Mechanical Engineering Fundamentals

Vipan Bansal

Department of Mechanical Engineering

(vipan10028@davuniversity.org)

Mechanical Engineering Fundamentals

(MEC103)

L	T	P	Cr
4	0	0	4

Content

1) Fundamental Concepts of Thermodynamics
2) Laws of Thermodynamics
3) Pressure and its Measurement
4) Heat Transfer
5) **Power Absorbing Devices**
6) Power Producing Devices
7) Principles of Design
8) Power Transmission Devices and Machine Elements

Lecture No. - 3

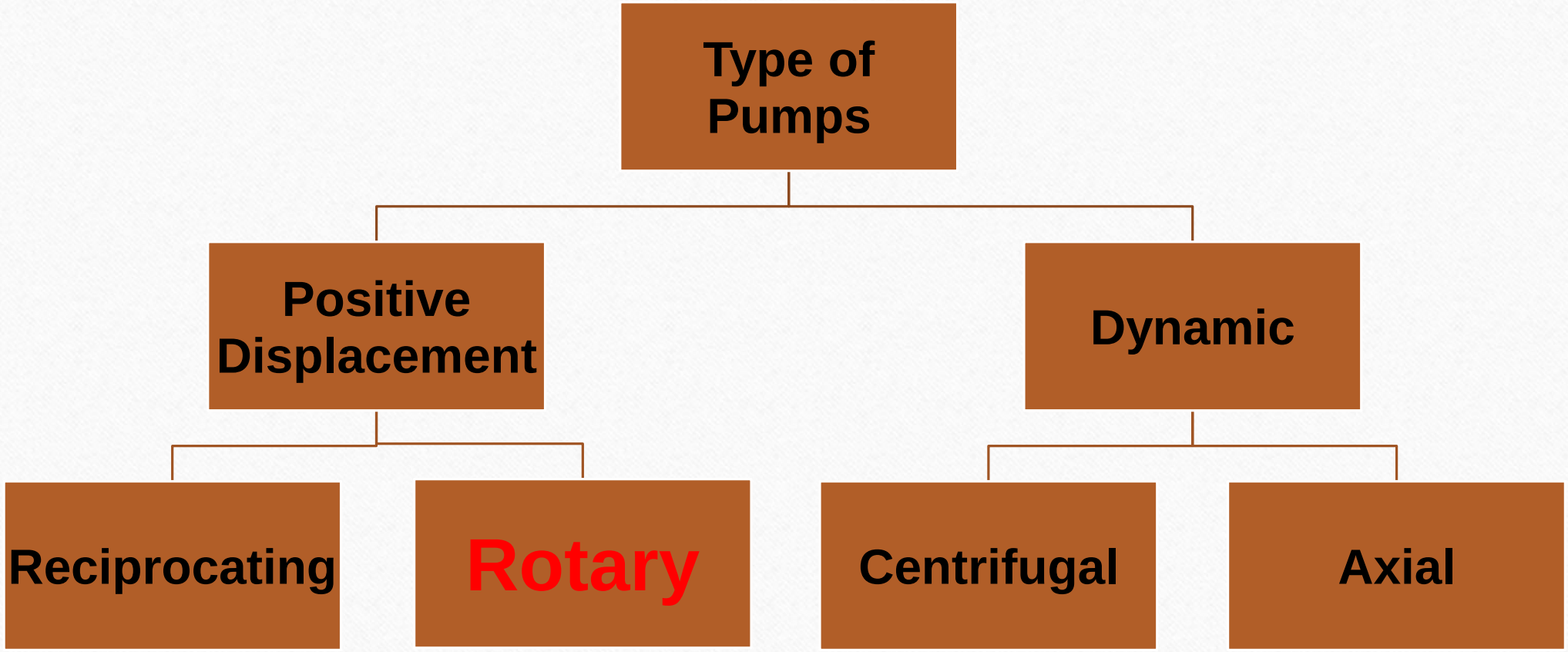
- Positive displacement Pumps

Power Absorbing Devices

The equipment's or devices that consume power for the working are called power absorbing devices.

Examples: Pumps, Compressor, Refrigerators etc.

Classification of Pumps



Positive Displacement vs Dynamic Pumps

S. No.	Parameter	Positive Displacement Pumps	Dynamic Pumps
1	Flow Rate	Low flow rate	High flow rate
2	Pressure	High	Moderate
3	Priming	Very Rarely	Always
4	Viscosity	Virtually No effect	Strong effect
5	Energy added to fluid	In positive displacement pumps, the energy is added periodically to the fluid.	In dynamic pumps, energy is added to the fluid continuously through the rotary motion of the blades.

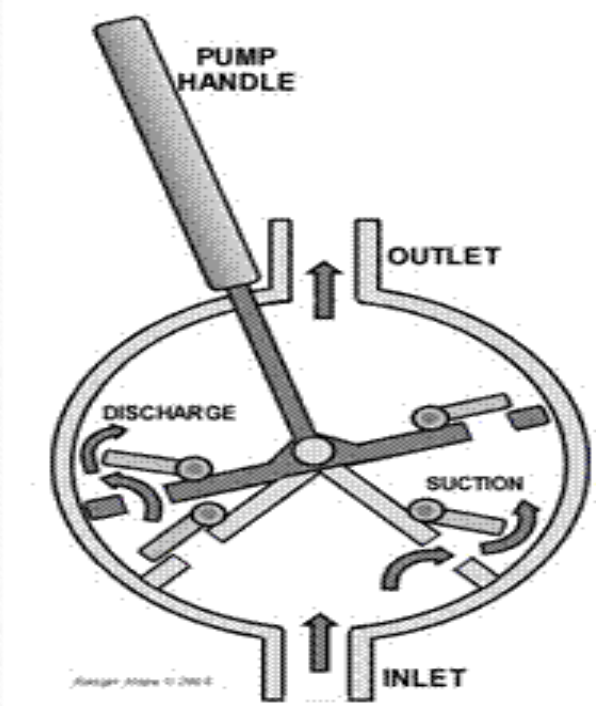
Rotary Pump

- Rotary pumps are positive displacement pumps thus displace a known quantity of liquid with each revolution of the pumping elements and for the functioning of these pumps no priming (No need to fill the cylinder with liquid before starting) is required in their starting.
- Rotary pumps deliver a constant, smooth flow, regardless of pressure variations.
- Rotary pumps are versatile and their popularity is due to their relatively compact design, high-viscosity performance.
- In rotary pumps the pumping element designs include gears, lobes, rotary pistons, vanes, and screws.

Construction and Working of the Rotary Pump

Following are the parts of the rotary pump:

- Suction
- Rotor
- Casing
- Handle
- Discharge



- 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.
- Rotary pumps are designed so that the rotating pumping elements draw the fluid at the suction port into the pumping cavity, transport it through the pumping elements and force it through the discharge port into the system.
- The geometry of the pump elements and pumping cavity determine the volume of fluid pumped per revolution of the shaft. This volume is called the displacement.
- Most rotary pump types are configured for fixed displacement; however, they can produce variable flow rates by varying the shaft speed.

Uses of Rotary Pump

- Rotary pump can pump not only thick and viscous liquid such as oil burners, soaps and cosmetics, sugars, syrup, and molasses, dyes, ink, bleaches, vegetable and mineral oils, greases etc. but they can also pump lighter liquids such as gasoline, alcohol etc.

Advantages of Rotary Pump

- Less Maintenance.
- Less Weight and Compact Size.
- Priming is not required in this pump.
- They can deliver liquid to high pressures.
- Give a relatively smooth output, (especially at high speed).
- Can pump viscous liquids

Disadvantages of Rotary Pump

- More expensive than centrifugal pumps.
- Should not be used for fluids containing suspended solids.
- Must never be used with the discharge closed.

Type of Rotary Pumps

Various types of rotary pumps are:

Single rotor (When there is only one rotating pumping element in the casing then these are called as single rotor pumps.)

- Rotary Vane Pump
- Rotary Screw Pump
- Rotary Piston Pump

Multiple rotor (When there are multiple rotating pumping elements in the casing then these are called as multiple rotor pumps.)

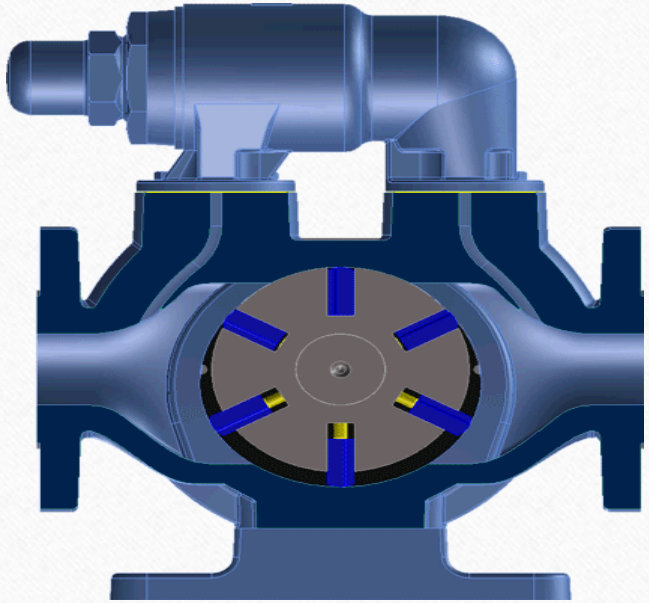
- Rotary Gear Pump
- Rotary Lobe Pump
- Rotary Screw Pump

Rotary Vane Pump (Pressure Increase by Volume Reduction)

- In vane pumps, a number of vanes slide in slots in a rotor which rotates in housing.
- Capacity and pressure ratings of a vane pump are generally lower than the gear pumps, but reduced leakage gives an improved volumetric efficiency of around 95%.
- In gear pump there is leakage due to gap between gear teeth and the pump housing. This limitation is overcome in vane pumps.

- The vane pumps generally consist of a rotor, vanes and ring with inlet and outlet ports. The rotor in a vane pump is connected to the prime mover through a shaft. The vanes are located on the slotted rotor.
- The **housing may be eccentric with th**e center of the rotor, or its shape may be oval. In some designs, centrifugal force holds the vanes in contact with the housing, while the vanes are forced in and out of the slots by the eccentricity of the housing.

- It provides a tight hydraulic seal to the fluid which is more at the higher rotation speed due to higher centrifugal force. This produces a suction cavity in the ring as the rotor rotates. It creates vacuum at the inlet and therefore, the fluid is pushed into the pump through the inlet. As the space or volume enclosed reduces, the liquid is forced.
- **The capacity of the pump depends upon the eccentricity, expansion of vanes, width of vanes and speed of the rotor.** It can be noted that the fluid flow will not occur when the eccentricity is zero



Applications of Rotary Vane Pump

- Refined Fuel
- LPG Cylinder Filling
- Alcohols
- Refrigerants

Advantages of Rotary Vane Pump

- Higher Pressure on Thin Liquids
- Self-lubricating and self-adjusting vanes
- Pumps develop good vacuum due to negligible leakage.
- Fast Vane Replacement
- Good controllability
- Compact Design

Disadvantages of Rotary Vane Pump

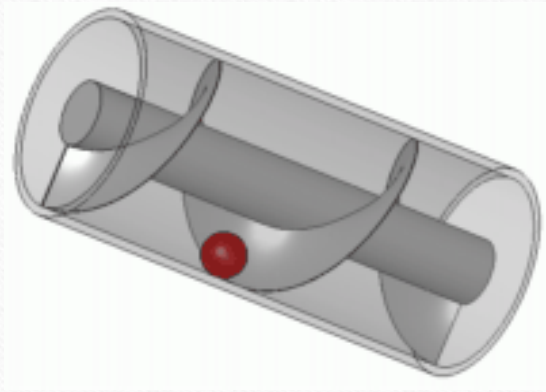
- Not suitable for high pressures
- Not suitable for high viscosity
- Not good with abrasives

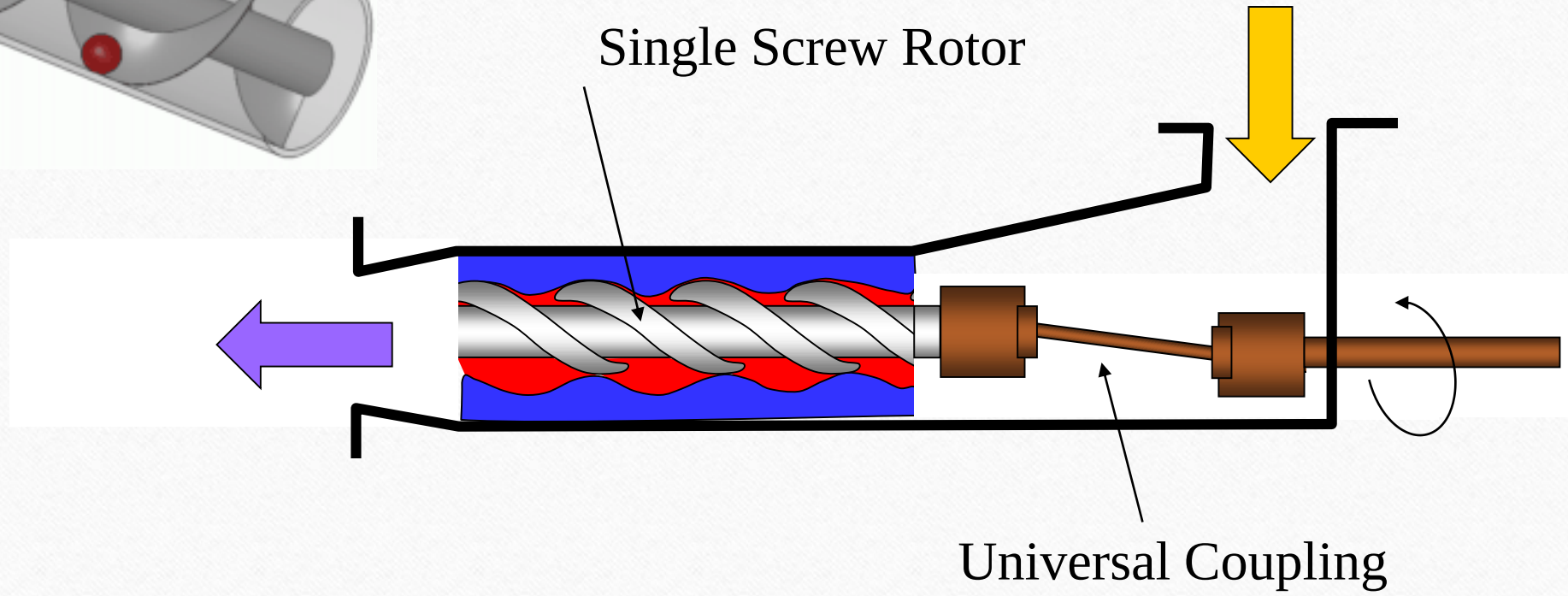
Rotary Screw Pump

- Screw pumps carry fluid in the spaces between the screw threads.
- Single screw pumps are commonly called progressive cavity pumps.
- They have a rotor with external threads and a stator with internal threads.

Rotary Screw Pump

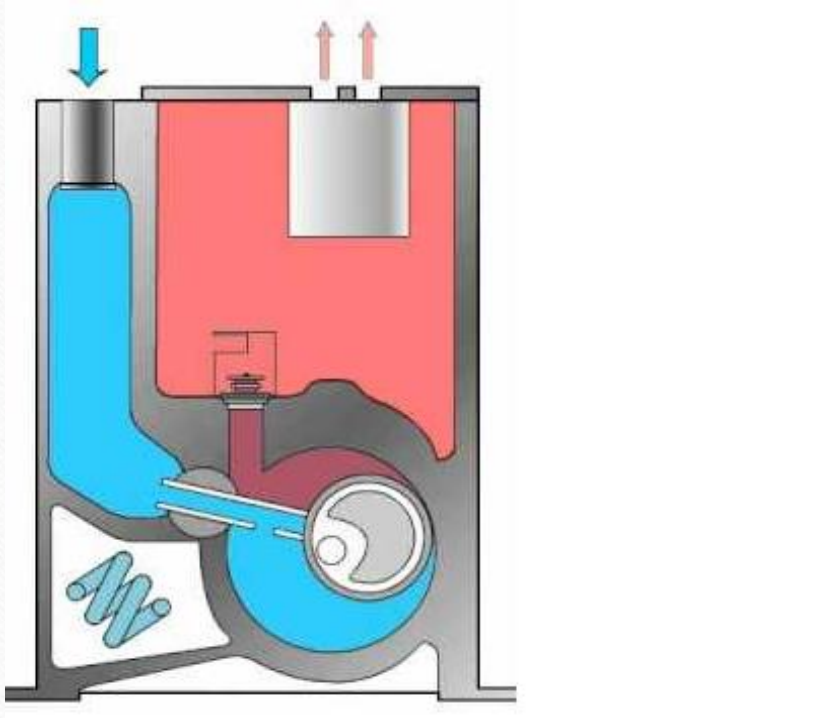
- The rotor threads are eccentric to the axis of rotation.
- A classic example of screw pump is the Archimedes screw pump that is still used in irrigation and agricultural applications.



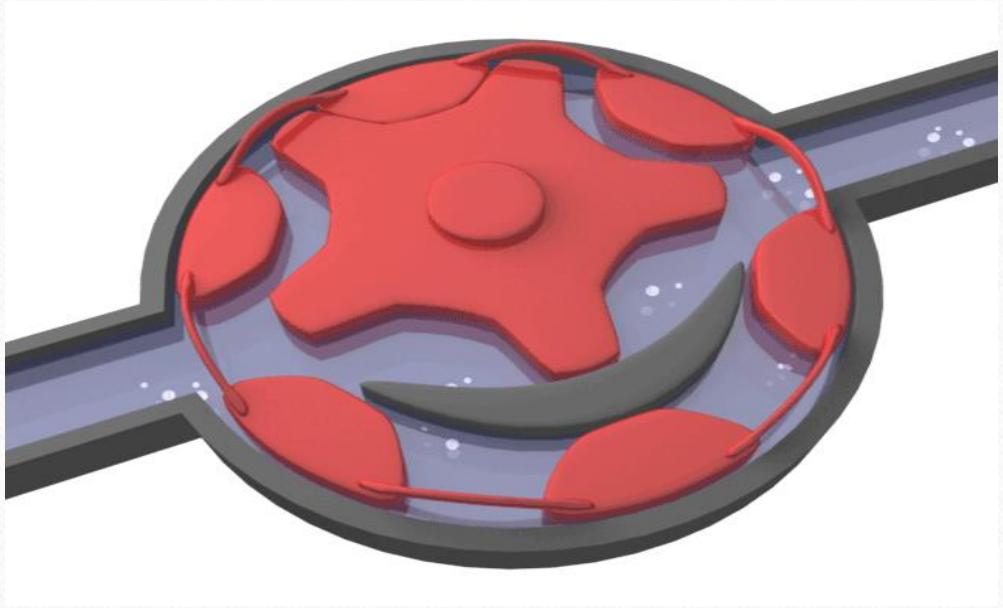

Single Screw Rotor
Universal Coupling

Rotary Piston Pump

- A rotary piston with slide valve across eccentric wheel driven by shaft within the housing.
- Piston pole can slide and swing freely in arch track.
- The whole pump chamber is divided into chamber A and chamber B by piston. When shaft rotates the volume of chamber A and chamber B are changed repetitively, so that pumping purpose could be achieved.

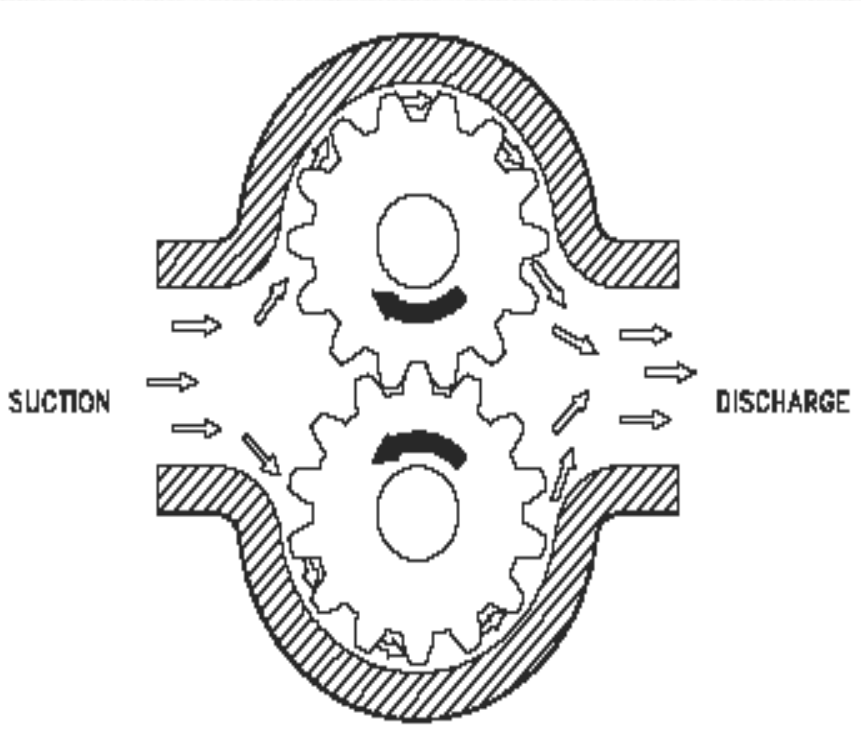


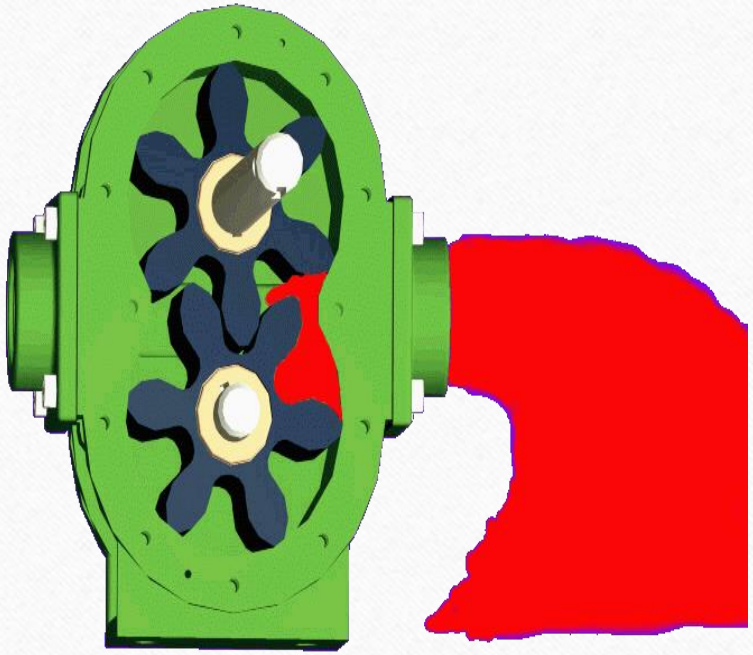
Gear Pump (Multiple Rotor Pump)



- A **gear pump** uses the meshing of gears to pump fluid by displacement.
- There are two main variations; *external gear pumps* which use two external spur gears and *internal gear pumps* which use an external and an internal spur gear.

External Gear Pump





External Gear Pump

- These pumps come with a straight spur, helical, or herringbone gears.
- Straight spur gears are easiest to cut and are the most widely used.
- Helical and herringbone gears run more quietly, but cost more.
- Usually, small external gear pumps operate at 1,750 or 3,450 rpm and larger versions operate at speeds up to 640 rpm.

External Gear Pump

- The design of external gear pumps allows them to be made to closer tolerances than internal gear pumps.
- External gear pumps handle viscous and watery-type liquids, but speed must be properly set for thick liquids.
- The pump does not perform well under critical suction conditions. Volatile liquids tend to vaporize locally as gear teeth spaces expand rapidly.

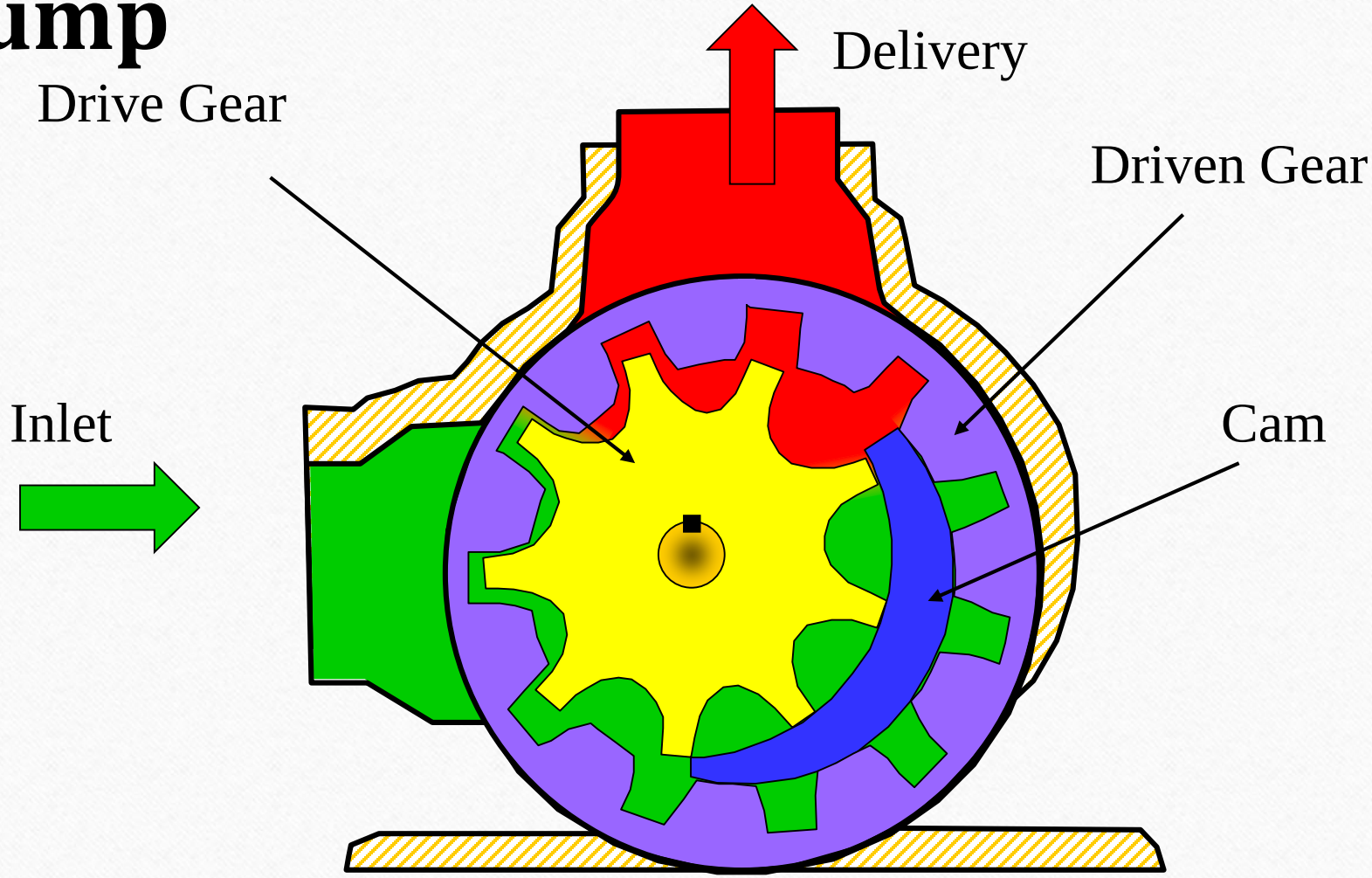
Working of External Gear Pump

- The simple gear pump consists of two spur gears meshing together and revolving in opposite directions within a casing to produce flow.
- One is the driving gear, and the other is the driven gear.
- Each gear in external gear pump is supported by a shaft with bearings on both sides of each gear.
- Because the gears are supported on both sides, external gear pumps are used for high pressure applications such as hydraulics.

- Clearances between the gear teeth (outside diameter of the gear) and the casing and between the end face and the casing are only a few thousandths of an inch.
- As the gears turn, the gears un-mesh and liquid flows into the pockets that are vacated by the meshing gear teeth. This creates the suction that draws the liquid into the pump.
- The liquid is then carried along in the pockets formed by the gear teeth and the casing. On the discharge side, the liquid is displaced by the meshing of the gears and forced out through the discharge side of the pump.

Internal Gear Pump

Gear Pump



Internal Gear Pump

- The speed of internal gear pumps is considered relatively slow compared to centrifugal types.
- Speeds up to 1,150 rpm are considered common. Because of their ability to operate at low speeds, internal gear pumps are well suited for high-viscosity applications and where suction conditions call for a pump with minimal inlet pressure requirements.
- For each revolution of an internal gear pump, the gears have a fairly long time to come out of mesh allowing the spaces between gear teeth to completely fill.
- These pumps can handle small suspended particulate in abrasive applications, but gradually wear and lose performance.

Working of Internal Gear Pump

- Liquid enters the suction port between the rotor (large exterior gear) and idler (small interior gear) teeth.
- 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. The pump head is now nearly flooded, just prior to forcing the liquid out of the discharge port.

Working of Internal Gear Pump

- Intermeshing gears of the idler and rotor form locked pockets for the liquid which assures volume control.
- 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.

Advantages of Gear Pump

- High pressures and low capacities.
- Handle a wide range of viscosities,
- Relatively simple to maintain and rebuild.
- Quite Operation

Disadvantages of Gear Pump

- Tight tolerances required.

Applications of Gear Pump

- Petrochemicals
- Chemicals
- Paint and Ink (Resins and Adhesives)
- Pulp & Paper (Acid, soap, lye, black liquor, kaolin, lime)
- Food (Chocolate, cacao butter, fillers, sugar, vegetable fats and oils, molasses, animal feed)

Lobe Pump

- Rotary pumps are considered as a simple gear pump having only two or three teeth per rotor; otherwise, its operation or the explanation of the function of its parts is no different.

Advantages of Lobe Pump

- Handle solids (e.g., cherries and olives), slurries, pastes, and a variety of liquids.
- If wetted, they offer self-priming performance.
- Lobe pump offers superb sanitary qualities, high efficiency, reliability, corrosion resistance and good clean-in-place and steam-in-place (CIP/SIP) characteristics.

Disadvantages of Lobe Pump

- Requires two seals
- Reduced lift with thin liquids

Applications of Lobe Pump

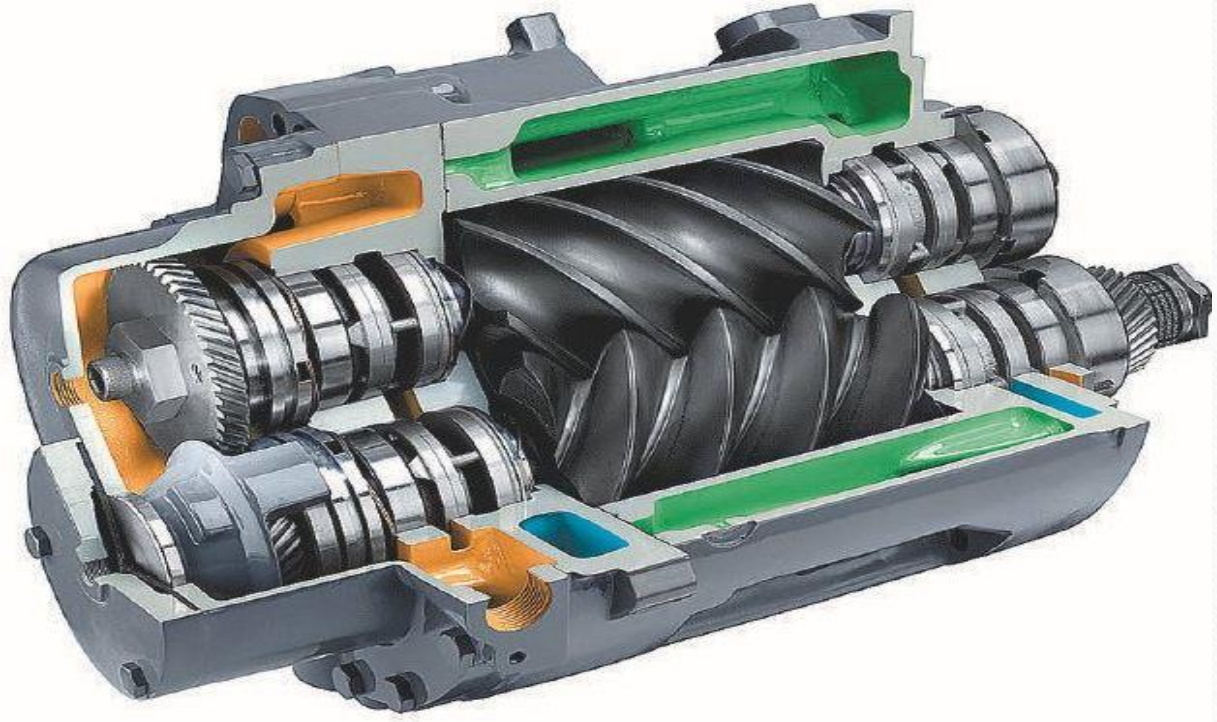
- Beverage
- Pharmaceutical
- Chemicals
- Pulp & Paper (Acid, soap, lye, black liquor, kaolin, lime)
- Food (Chocolate, cacao butter, fillers, sugar, vegetable fats and oils, molasses, animal feed)

Rotary Screw Pump

- Screw pumps are rotary, positive displacement pumps that can have one or more screws to transfer high or low viscosity fluids along an axis.
- Multiple screw pumps have two or more inter-meshing screws rotating axially clockwise or counterclockwise.
- Each screw thread is matched to carry a specific volume of fluid. Like gear pumps, screw pumps may include a stationary screw with a rotating screw or screws.
- Fluid is transferred through successive contact between the housing and the screw flights from one thread to the next. Geometries can vary.

Rotary Screw Pump

- Screw pumps provide a specific volume with each cycle and can be dependable in metering applications.
- Multiple screw pumps provide remarkably good operating efficiencies versus centrifugal pumps when handling viscous liquids such as heavy crude oil, bunker or residual fuel oils and low sulfur fuels.
- It also provide higher pressure or flow capability, better wear resistance, improved corrosion resistance, and lower leakage emissions.



THANK YOU