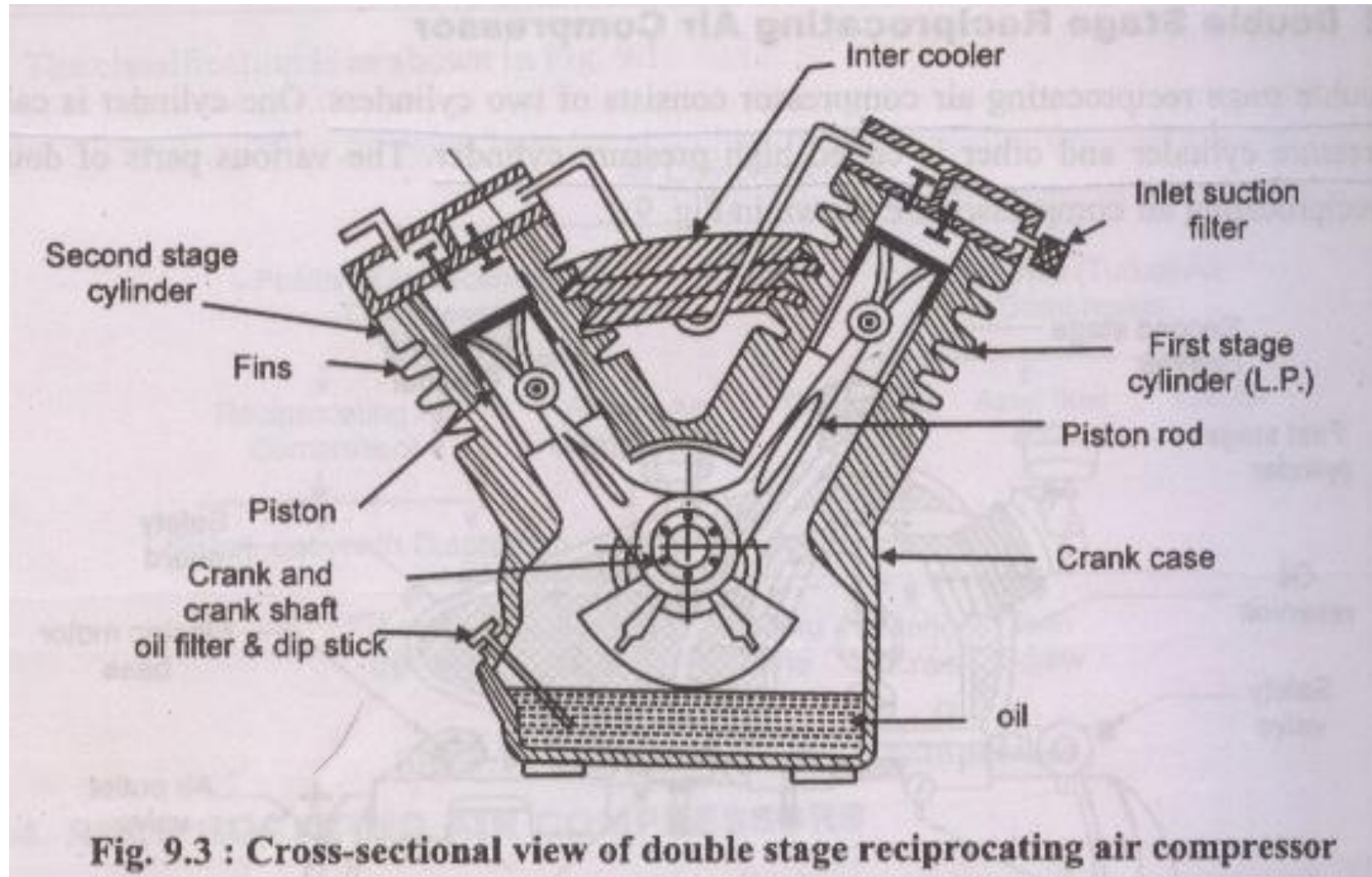
Single stage reciprocating air compressor



Single stage Reciprocating Air compressors

- In this type the entire compression is carried out in a single cylinder
- When piston starts moving downwards, the pressure inside the cylinder falls below atmospheric pressure that opens suction valve.
- The pressure of the air in the cylinder rises during compression and at the end of compression, delivery valve opens and discharges the compressed air into the receiver tank.
- Single stage air compressor develop pressure upto 7 bar.
- For higher pressures multistage compressors are suitable

Double stage reciprocating air compressor



Double stage Reciprocating Air compressors

- It consist of two cylinders – low pressure cylinder and high pressure cylinder
- Piston, crankcase, piston rod, crank, crankshaft, oil, fins etc.
- The fresh air is drawn inside the L.P. cylinder through inlet suction filter.
- This air is compressed by piston
- As the piston moves towards the end of cylinder, the air compression took place.
- The delivery valve opens and this compressed air from L.P. cylinder is directed to enter inside the high pressure cylinder.
- In high pressure cylinder this pressurized air is further compressed to higher pressure.

Double stage Reciprocating Air compressors

- The high pressure air from H.P. cylinder is then delivered to receiver through discharge valves.
- In this compressor, a pressure of air delivered is upto 13 bar.

Double stage Reciprocating Air compressors

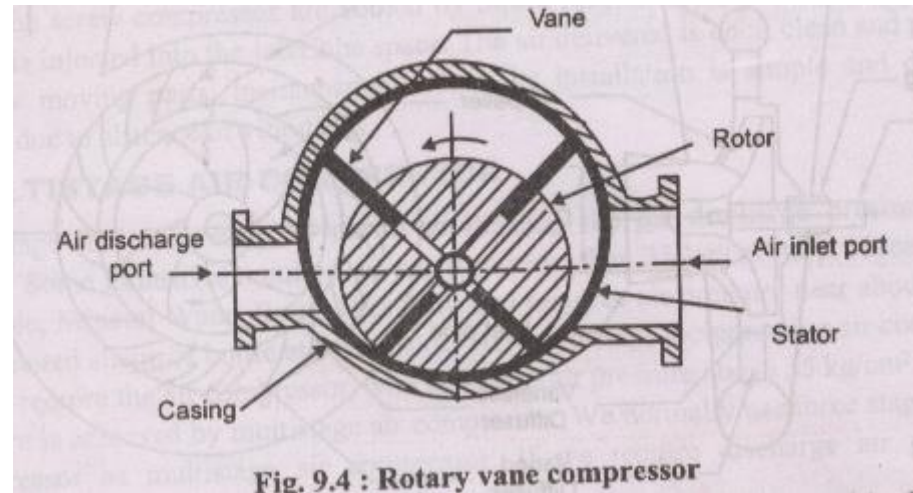
Advantages

- Simple in design
- Lower initial cost
- Easy to install
- Higher efficiency

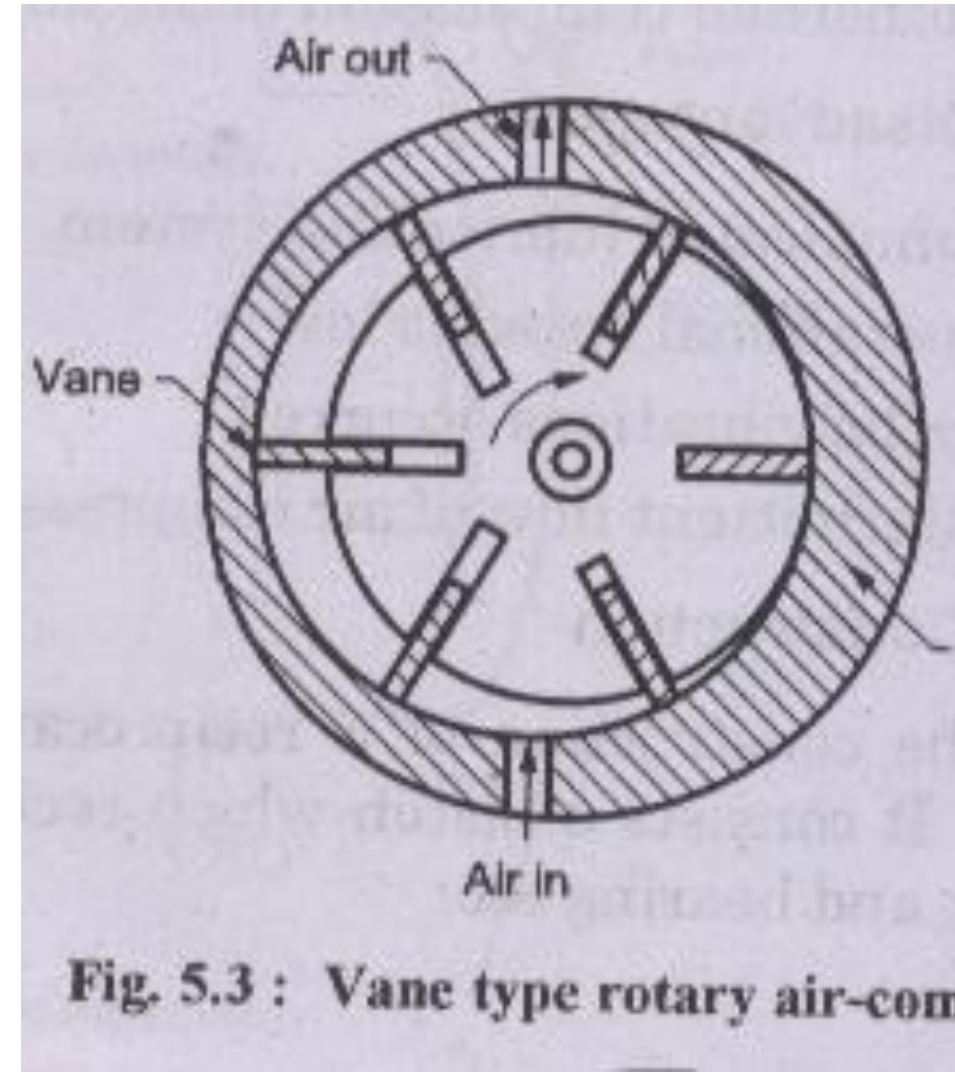
Disadvantages

- Number of moving parts are more
- Higher maintenance cost
- Heavy foundation is required as it has vibration problem
- Cannot run at full capacity

Rotary vane compressor



Rotary vane compressor



Rotary vane compressor

- It is positive displacement type compressor.
- It provides higher efficiency and flow rates over a wide range of pressure
- Rotary vane compressor consist of rotor with a number of vanes inserted in the radial slots cut in rotor.
- The rotor is mounted eccentric in a casing.
- The vanes slides radially in and out of the rotor.
- As the rotor rotates at higher speed, centrifugal force throws the vanes outward keeping the end of vane in contact with the stator ring.

Rotary vane compressor

- As the rotor turns, compression is achieved as the volume goes from a maximum at intake port to minimum at the exhaust port.
- An oil is injected into the air intake and along the stator walls to cool the air and lubricate bearing and vanes and to provide a seal between the vane and stator wall to reduce internal leakage.

Rotary vane compressors

Advantages

- Simple design
- Compact in size
- Light in weight
- Easy to install
- Low cost
- Low maintenance cost
- Longer life
- Few moving parts
- Low rotational speed
- Expensive foundation not required

Disadvantages

- Lower efficiency
- Difficulty with higher pressure above 200 psi
- Oil injected designs have oil carryover

Comparison Between Reciprocating and Rotary Compressors

Aspect	Reciprocating Compressors	Rotary Compressors
Pressure Ratio	Discharge Pressure of air is high. The pressure ratio per stage will be in the order of 4 to 7.	Discharge pressure of air is low. The pressure ratio per stage will be in the order of 3 to 5.
Handled Volume	Quantity of air handled is low and is limited to 50m ³ /s.	Large measure of air handled can be handled and it is about 500 m ³ /s.
Speed of Compressor	Low speed of compressor.	High speed of compressor.
Vibrational Problem	Due to reciprocating section, greater vibrational problem, the parts of machine are poorly balanced.	Rotary parts of machine, thus it has less vibrational problems. The machine parts are fairly balanced.
Size of compressor	Size of Compressor is bulky for given discharge volume.	Compressor size is small for given discharge volume.
Air supply	Air supply is intermittent.	Air supply is steady and continuous..

Comparison Between Reciprocating and Rotary Compressors

Aspect	Reciprocating Compressors	Rotary Compressors
Purity of compressed air	Air delivered from the compressor is dirty, since it comes in contact with lubricating oil and cylinder surface.	Air delivered from the compressor is clean and free from dirt.
Compressed efficiency	Higher with pressure ratio more than 2.	Higher with compression ratio less than 2.
Maintenance	Higher due to reciprocating engine.	Lower due to less sliding parts..
Mechanical Efficiency	Lower due to several sliding parts..	Higher due to less sliding parts.
Lubrication	Complicated lubrication system.	Simple lubrication system.
Initial cost	Higher.	Lower.
Flexibility	Greater flexibility in capacity and pressure range.	No flexibility in capacity and pressure range.
Suitability	For medium and high pressure ratio. For low and medium gas volume.	For low and medium pressures. For large volumes.

What is belt conveyor? Explain how does it works?

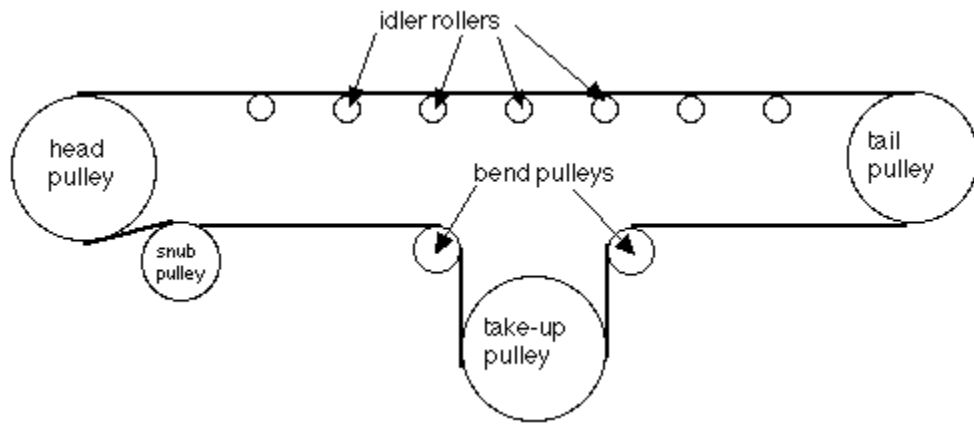
Introduction to Belt conveyor

- Belt conveyor is a machine transporting material in a continuous way by friction drive. It is mainly composed by rack, conveyor belt, belt roll, tensioning device and gearing.
- It can form a material delivery process between the initial feeding point and the final discharging point of jaw crusher .
- It can transport not only granular material, but also work piece. Besides the pure material transporting, it can also form a rhythmic flow transport line complying with the requirements of various industrial production processes.
- The belt conveyor can be used for horizontal transportation or inclined transportation in a convenient way, and widely used in modern industrial enterprises, such as: mine tunnel, mine surface transportation system, open-pit and concentrator.

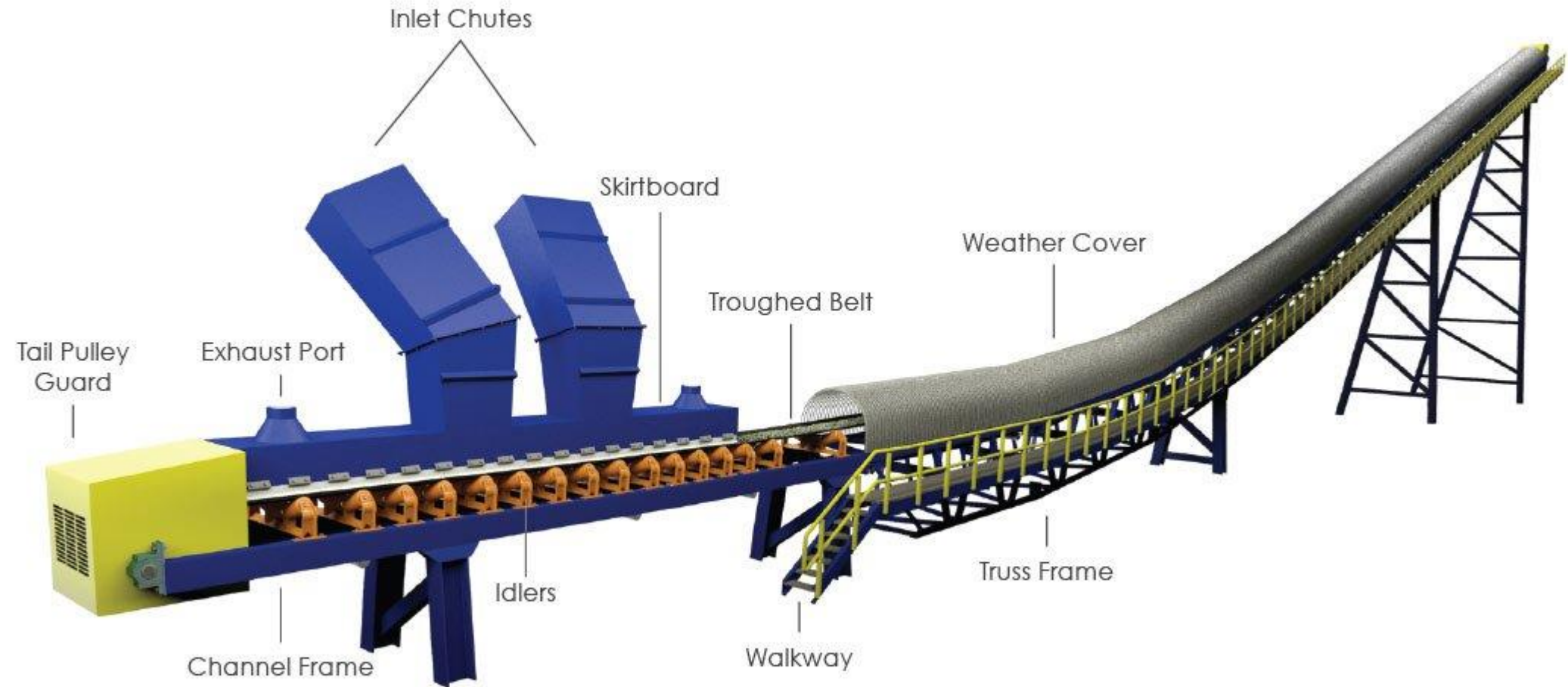
Working of Belt Conveyor

- Belt conveyor is composed by two endpoint pulleys and a closed conveyor belt. The pulley that drives conveyor belt rotating is called drive pulley or transmission drum; the other one—only used to change conveyor belt movement direction—is called bend pulley.
- Drive pulley is driven by the motor through reducer, and conveyor belt dragging relies on the friction drag between the drive pulley and the conveyor belt.
- The drive pulleys are generally installed at the discharge end in order to increase traction and be easy to drag. Material is fed on the feed-side and landed on the rotating conveyor belt, then rely on the conveyor belt friction to be delivered to discharge end.

Belt Conveyor



Mechanical Construction of a **BELT CONVEYOR**



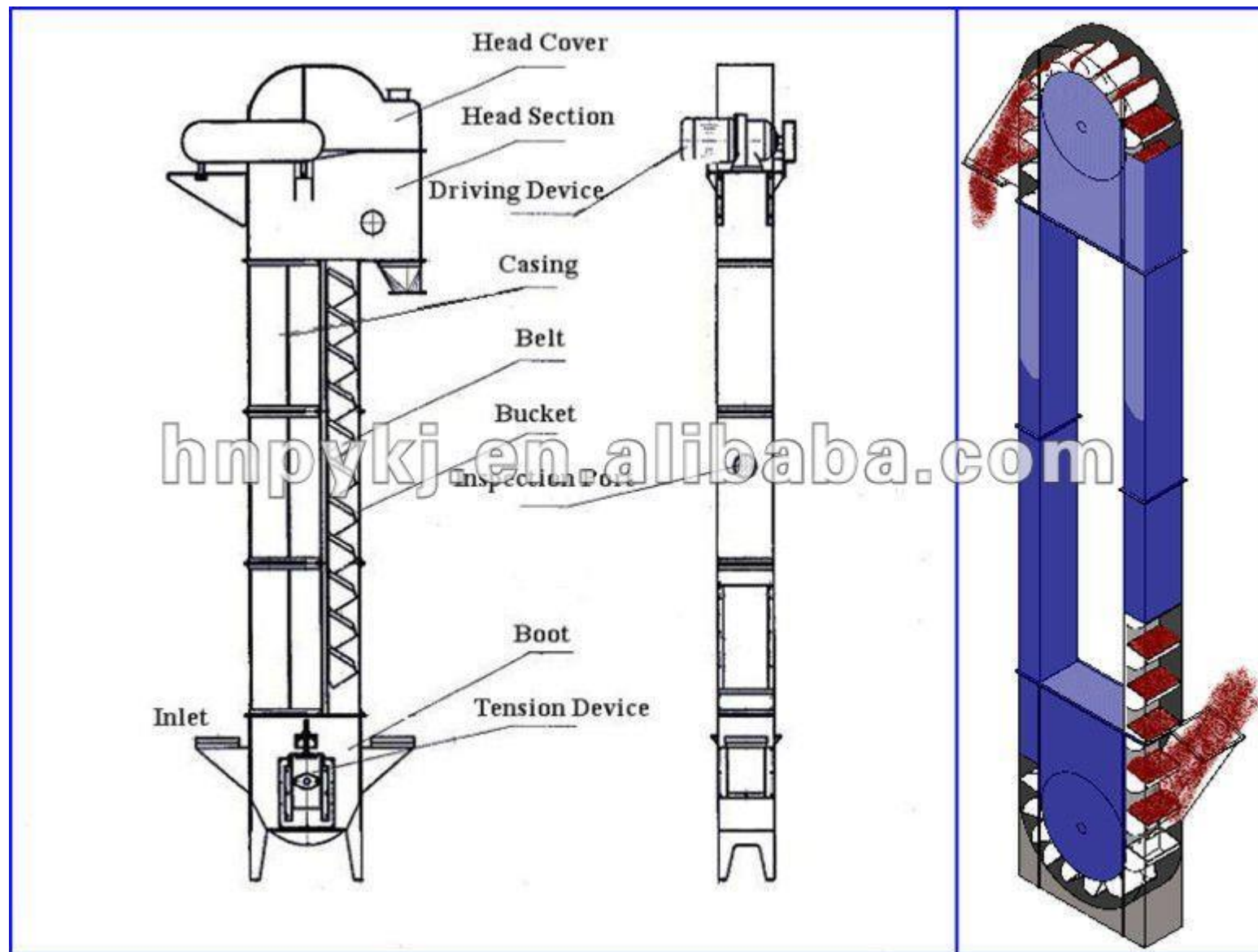
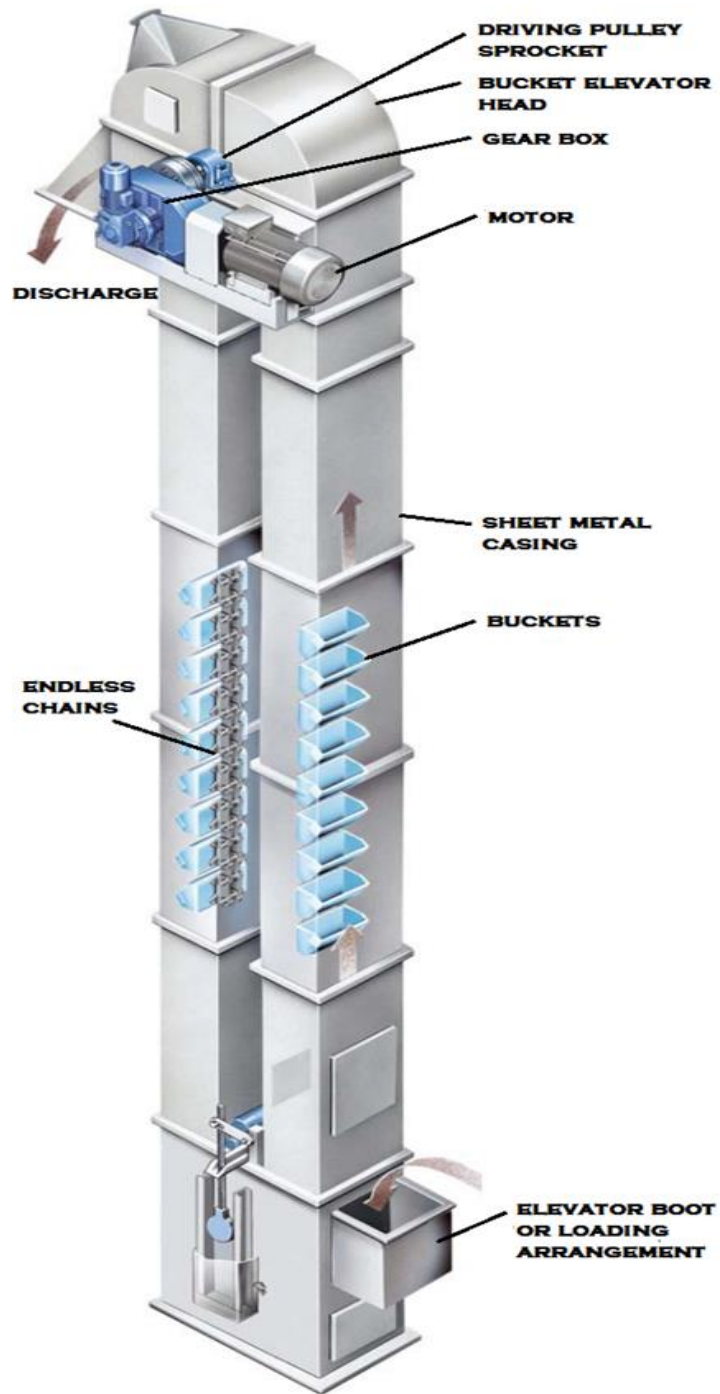
What is bucket elevator? Explain how it works?

Bucket elevator

- If material needs to be moved vertically, chances are a bucket elevator is the ideal solution for the job.
- In fact, the versatility and configurability of this equipment make bucket elevators a common material handling system in a number of different industries.

How Do Bucket Elevators Work

- In simple terms, bucket elevators vertically convey bulk materials. They are considered similar to conveyor belts, with the greatest difference being that bucket elevators move material using buckets attached to a rotating belt or chain.
- The buckets work to pick up material, move it to the desired endpoint, discharge material, and finally return to the starting point to pick up a new load.
- Typical elevator consists of:
 - An endless belt
 - A chain or chains, to which buckets are attached
 - Necessary loading and discharging terminal machinery
 - A drive arrangement
 - Supporting frame or casing.



Assignment-1

1. Classify pumps and describe any one pump in brief.
2. Explain centrifugal pump in brief.
3. Explain reciprocating pump in brief.
4. Explain plunger pump.
5. Explain gear pump in brief.
6. Explain lobe pump in brief.
7. Differentiate pump and compressors.

Assignment-2

1. Write a short note on compressor.
2. Classify compressors describe any one compressor in brief.
3. Explain in brief the rotary compressor with schematic diagram.
4. How does reciprocating compressor works?
5. What is belt conveyor? Explain how does it works?
6. What is bucket elevator? Explain how it works?