2.8 Hydraulic pumps

2.8.1. Introduction

A pump, which is the heart of hydraulic system, convers mechanical energy into hydraulic energy. The mechanical energy is delivered to the pump via a prime mover such as an electric motor. Due to mechanical action, the pump creates partial vacuum at its inlet. This permits atmospheric pressure to force the fluid through the inlet line and into the pump. The pump then pushes the fluid into the hydraulic system.

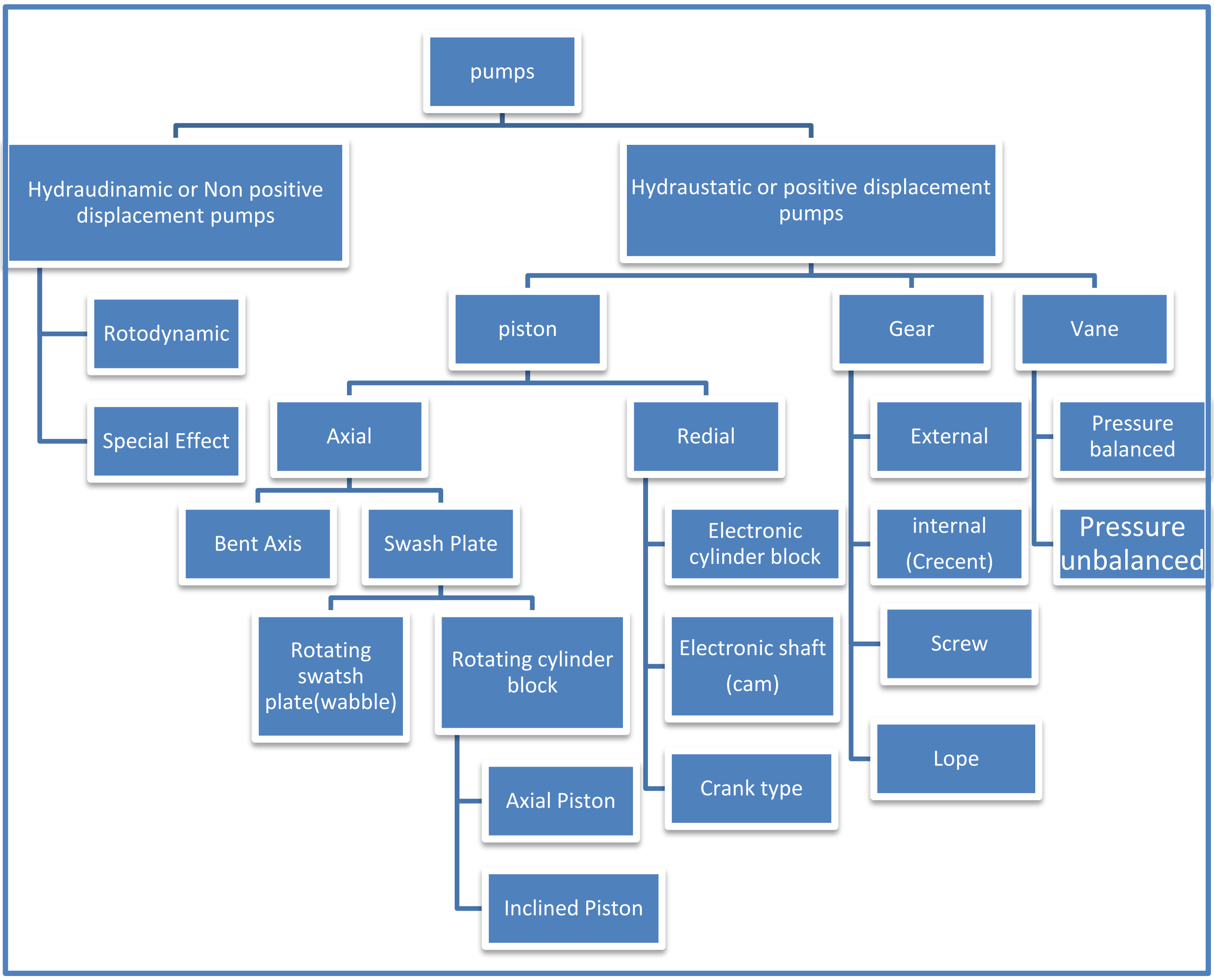

Fig .2.9. The Classification of hydraulic pumps

2.8.2. Classification of hydraulic pumps.

There are two board classifications of pumps as identified by the fluid power industry.

1. **Non positive displacement pumps:**

This type is generally used for low-pressure, high-volume flow applications. Because they are not capable of with standing high pressures, they are little use in the fluid power field. Normally their maximum pressure capacity is limited to 250-300 psi. This type of pump is primarily used for transporting fluids from one location to another.

2. **positive displacement pumps:**

This type is universally used for fluid power systems. As the name implies, a positive displacement pump ejects a fixed amount of fluid into the hydraulic system per revolution of pump shaft rotation. Such a pump is capable of overcoming the pressure resulting from the mechanical load on the system as well as the resistance to flow due to friction. These are two features that are desired of fluid power pumps. These pumps have the following advantage over nonpositive displacement pumps:

- **a.** High pressure capability (up to 10,000 psi or higher).
- **b.** Small, compact size.
- **c.** High volumetric efficiency.
- **d.** Small change in efficiency throughout the design pressure range.
- **e.** Great flexibility of performance (can operate over a wide range of pressure requirements and speed ranges)

Positive displacement pump can be classified by the type of motion of internal elements. The motion may be either rotary or reciprocating. Although these pumps come in a wide verity of different designs there are essentially three basic types:

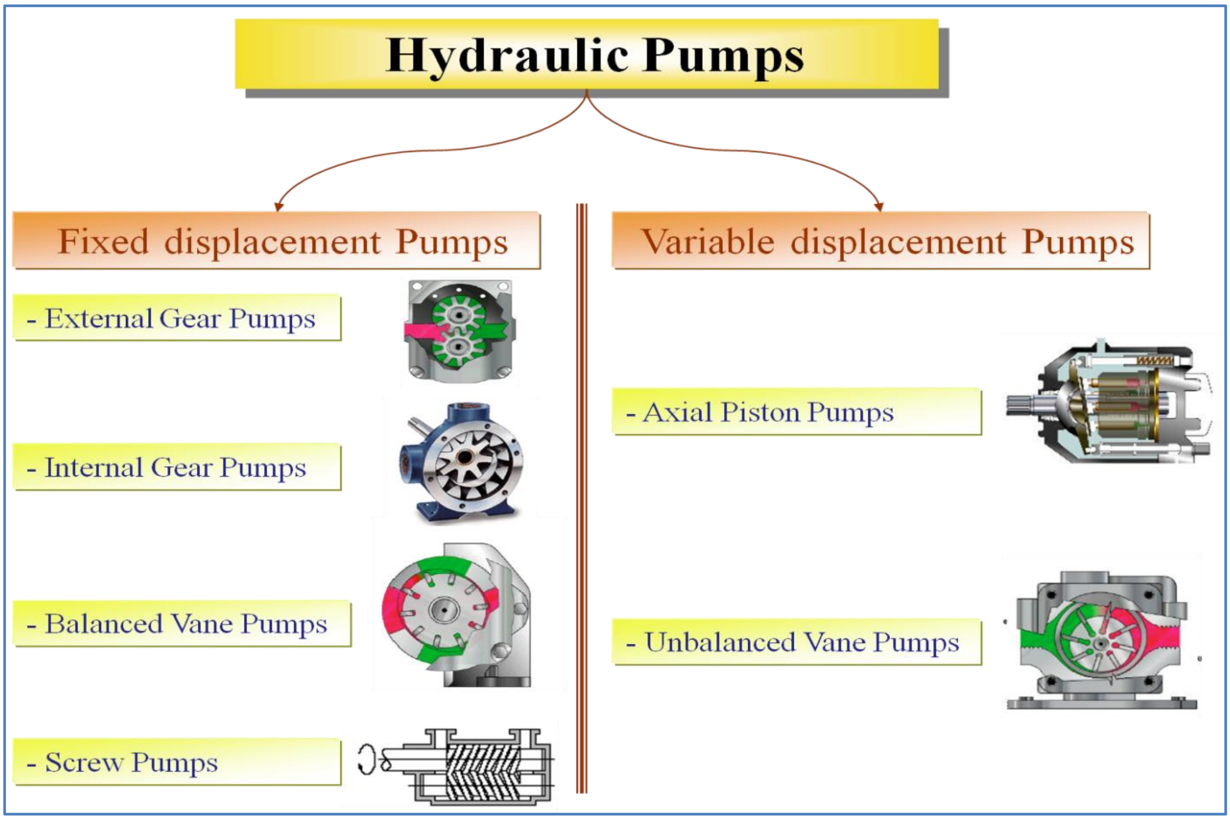

Fig .2.10 the Classification of Positive displacement pump

2.10. Explain the operation of the displacement pump.

The pump operation is summarized in the following steps.

1- During the expansion of the pumping chamber, it is connected to the suction line. The expansion develops an under pressure inside the chamber, forcing the liquid to be sucked in.
2- When the volume of the chamber reaches its maximum value, the chamber is separated from the suction line.
3- During the contraction period of the chamber, it is communicated with the pump. delivery line. The fluid is then displaced to the pump exit line and is acted on by the pressure necessary to overcome the system resistance
4- The delivery stroke ends when the volume of the chamber reaches its minimum value. Then the chamber is separated from the delivery line.

A. Rotary pumps

1. Gear pumps

Gear pumps are multiple rotor type of pumps and the rotor's are "gear toothed". The pumping action is achieved by relative motion of the rotors. Gear pumps are primarily of the external or internal gear type. One of the rotors (driver) receives drive from a prime mover and it transmits drive to the other rotor.

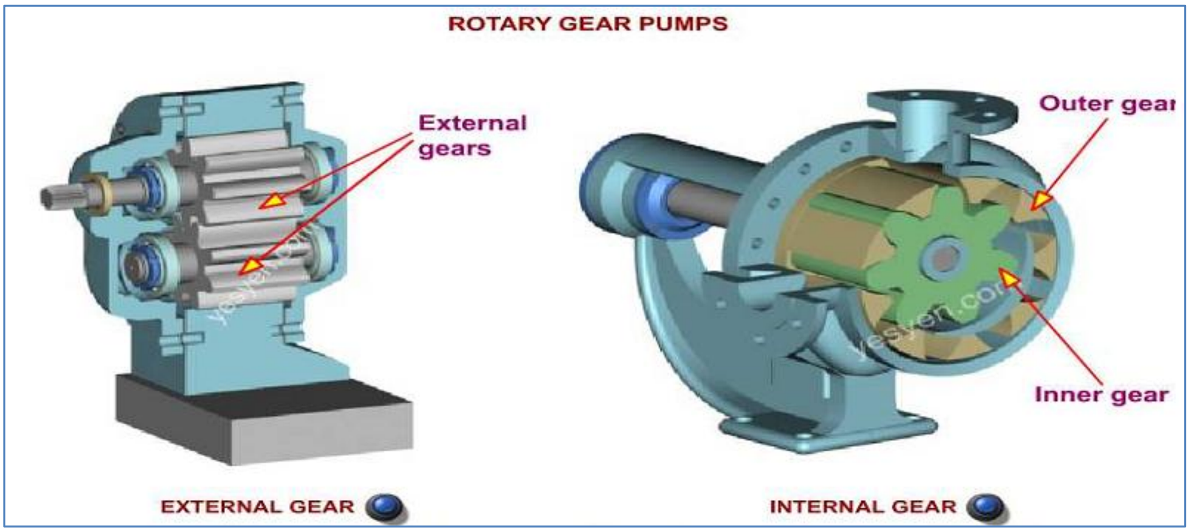

Fig .2.11 Rotary gear pump

1. a. External gear pumps

External gear pumps maybe of the straight spur gear or helical gear type. The representation shows a spur type gear pump and this type is more common. The suction and discharge of the pump is primarily decided by the direction of rotation of the gears. One of the gears (driver) receives drive from a prime mover. The driver in turn transmits motion to the driven gear.

1. b. Internal gear pumps:

The internal gear pump is a multiple rotor type of pump, and the working primarily differs from the external gear pump in that, here an outer gear (having internal gear tooth) meshes with a gear which is within it or inner to it. The inner gear is off-center with respect to the casing and outer gear. In the pump shown. The outer gear (driver) receives drive from an external source (prime mover). The outer gear drives the inner gear or idler gear on a stationary pin.

2. Vane pumps:

Vane pumps are of the single rotor type. They are primarily of the sliding Vane and flexible Vane (flexible impeller) design. In sliding vane pumps the pumping action is achieved by a rigid sliding action of vanes along the casing wall. The vanes move up-and-down inside slots in a rotor, which is eccentrically located in the casing. These pumps can develop high suction heads and can handle suspended non-abrasive solids. In the flexible vane (impeller) pumps, the vanes flex against the casing wall, which is oblong at one end. The pump has low suction capabilities.

2.1. Sliding vane pumps:

The basic, design of the pump involves a rotor, eccentrically mounted inside a cylindrical casing. The rotor has several radial slots in which sliding vanes are located. If the rotor is rotated, the sliding vanes are pushed against the wall of the casing by centrifugal force and hydraulic pressure. Some design also incorporate spring force to push the sliding vanes against the casing wall.

2.2.Flexible vane pumps

In flexible vane pumps, the rotor includes flexible vanes and the principle of operation is very similar to the sliding vane pump except that the vanes flex and do not rigidly slide against the casing wall.

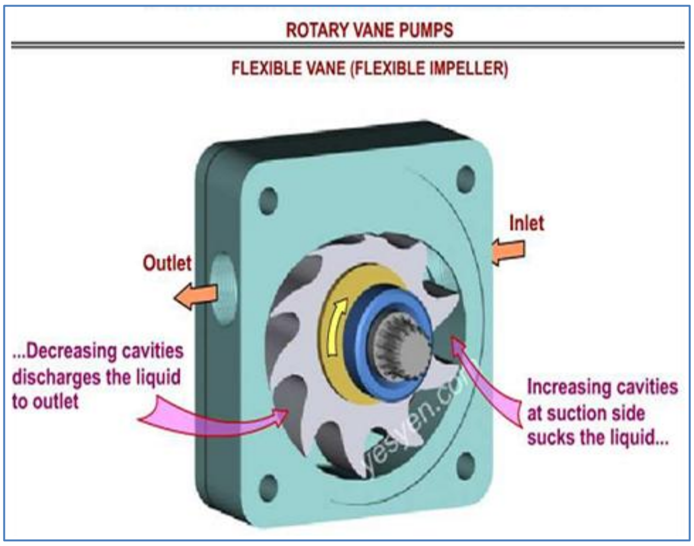

Fig. 2.12. Flexible vane pump

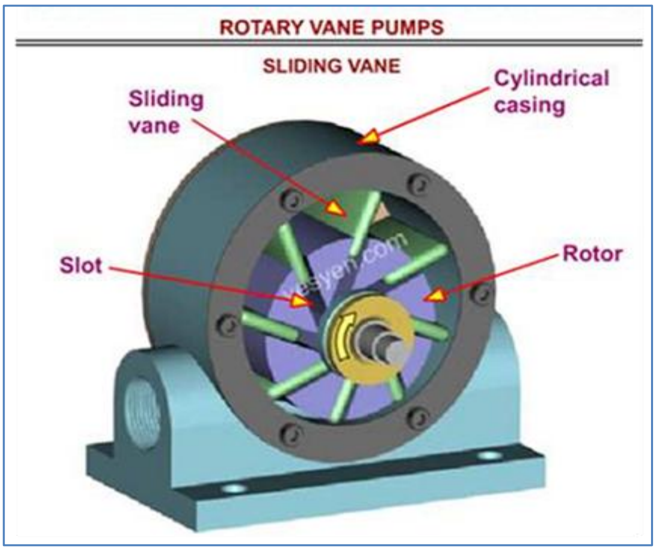

Fig .2.13. Sliding vane pump

3.Rotary lope pumps:

Lobe pumps are multiple rotor type of pumps and the rotors utilize a lobe shaped design. The pumping action is achieved by relative motion of the rotors. They are primarily of the external lobe type and internal lobe (gerotor) type. In the external lobe design. The relative motion between rotors is achieved by timing gears and therefore the internal contact between the lobes is a sealing contact and not a driving contact. Since the lobes do not directly mate, lobe pumps are suitable for handling liquids with suspended solids.

3.1.External lope:

Lobe pumps may be of various designs and the rotors may be of bi-wing, tri-Lobe, or multi-lobe configurations. In the model shown, the rotors are of the bi-wing type and are supported on either side. The rotors can also be of the over-hanging design.

3.2.Internal lope (Gerotor)

The internal lobe pump and is also called as a gerotor pump; the name derived from the term "generated rotor". The pump is also referred to as an internal gear pump and operates primarily on the same principle but without a crescent.

A gerotor unit consists of an inner and outer lobe where the inner rotor has n lobes, and the outer rotor has n+1 lobes. The prime mover transmits drive to the inner lobe (driver), which in turn drives the outer lobe (idler).The inner lobe is located off-center to the outer lobe.

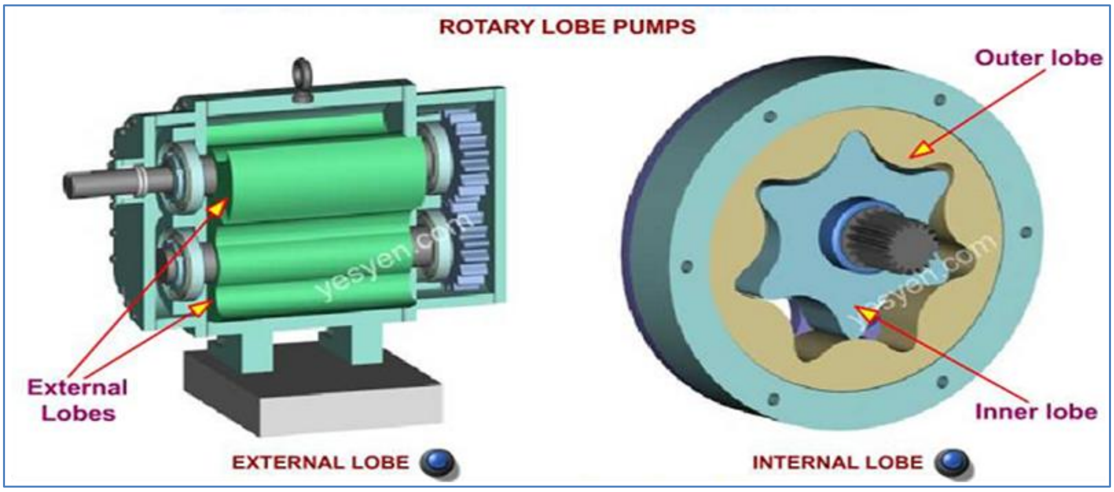

Fig.2.14. Rotary lope pumps

4. Rotary screw pumps:

Screw pumps are unique because the flow through the pumping elements is truly axial. It provides several advantages in many applications where liquid agitation or churning is objectionable. Screw pumps are classified into the single rotor (progressing cavity) and multiple rotor type. In the single screw type, the pumping action is achieved by a rotor which mates with threads inside a stator. In multiple rotor pumps the pumping action is achieved by the relative motion between the rotors, which may be synchronized by gears or the drive may be transmitted directly from one rotor to the other.

4.1. Single screw pump (Progressive cavity):

These pumps are of the single rotor type and are commonly called as progressive cavity pumps. The pump consists of two key components; the rotor and the stator.

4.2.Multiple screw pump:

These pumps have more than one rotor and are actually a modification of the helical gear pumps. Here liquid is trapped and forced through the pump by the action of rotating screws. One of the rotors receives drive from the drive shaft while the other rotor 'is driven by timing gears. The timing gears synchronize the mesh of the non-contacting screws.

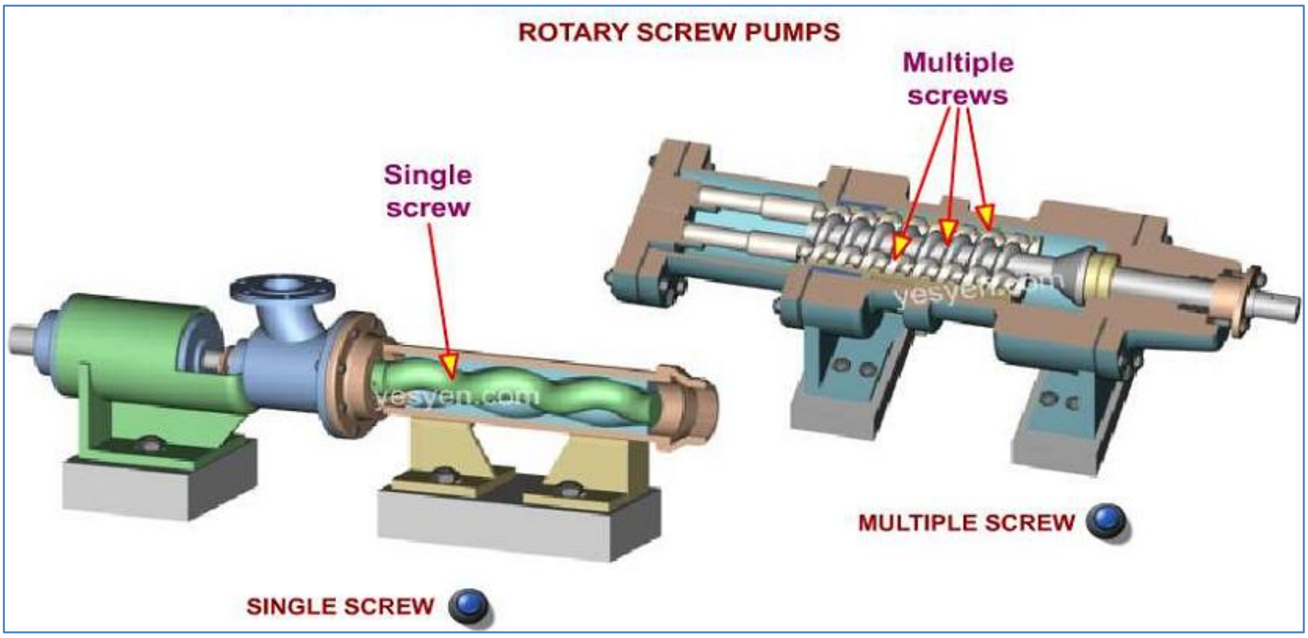

Fig .2.15 Rotary screw pumps

5.Rotary piston pumps:

In piston pumps, the pumping action is achieved by the reciprocating action of pistons inside a cylinder-block. However, the reciprocating action is directly imparted by a rotating member inside the pump and therefore these pumps are generally classified under rotary pumps. Piston pumps are categorized into radial piston or axial piston pumps. 'In the radial type the pistons reciprocate in a direction radial to the cylinder-block axis, while in the axial type the pistons reciprocate in-line to the cylinder-block axis. Piston pumps are available in a wide range of capacities and can operate in medium to high pressure ranges. They are well suited for hydraulic services.

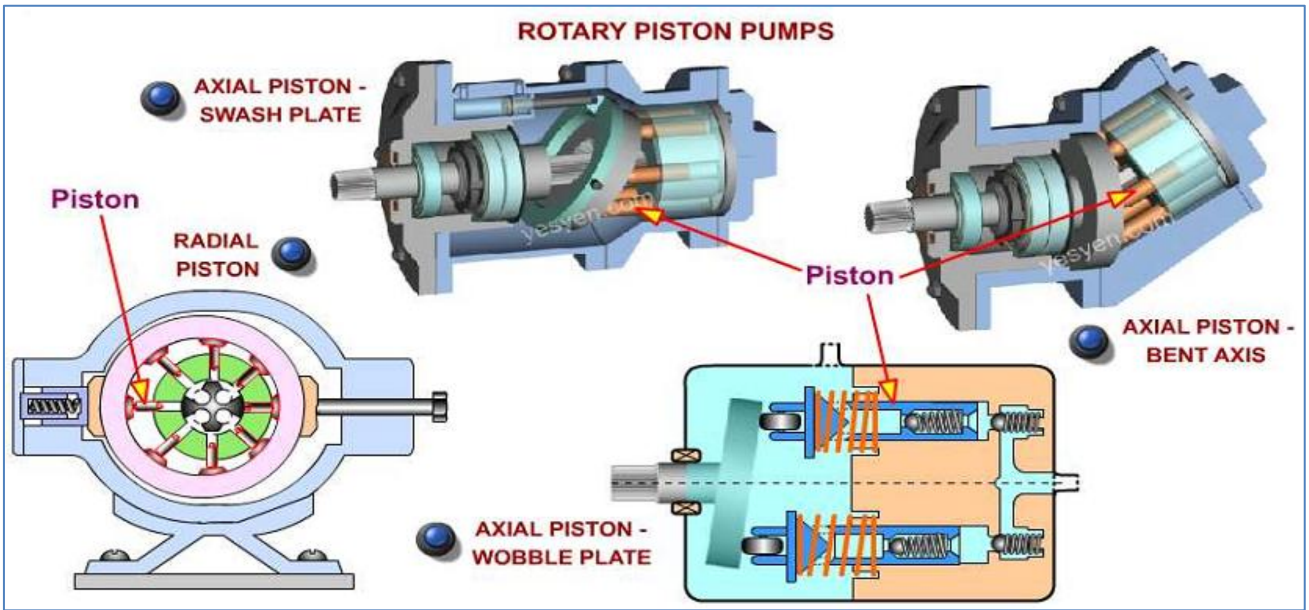

Fig .2.16 Rotary piston pump

5.1.Radial piston

The pump has several pistons that are uniformly spaced apart and housed radially in a cylinder block (piston-block). The pistons reciprocate in a direction radial to the cylinder-block axis and hence the term "radial piston pumps",

In the pump design. The drive shaft transmits drive torque to the piston-block by means cross of disc coupling. The piston-block rotates around a pintle, which has ducts routed to inlet and outlet connections behind the pump. There are several pistons arranged radially inside slots in the piston-block, which abut against a stroke ring through slipper pads. The piston is connected to the slipper pad by means of a ball and socket joint and the slipper pad is guided in the stroke ring by means of two overlapping rings. The stroke ring is eccentrically located with respect to the piston block.

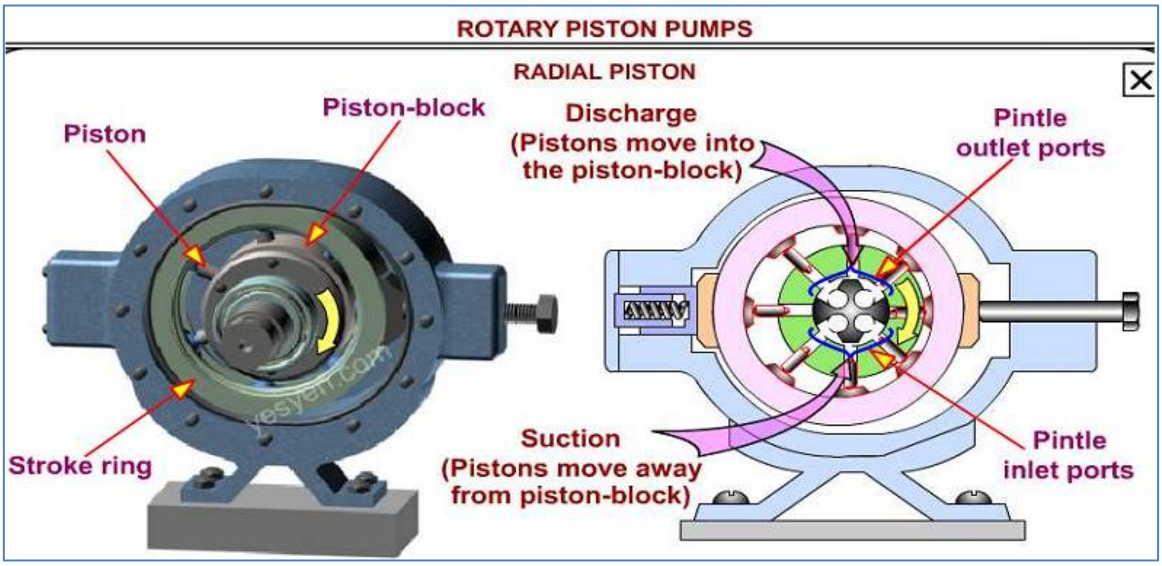

Fig.2.17 Radial piston

5.2.Axial piston - in-line - swash plate:

The pump is of the axial piston type. Unlike the radial piston pump, the design consists of several pistons that are located parallel to each other inside slots in a piston-block and the pistons reciprocated axially inside the piston-block. The drive shaft and the piston-block axis are in-line (collinear).

The pistons are made to bear against a swash plate by suitable arrangements like springs or a shoe plate. The swash plate is inclined to the axis of rotation.

As observed in the cut-section, the suction and discharge ports are semi-circular holes in the valve plate.

As the driver shaft rotates, it transmits drive to the piston-block. As the piston-block rotates, the pistons follow the angled stationary swash plate, causing the pistons to reciprocate. At the suction side, along the direction of rotation, the distance between the piston-block and swash plate increases and the piston are pulled out, thus resulting in suction. Alternately, the pistons are pushed in as they pass along the discharge port, thus resulting in discharge. This reciprocating or the pistons as the drive shaft rotates results in the pumping of the liquid.

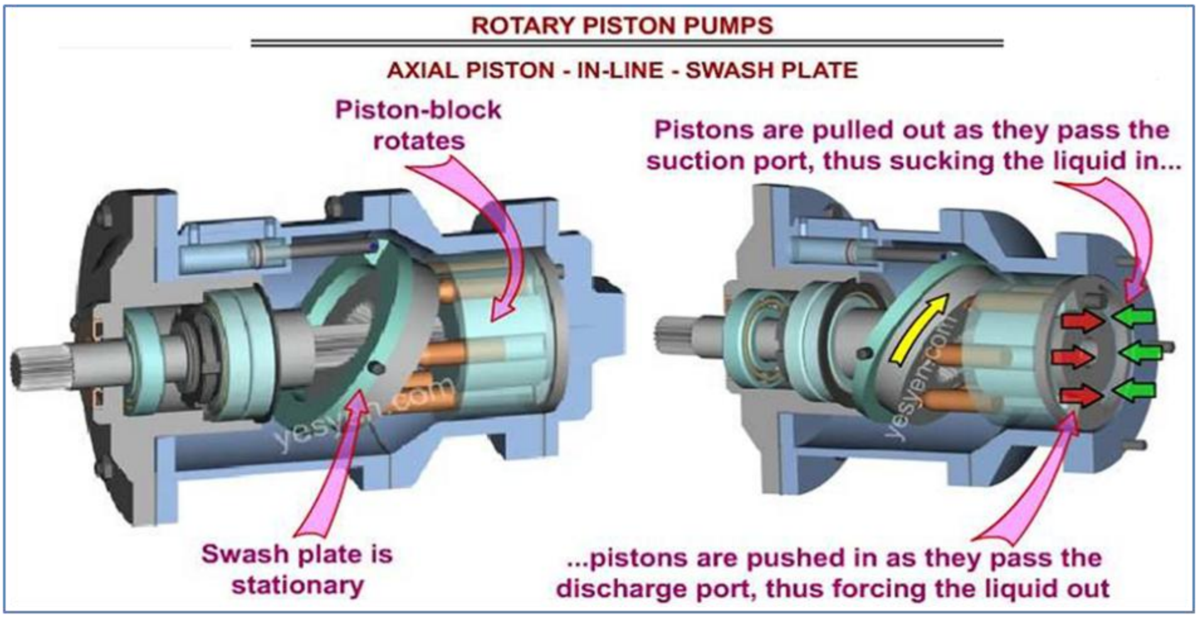

Fig .2.18 Axial piston - in-line - swash plate

5.3. Axial piston- in-line - wobble plate:

The cross-section of a typical wobble plate pump is depicted. Like the swash plate, this is also an in-line axial piston type of pump. There are several pistons (only two are shown} arranged parallel to each other inside slots in a piston-block. The drive shaft and the piston-block axis are in-line (collinear).

The pistons are made to bear against a wobble plate by using spring force. The wobble plate is inclined to the axis of rotation. The main difference in the working principle of the wobble plate pump when compared to the swash plate pump is that, here the piston-block remains stationary while it is the wobble plate that rotates

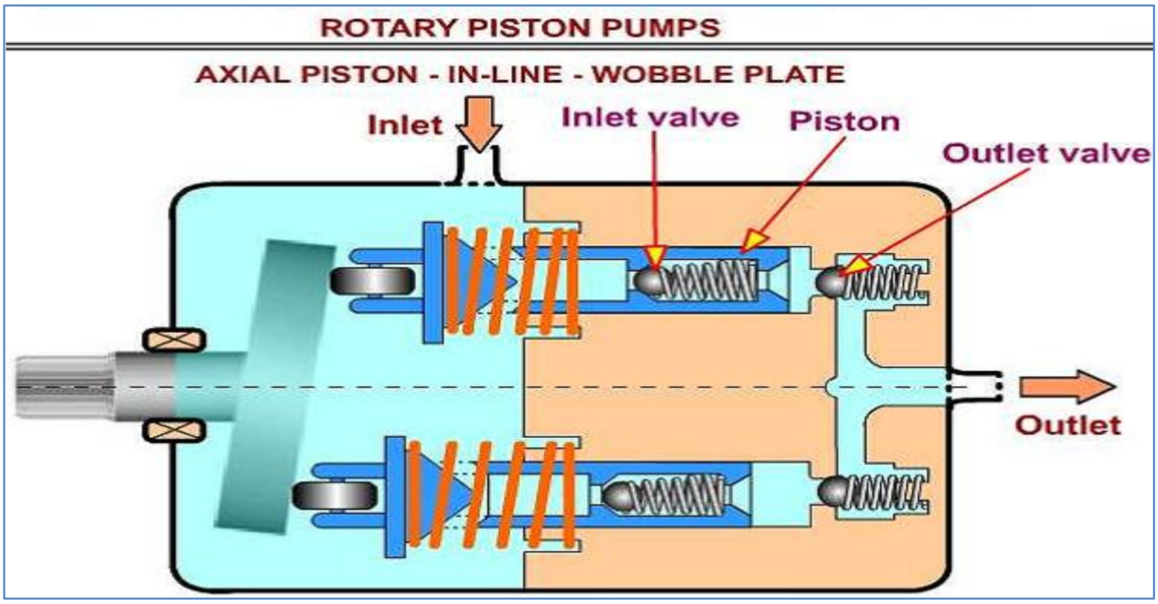

Fig .2.19 Axial piston- in-line - wobble plate pump

5.4. Axial piston bent axis:

Like the swash plate and wobble plate pump, this pump is also of the axial piston type. There are several pistons that are parallel to each other and reciprocate axially in a piston-block. However unlike the swash and wobble plate pumps, the drive shaft is inclined at all angle to 'the piston-block and hence the term 'bent axis".

The pistons are housed within slots in the piston-block and they are connected to the drive shaft flange. A universal link keys the piston-block to the drive shaft to maintain alignment and to assure that they rotate together.

As observed in the cut-section, the suction and discharge ports are semi-circular holes in the valve plate,

AS the driver shaft rotates, it transmits drive to the pistons and piston-block. At the suction side, along 'the direction of rotation, the distance between the piston-block and driver shaft-flange increases and the pistons are pulled out, thus resulting in suction. Alternately, the pistons are pushed in as they pass along the discharge port, thus resulting in discharge. This reciprocation of the pistons as the drive shaft rotates results in the pumping of the liquid.

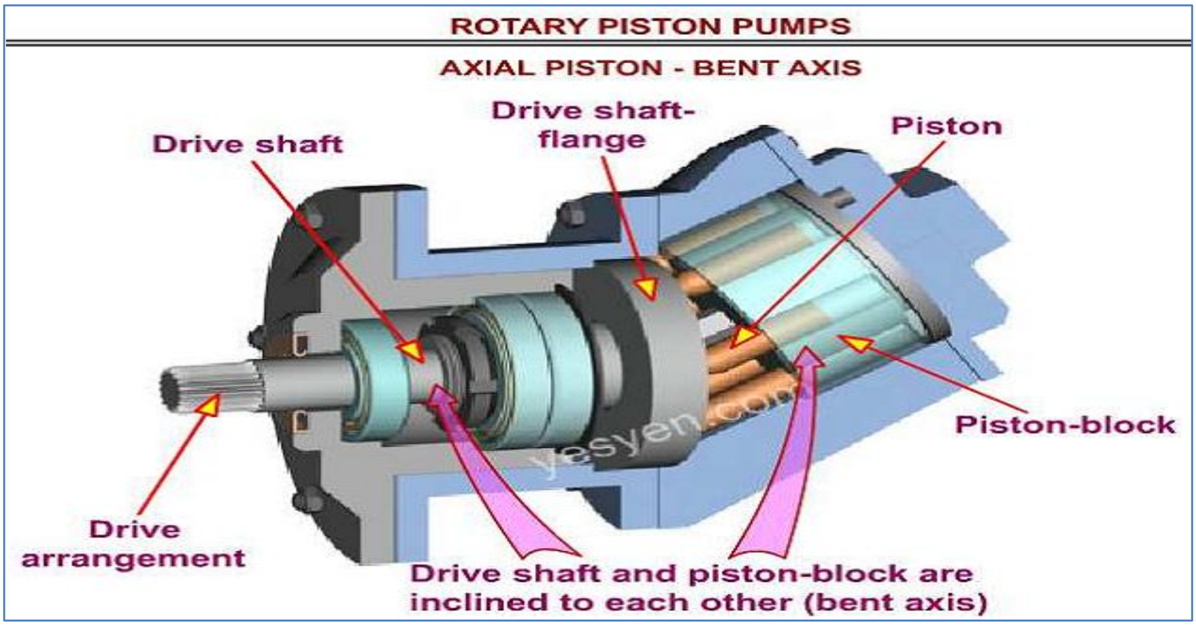

Fig .2.20 Axial piston bent axis pump

B.RECIPROCATING PISTON PUMPS

1.Piston pump

Piston pumps utilize a piston to reciprocate inside a cylinder to achieve the pumping action. The pistons have circumferential piston rings, to seal the piston top end from the bottom end. A piston rod connects the piston to the driving member. Piston pumps are either single-acting or double acting. In single acting pumps the liquid is pumped at only one end of the piston, while in double acting pumps the liquid is pumped at both ends resulting in two discharge strokes in one cycle. The pumps may be of a single cylinder or multicylincer design. Multicylincer pumps have two or more cylinders arranged in parallel for increased capacity. Piston pumps are well suited as power pumps, which have to deliver larger capacity at higher heads.

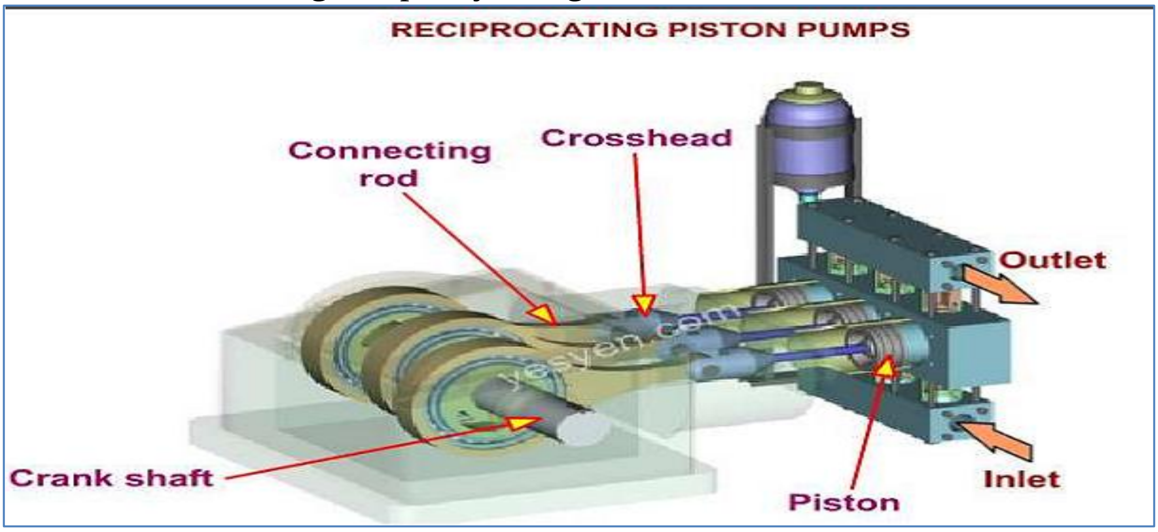

Fig .2.21 Piston pump

2.Plunger pump

Plunger pumps are similar in operation to piston pumps, except that they utilize constant-diameter plungers, which reciprocate through packing glands. The plungers are highly polished and made relatively long so that only very little liquid can escape through the clearances. They do not utilize piston rings as in piston pumps. Plunger pumps are always single-acting, that is, the liquid can be pumped at only one end of the piston. The pumps may be of a single cylinder or multicylincer design. Multicylincer pumps have two or more cylinders arranged in parallel for increased capacity. Plunger pumps are very much used in metering services and are also used as power pumps.

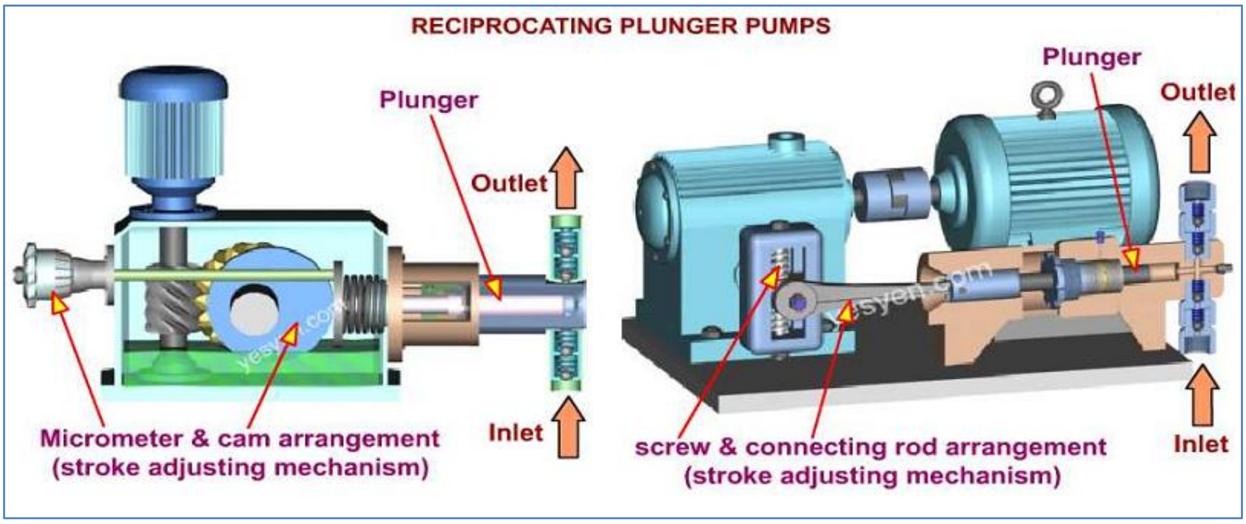

Fig .2.22 Plunger pump

3.Diaphragm pump

Diaphragm pumps perform similarity to piston I plunger pumps, but the reciprocating driving member is a flexible diaphragm fabricated of metal, rubber, or plastic, The diaphragm is flexed to-ano-fro, thus decreasing and increasing volume in a chamber, resulting in the liquid to get sucked inside and discharged alternately. The drive may be transmitted to the diaphragm by means of a reciprocating plunger (piston). The plunger can receive direct mechanical drive or may be driven by magnetic force .. In some designs, the diaphragm is hydraulically actuated by the reciprocation of a plunger in power oil. The diaphragm may also be pneumatically driven. These pumps offer a main advantage in that, the diaphragm completely eliminates all packing and seals exposed to the pumped liquid. Hence the pumps are very suitable to handle hazardous or toxic liquids. Diaphragm pumps are used in metering services and are also used as power pumps.

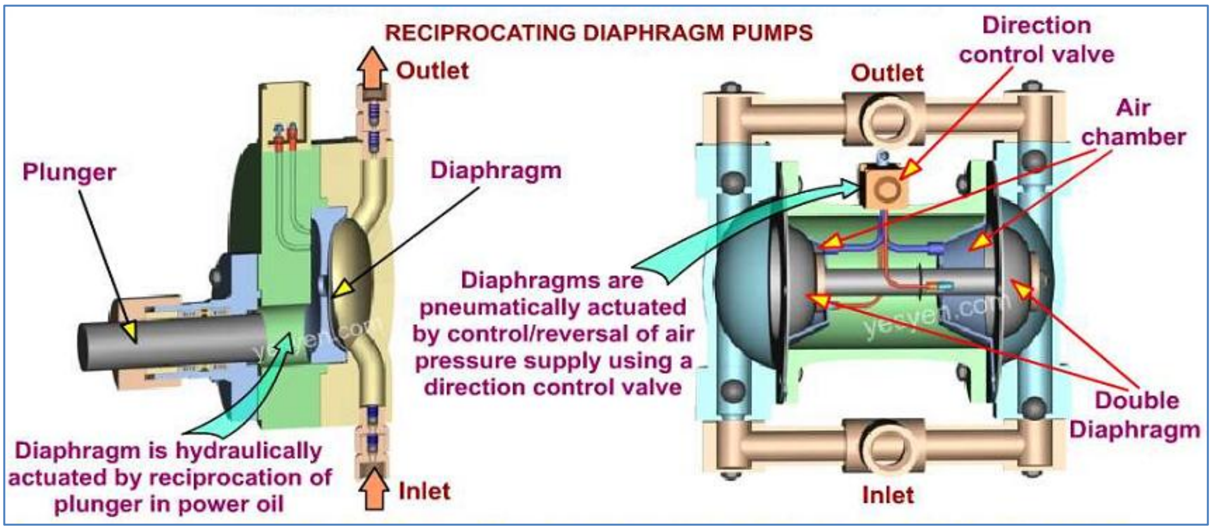

Fig .2.23 Diaphragm pump