

Topic 1. Basics of Oil Hydraulic Systems

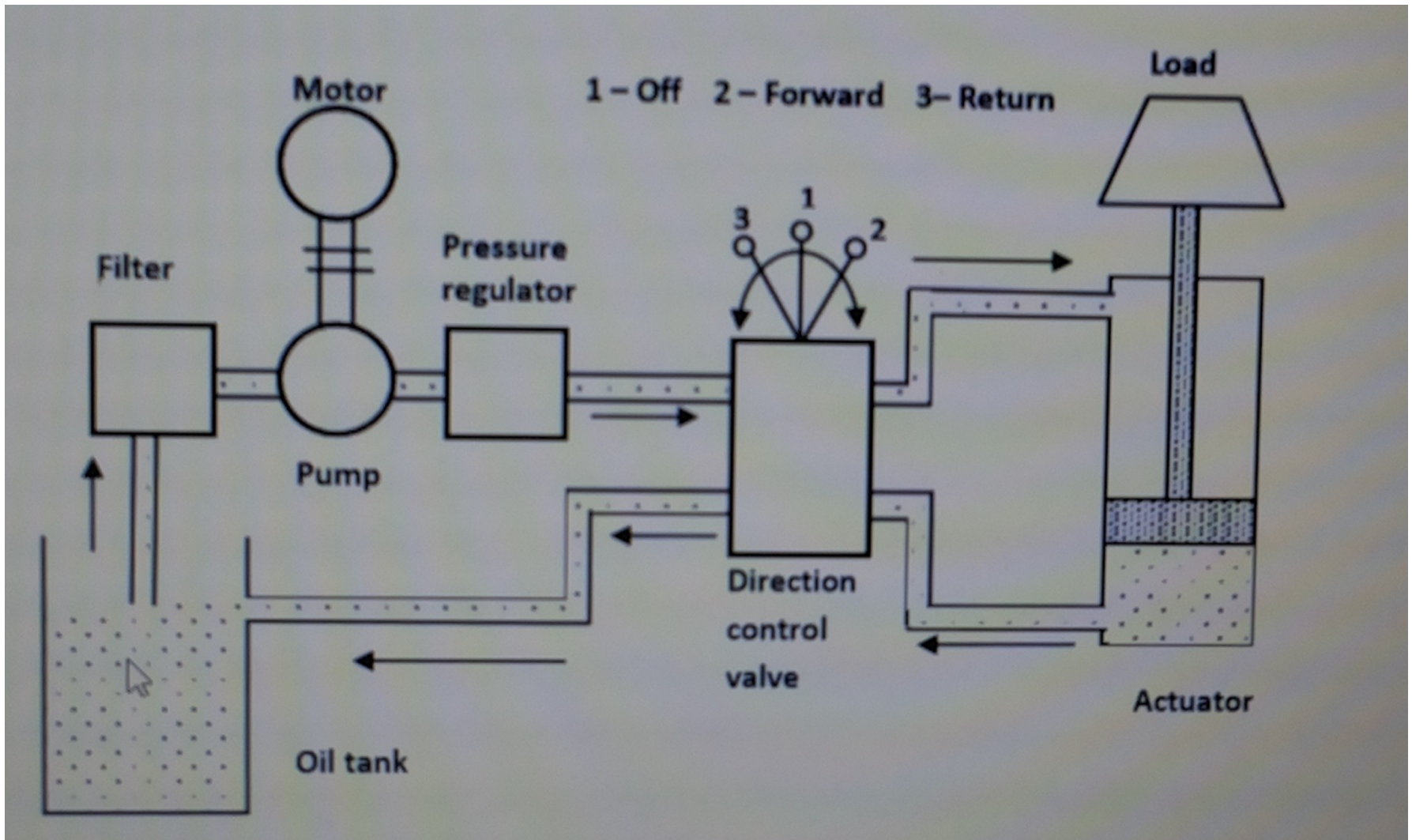
Fluid power

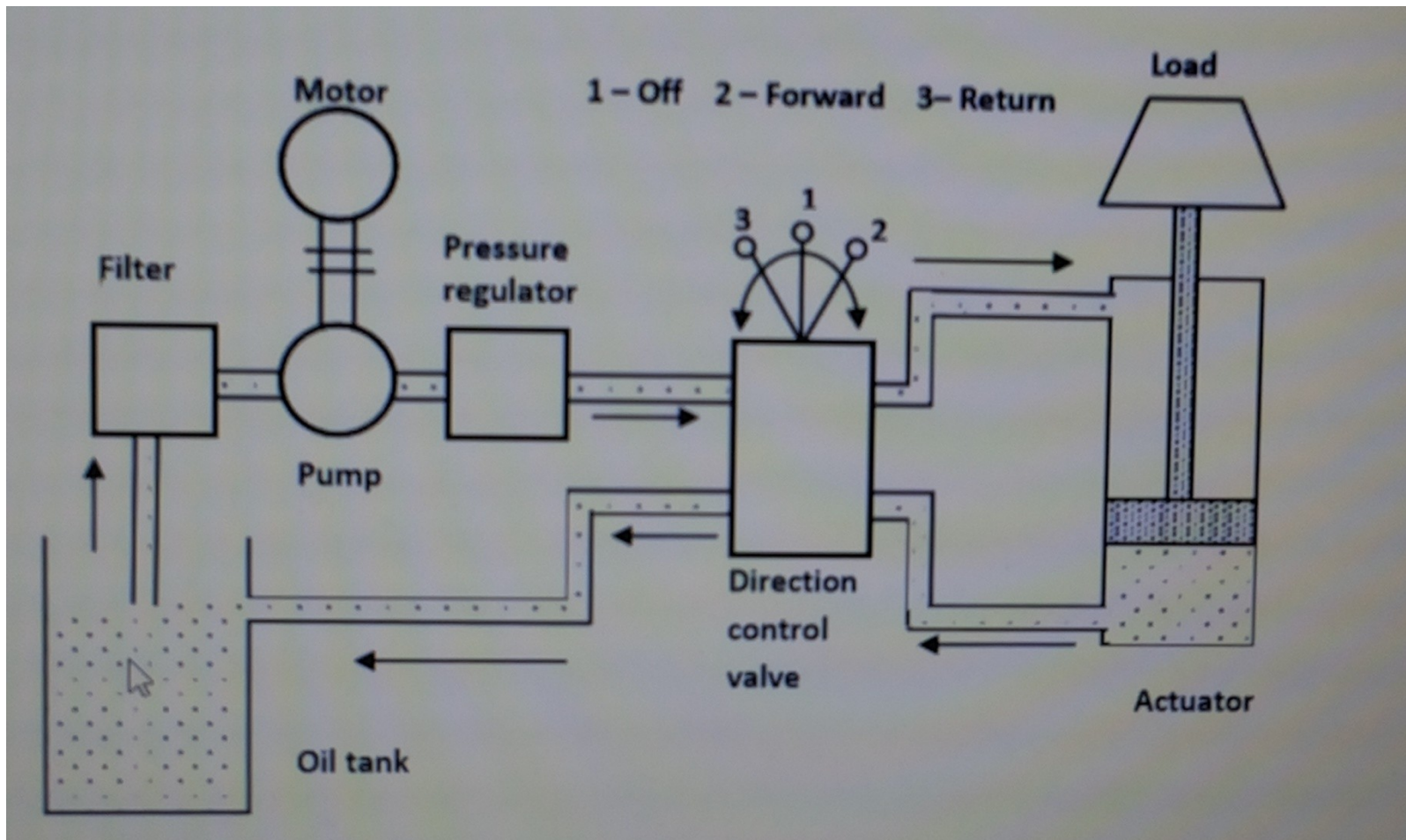
- Fluid power is the technology that deals with the generation, control and transmission of forces and movement of mechanical element or system with the use of pressurized fluids in a confined system.

Definition

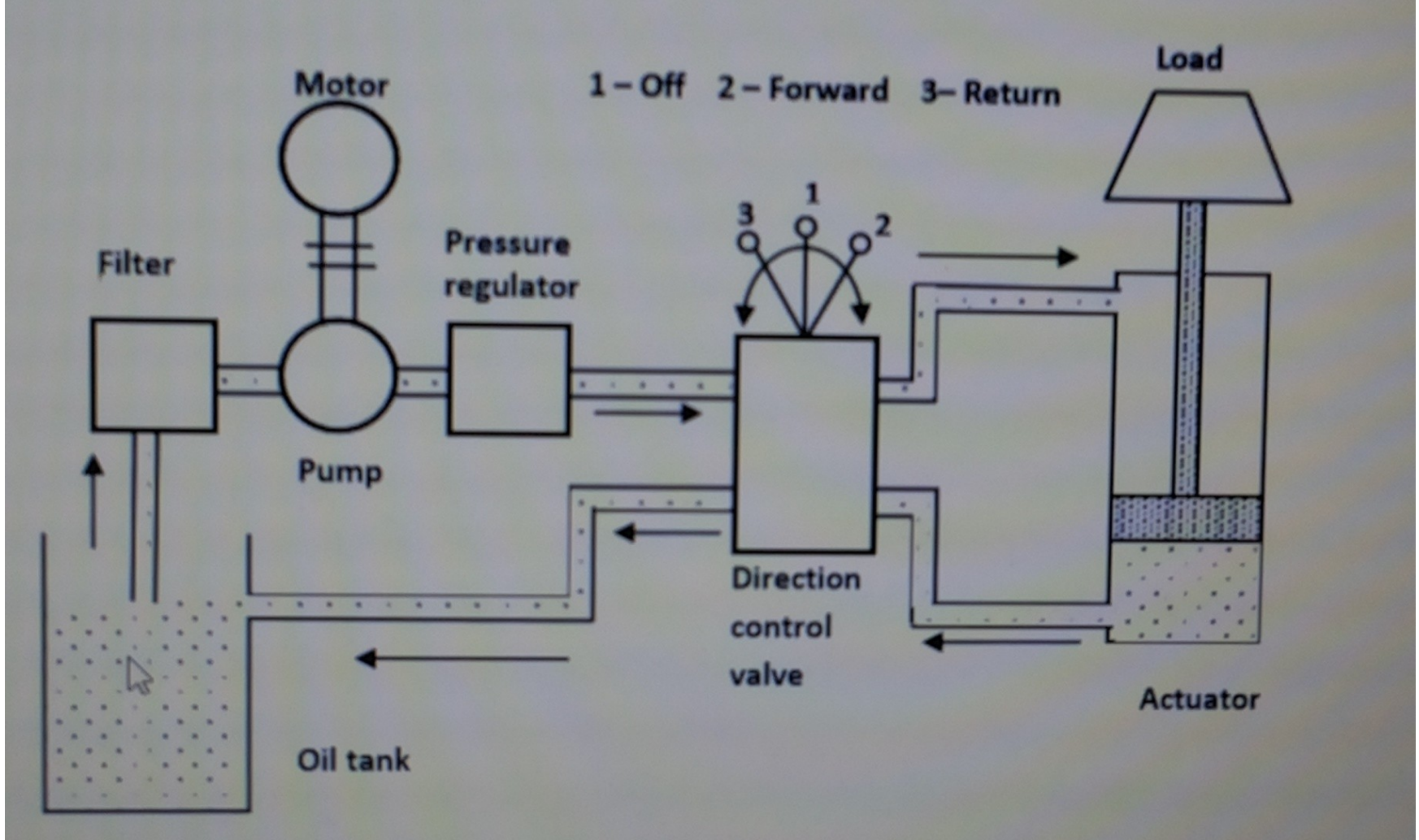
- It is the use of a confined fluid flowing under pressure to transmit power from one location to another.
- It is one of the three commonly used methods of transmitting power in an industrial setting.
- Others are Electrical and Mechanical power transmissions.
- Two of the most important advantages of fluid power transmission are its ability to multiply force and its flexibility to change direction quickly without damage to the system.

Basic Components of a Hydraulic System

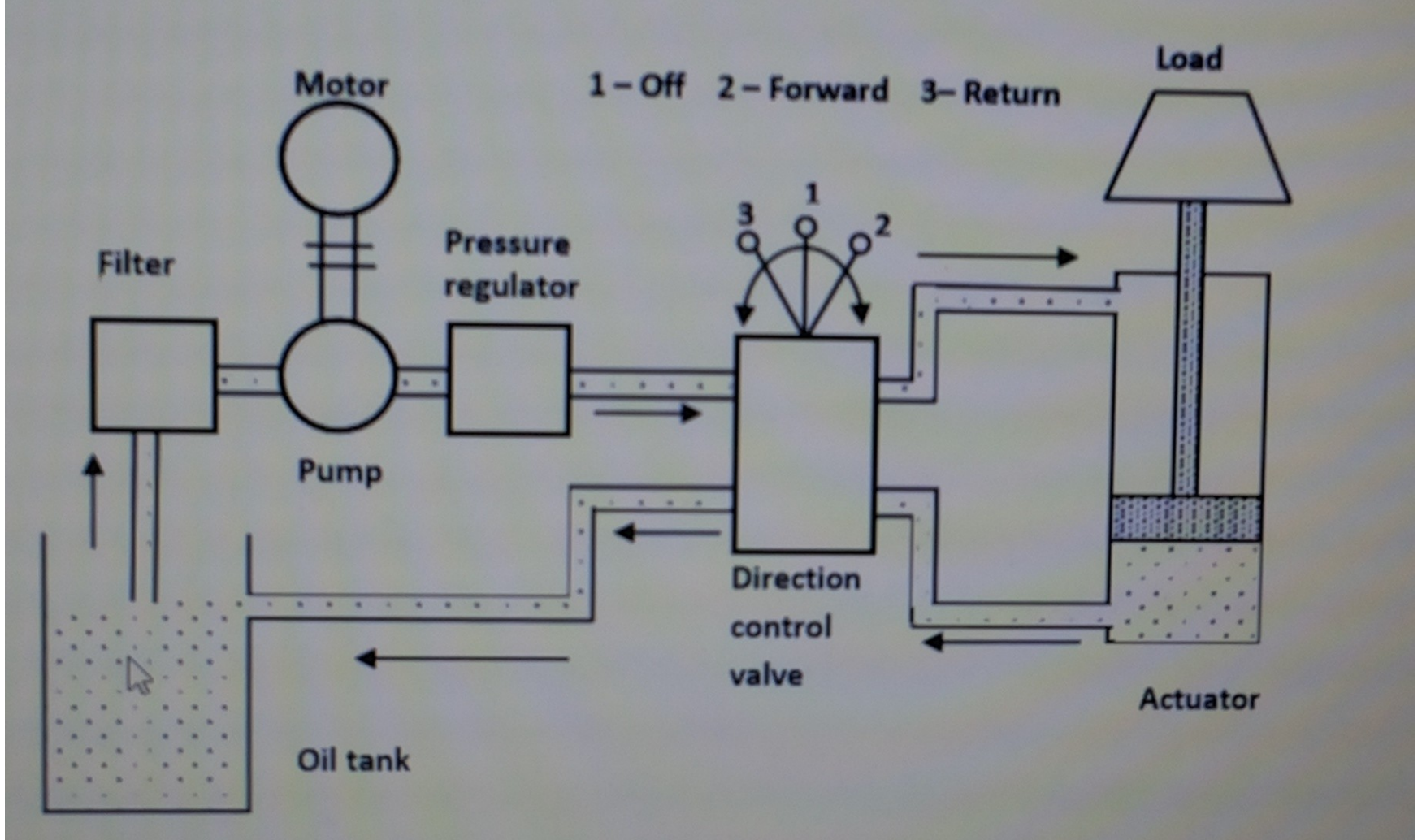




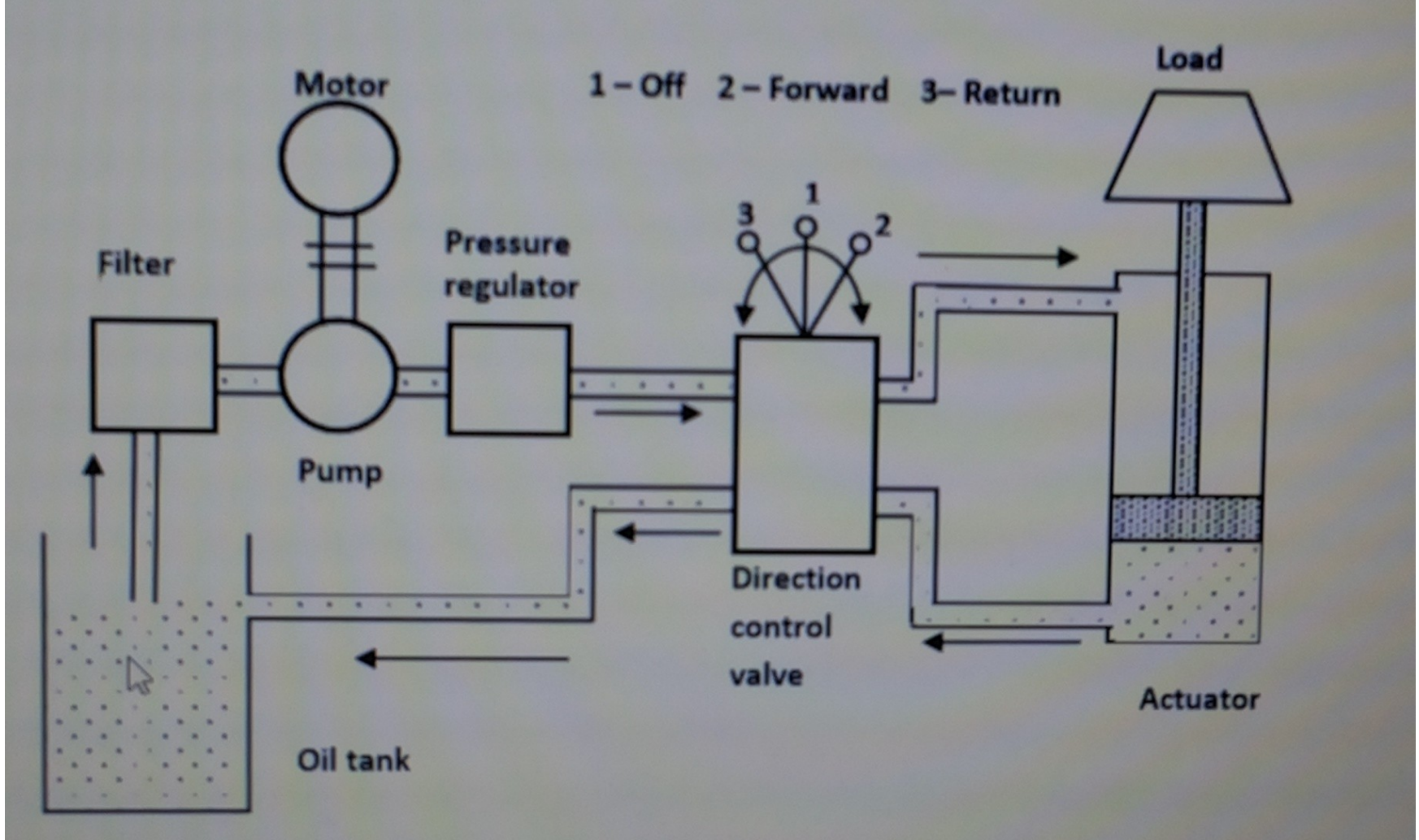
- 1. The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work.
- The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type (e.g., hydraulic motor) to provide linear or rotary motion, respectively.



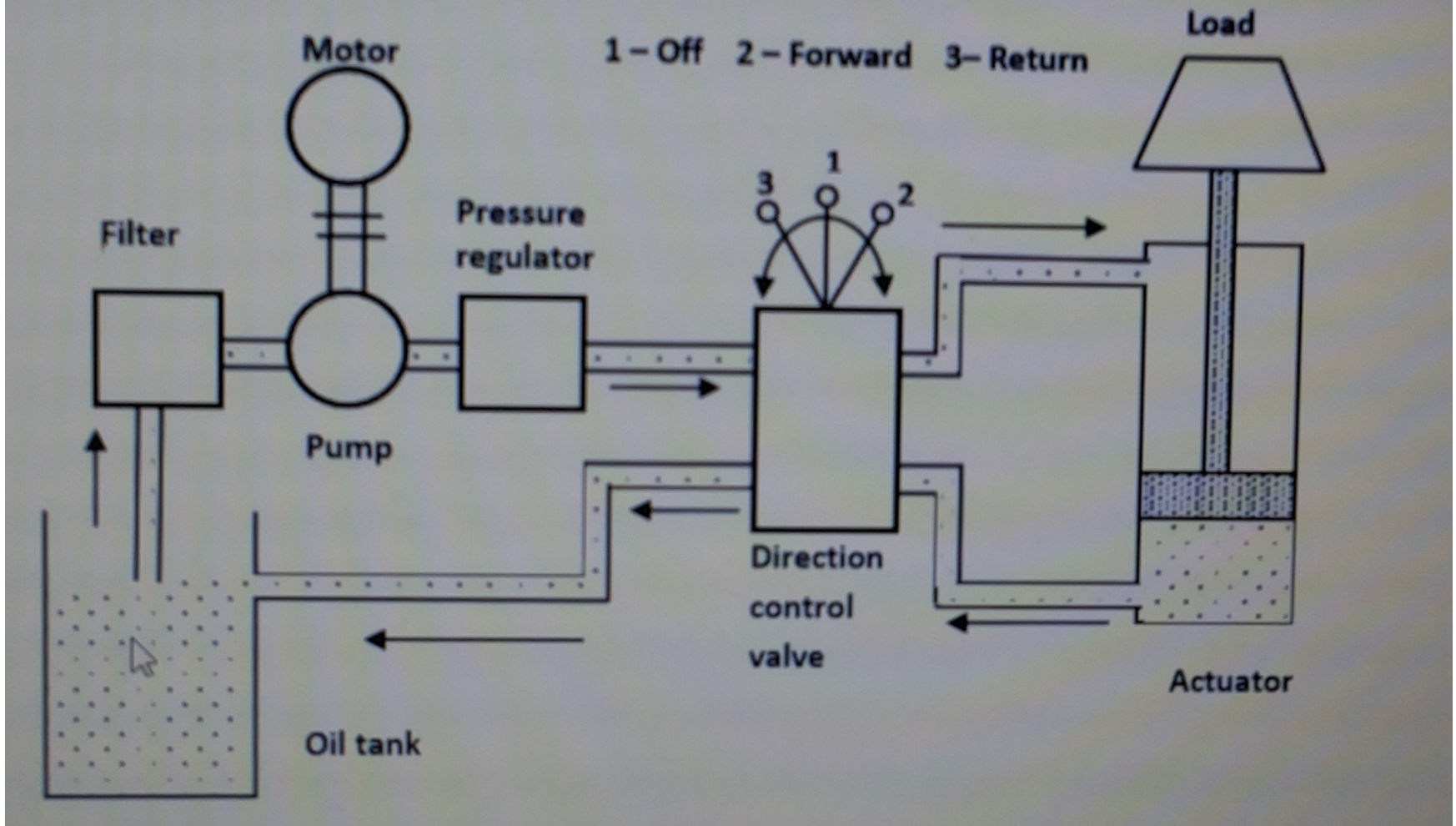
2. The hydraulic pump is used to force the fluid from the reservoir to rest of the hydraulic circuit by converting mechanical energy into hydraulic energy.



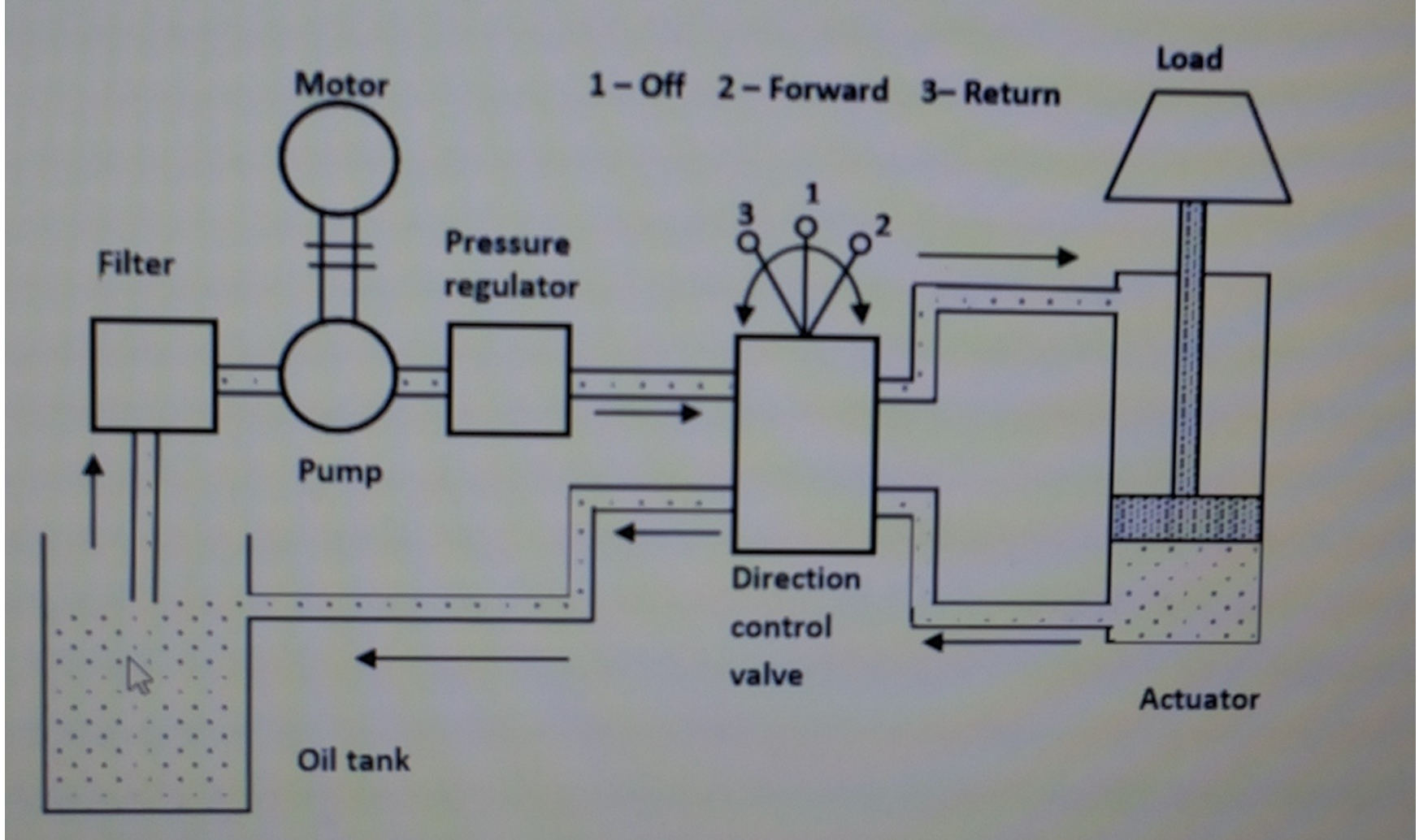
3. Valves are used to control the direction, pressure and flow rate of a fluid flowing through the circuit.



4. External power supply (motor) is required to drive the pump.
5. Reservoir is used to hold the hydraulic liquid, usually hydraulic oil.



6. Piping system carries the hydraulic oil from one place to another.
7. Filters are used to remove any foreign particles so as keep the fluid system clean and efficient, as well as avoid damage to the actuator and valves.



8. Pressure regulator regulates (i.e., maintains) the required level of pressure in the hydraulic fluid.

VIDEO 1

- Advantages of Hydraulic system
- 1. Large load capacity with almost high accuracy and precision.
- 2. Smooth movement.
- 3. Automatic lubricating provision to reduce to wear.
- 4. Division and distribution of hydraulic force are easily performed.
- 5. Limiting and balancing of hydraulic forces are easily performed.

Disadvantages of Hydraulic system

1. A hydraulic element needs to be machined to a high degree of precision.
2. Leakage of hydraulic oil poses a problem to hydraulic operators.
3. Special treatment is needed to protect them from rust, corrosion, dirt etc.,
4. Hydraulic oil may pose problems if it disintegrates due to aging and chemical deterioration.
5. Hydraulic oils are messy and almost highly flammable.

Important properties of hydraulic oils

- **Compressibility:**
- Liquids are incompressible in nature hence they are suitable for precise motion control.
- Hydraulic oil should have low compressibility for better performance.
- **Viscosity:**
- Oils with low viscosity flow easily but thick.
- Oil flows with some difficulty and result in pressure loss in the pipes and fittings.
- The low viscosity oil do not lubricate very well hence the right balance between pressure loss and lubricity is required while selecting oil viscosity.

- **Demulsibility**
- The ability of oil to resist with mixing with water is known as Demulsibility.
- **Low foaming tendency:**
- A good hydraulic fluid will not absorb air easily and will release it quickly without causing foam.
- **Oxidation:**
- Oxidation causes the oil to thicken and produces varnishes which strain the component surface.
- **It reduces life of oil.**
- **Chemicals may be added to improve oxidation of oil.**

- **Good heat dissipation**
- The oil should carry out the heat generated and dissipate to the atmosphere easily and at faster rate.
- **Wear resistant (good lubricity)**
- Chemicals are added to improve wear resistance of oil for reduction of wear during contact with moving components.
- **Corrosion resistance**
- The oil should have high corrosion resistance to eliminate the problems related to corrosion.

- **Pour points**
- It is important during low temperature application in cold climates.
- The oil should have low pour point temperature.
- **Flash point**
- It is the temperature at which vapor of oil given off when in contact with flame.
- It is required for high temperature application.
- **Non toxic , easy to handle and easily available:**
- Hydraulic oil should be nontoxic for safe use and handling.
- It should be easily available at economic price.

Applications

- Automobile power steering,
- brakes,
- aircraft landing gear
- lift trucks,
- front end loaders





Pumps

Rotary pumps are positive displacement pumps. The rate of flow (discharge) of rotary pump remains constant irrespective of the pressure.

That is, even at very high pressure, these pumps can give the same amount of discharge.

They can develop very high-pressure up to 1000 bar or even more.

The discharge/pressure of rotary pumps is smooth, not pulsating.

Very less vibration and noise is observed with these pumps.

Hence these pumps are well suited for oil hydraulic machineries, such as, earth moving machines, metal cutting machines, and many automatically controlled machines.

Basically, there are three types of rotary pumps.
They are gear pumps, vane pumps and piston pumps.
And further, they are again classified into sub-groups, which is as given below.

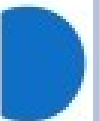
CLASSIFICATION of ROTARY PUMPS:

Gear pumps: External gear pump,
Internal gear pump,
Lobe pump ,
Ge-rotor pump,
Screw pump.

Vane pump: Unbalanced vane pump
Balanced vane pump

Piston pump: Axial piston pumps
Straight axis piston pump
Bent axis piston pump
Radial piston pumps
Stationary cylinder type
Rotating cylinder type

VANE PUMPS



UNBALANCED TYPE VANE PUMP:

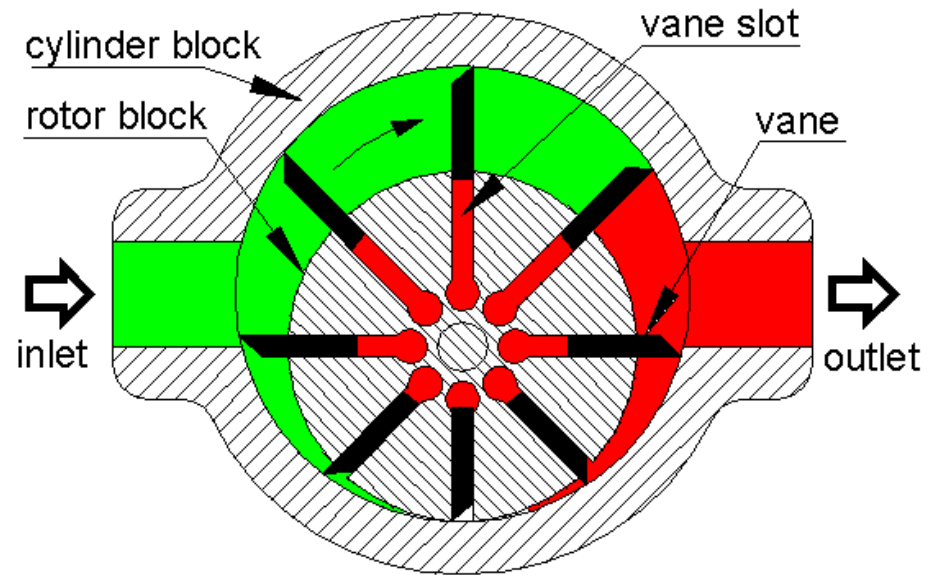
It consists of a cylindrical rotor, which is mounted with an offset inside a circular casing.

The vanes are seated in the radial slots of the rotor and held against the casing by spring or hydraulic force.

Hence there will not be any leakage of oil between the vane tips and the casing.

But still, there is some leakage of oil between the rotor faces and the body sides.

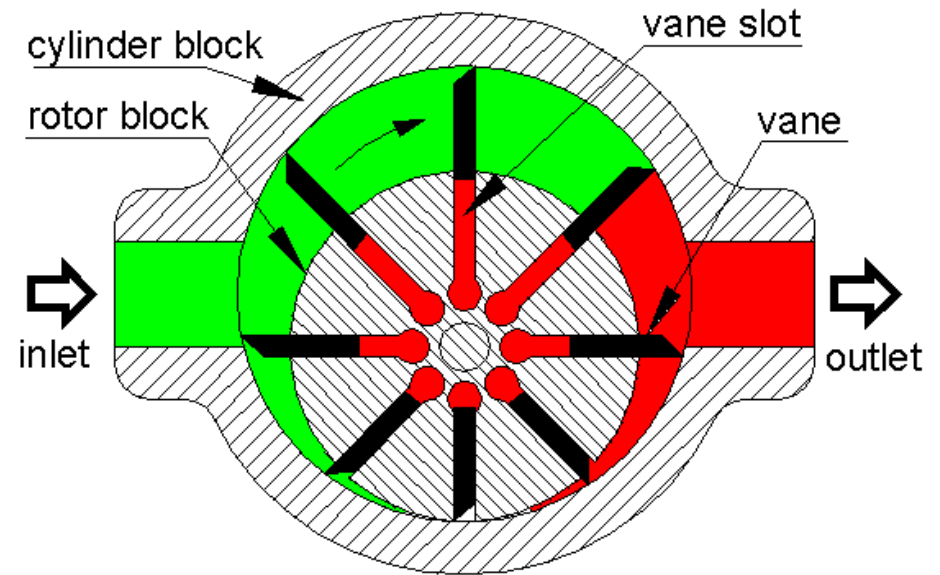
Hence its volumetric efficiency will be around 95%.



UNBALANCED TYPE VANE PUMP:

As the rotor rotates, the vanes carry the liquid from inlet port to outlet port.

The difference in pressure between inlet and outlet ports create a side thrust on the rotor shaft, which consequently load bearings.



VIDEO 2


- ***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
- Develops good vacuum

- ***Disadvantages***

- Complex housing and many parts
- Not suitable for high pressures
- Not suitable for high viscosity
- Not good with abrasives

- ***Applications***
- Aerosol and Propellants
- Aviation Service - Fuel Transfer, Deicing
- Auto Industry - Fuels, Lubes, Refrigeration Coolants
- Bulk Transfer of LPG and NH_3
- LPG Cylinder Filling
- Alcohols
- Refrigeration - Freon's, Ammonia
- Solvents
- Aqueous solutions

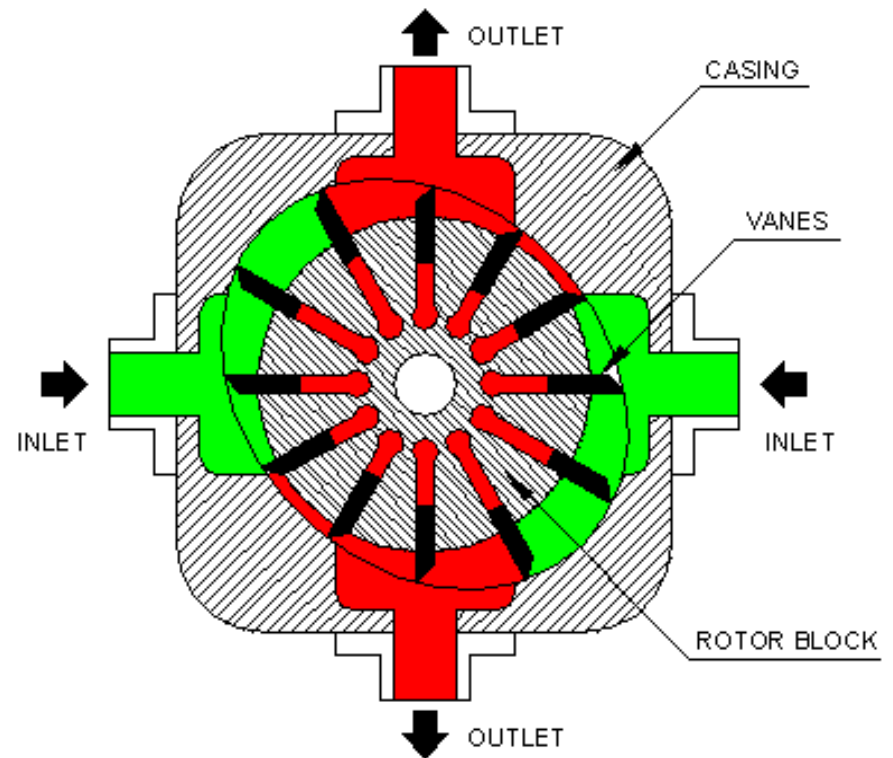
- ***Materials Of Construction / Configuration Options***
- **Externals (head, casing)** - Cast iron, ductile iron, steel, and stainless steel.
- **Vane, Pushrods** - Carbon graphite, PEEK .
- **End Plates** - Carbon graphite
- **Shaft Seal** - Component mechanical seals, industry-standard cartridge mechanical seals, and magnetically-driven pumps.
- **Packing** - Available from some vendors, but not usually recommended for thin liquid service
-
- ***Manufacturers***
- [Viking Pump, Inc.](#)
- [Corken, Inc.](#)

BALANCED TYPE VANE PUMP:

In this type of pump two inlets and two outlets are employed.

The center axis of the rotor and that of the elliptical casing are the same.

Pressure loading still occurs, but the two identical halves of the pump created equal but opposite loads on the pump shafts and bearing.

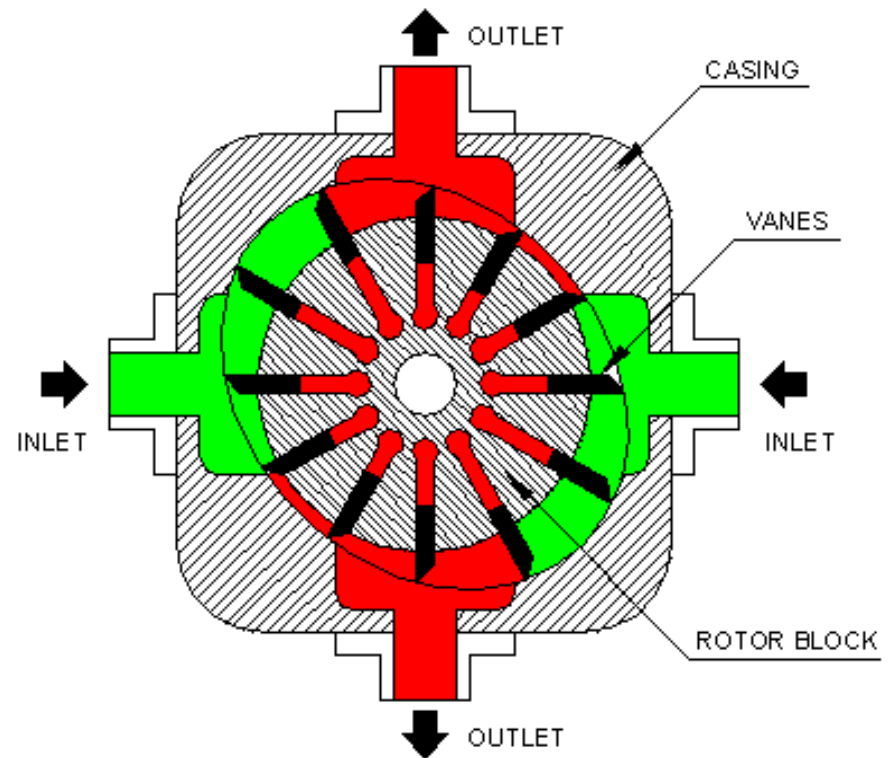


BALANCED TYPE VANE PUMP:

Hence, balanced vane pump gives better service and larger life compared to unbalanced type vane pump.

Capacity and pressure ratings of vane pumps are less than that of gear pumps.

VIDEO 3



Advantage and application

Applications

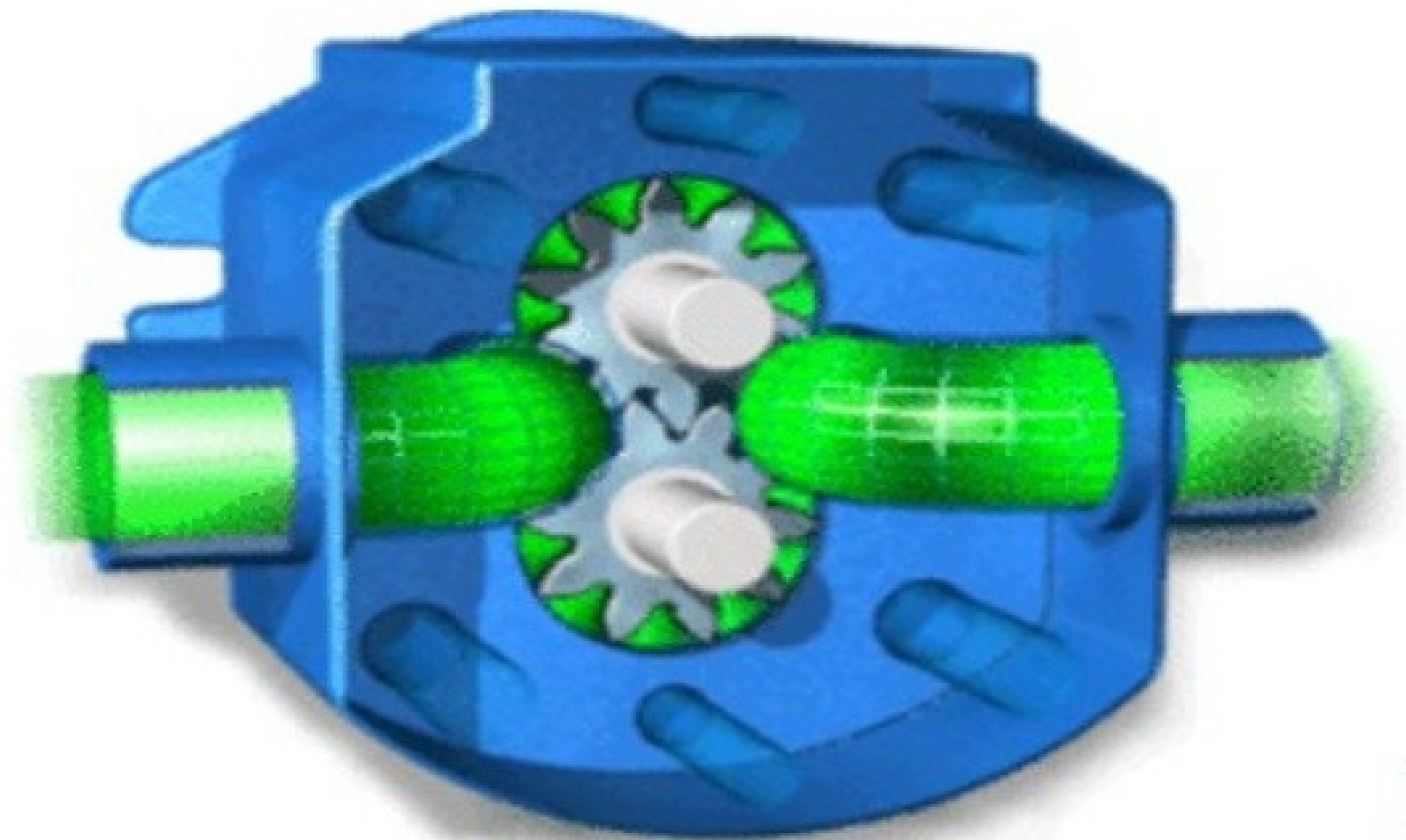
Unbalanced vane pumps are generally used for pressure up to 100 kg/ cm², while balanced vane pumps can be used for pressure up to 180 kg / cm².

These pumps are also built as single, double and triple pumps and find similar applications as the gear pumps. Volumetric efficiency of vane pumps is about 90%.

Advantages

1. Low cost with respect to power output.
2. Less noisy.
3. Long service life.
4. Variable delivery and pressure compensation features are possible

EXTERNAL GEAR PUMP



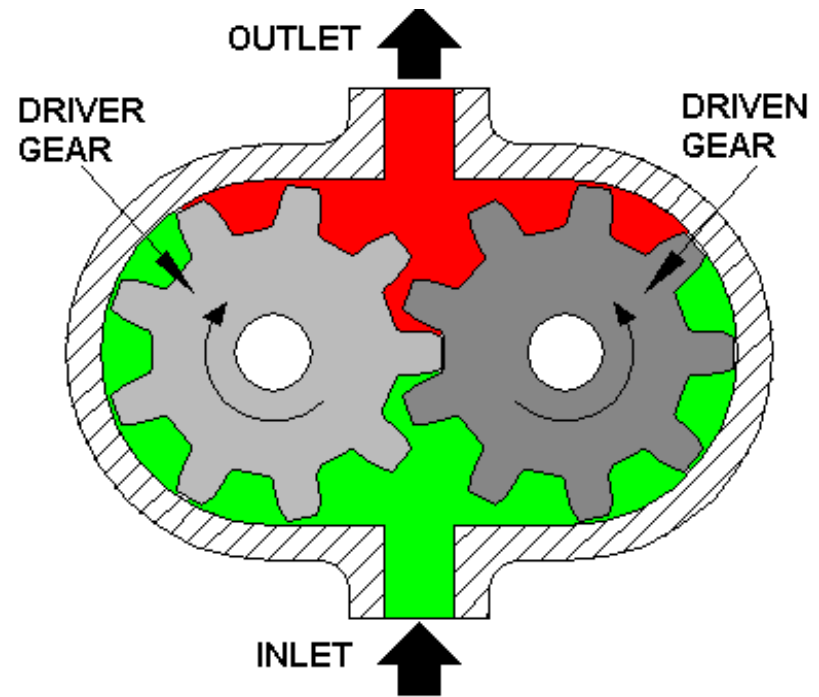
EXTERNAL GEAR PUMP:

External gear pump consists of two spur or helical gears, which are in mesh with each other, and mounted inside the casing.

One is driver and other is driven.

When the driver is rotated by means of any prime mover (i.e. electrical motor), driven will also rotate.

Oil is trapped in the pockets between teeth and the casing, and carried towards the outlet port.



Gear pumps can produce pressure up to 200 bars.

Volumetric efficiency of gear pumps is about 80%.

VIDEO 4

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

INTERNAL GEAR PUMP

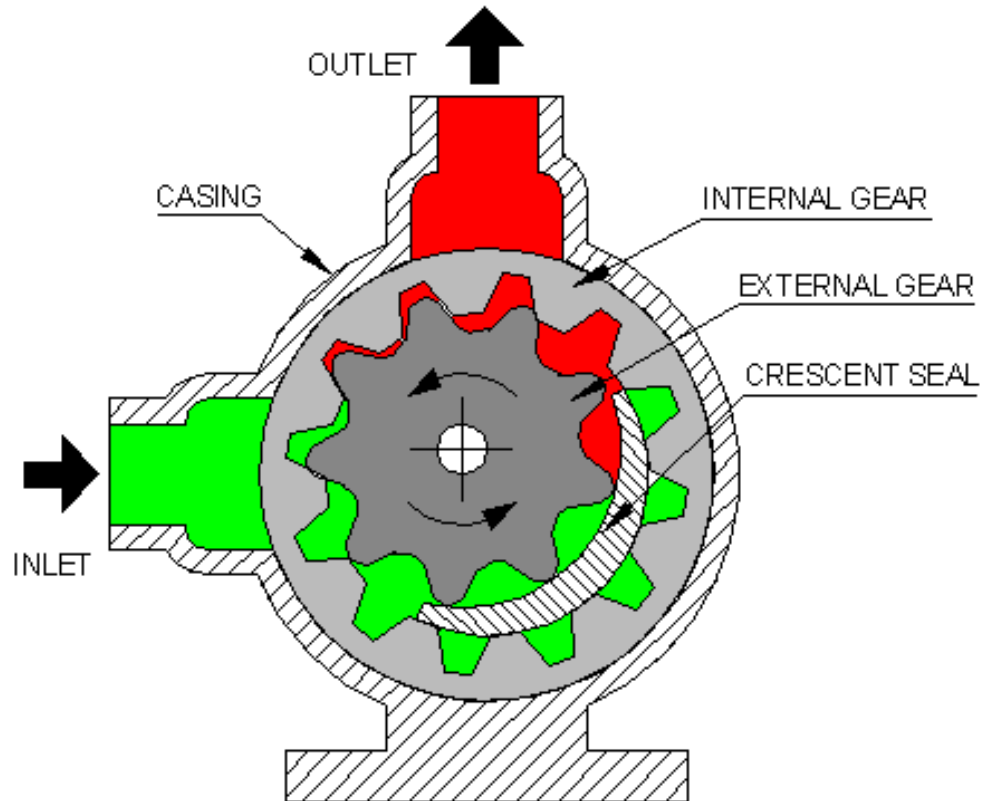
It has two gears, one is having external teeth and the other is having internal teeth.

The external gear is inside the internal gear.

The two gears are in mesh with each other.

A crescent seal is provided between these two gears, which fills the gap between the two gears.

Oil fills in the pockets between the teeth, crescent seal and the casing, and carried along with the gear towards outlet and finally delivered at outlet port.



VIDEO 5

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

Disadvantages:

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

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

Materials Of Construction / Configuration Options

- **Externals (head, casing, bracket)** - Cast iron, ductile iron, steel, stainless steel, Alloy 20, and higher alloys.
- **Internals (rotor, idler)** - Cast iron, ductile iron, steel, stainless steel, Alloy 20, and higher alloys.
- **Bushing** - Carbon graphite, bronze, silicon carbide, tungsten carbide, ceramic, colomony, and other specials materials as needed.
- **Packing** - Impregnated packing, if seal not required.

Gear Pumps are generally used for:

1. **PETROCHEMICALS:** Pure or filled bitumen, pitch, diesel oil, crude oil, lube oil etc.
2. **CHEMICALS:** Sodium silicate, acids, plastics, mixed chemicals, isocyanates etc.
3. **PAINT & INK.**
4. **RESINS & ADHESIVES.**
5. **PULP & PAPER:** acid, soap, lye, black liquor, kaolin, lime, latex, sludge etc.
6. **FOOD:** Chocolate, cacao butter, fillers, sugar, vegetable fats and oils, molasses, animal food etc.

- ***Manufacturers***
- [Viking Pump, Inc.](#)
- [Viking Pump \(Europe\) Ltd.](#)
- [Micropump, Inc.](#)

GEROTOR PUMP



GENERATED ROTOR PUMP. (GE-ROTOR) PUMP.

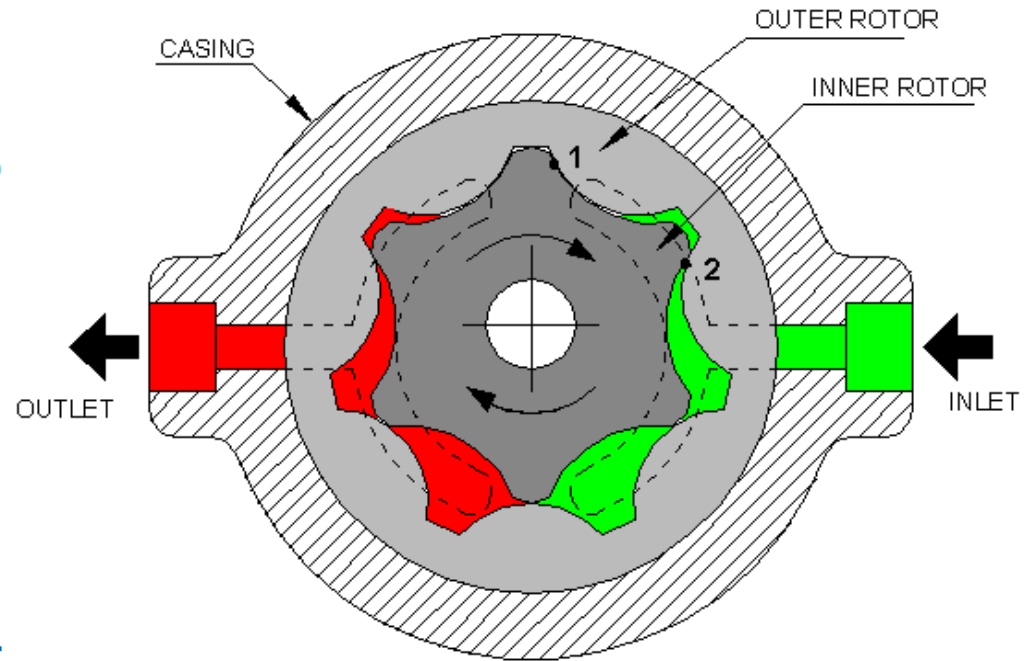
This pump has two generated rotors as shown in the figure.

One is having external teeth and other is having internal teeth.

The rotor with external teeth rotates inside the rotor having internal teeth.

The inner rotor is having one tooth less than that of outer rotor.

The inner rotor is driver to which, the shaft of any prime mover is coupled.



GENERATED ROTOR PUMP. (GE-ROTOR) PUMP.

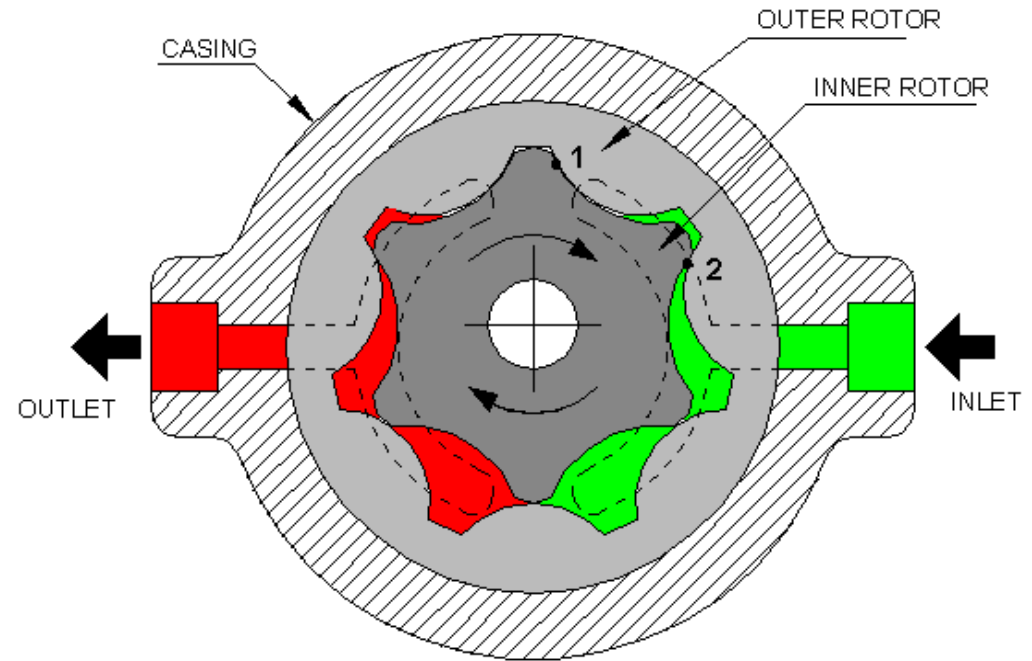
Consider the gap (1-2) between the rotors as a pocket.

The size of the pocket goes on increasing as the rotor rotates.

Thus more and more oil fills in the pocket.

After 180° of rotations, further rotation causes the size of the pocket to reduce, causing the oil to flow out of the pocket.

Thus, from each pocket, oil is sucked in from inlet port during first half of rotation and oil is delivered to outlet port during the next half.



There are six such pockets; three of them are performing suction and while the remaining three are delivering the oil. Hence the flow is continuous.

- VIDEO 6

- ***Advantages***

- High Speed
- Only two moving parts
- Constant and even discharge regardless of pressure conditions
- Operates well in either direction
- Quiet operation
- Can be made to operate with one direction of flow with either rotation

- ***Disadvantages***

- Medium pressure limitations
- Fixed clearances
- No solids allowed
- One bearing runs in the product pumped
- Overhung load on shaft bearing

- ***Applications***

- Common gerotor pump applications include, but are not limited to:
 - Light fuel oils
 - Lube oil
 - Cooking oils
 - Hydraulic fluid
 -

- ***Materials Of Construction / Configuration Options***

- **Externals (head, casing)** - Cast iron
- **Internals (rotor, idler)** - Steel
- **Bushing** - Carbon graphite, bronze, and other materials as needed
- **Shaft Seal** - Lip seals, component mechanical seals
- **Packing** - Not commonly used for gerotor pumps
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- ***Manufacturers***

- Viking Pump Inc.

SCREW PUMP

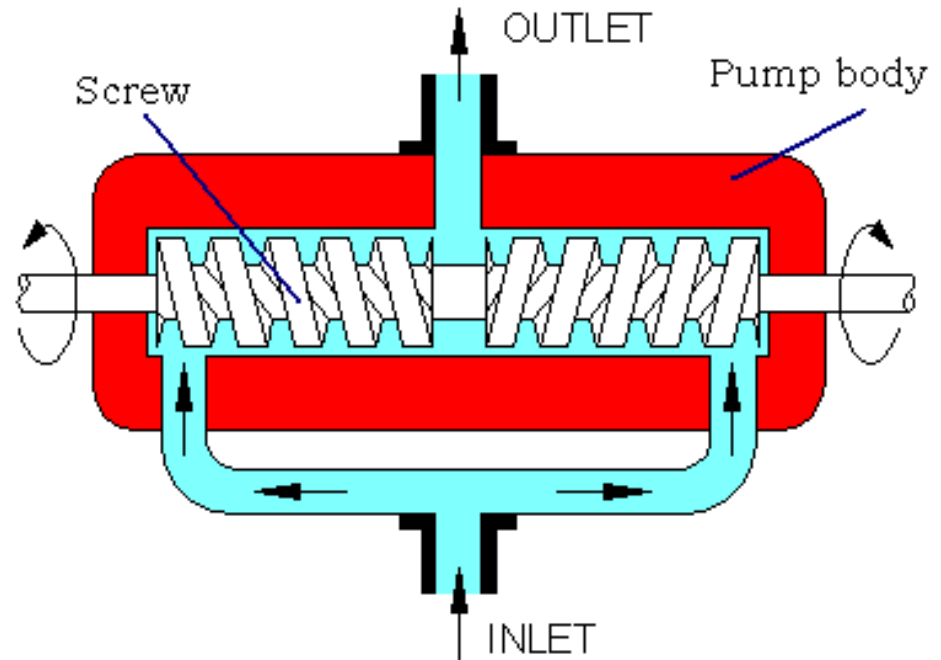


SCREW PUMP:

The screw pump is a positive displacement pump, which comes with two or three screws.

(A single screw version is called a "progressing cavity" pump shown in figure.)

Each shaft has a left-hand screw and a right-hand screw, for hydraulic pressure balance.

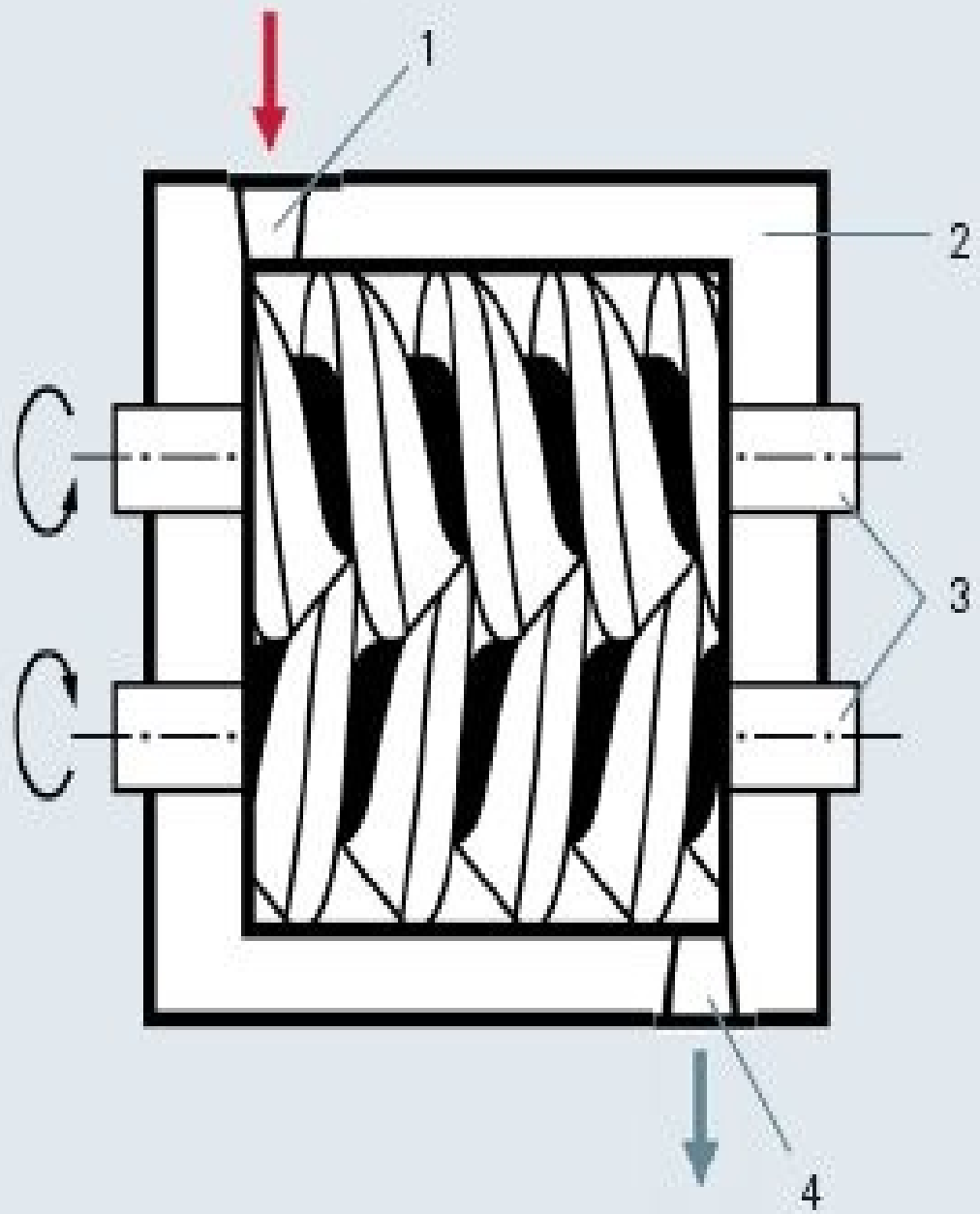


The inlet is at each end and the outlet is in the middle.

While running, liquid fills in the gap between the screws and the casing and moves it along with the screws from inlet to outlet.

Screw pumps are used in lubricating systems.

They have no valves or small parts to wear out or break. Hence maintenance cost is less and has more life.



- 1) Inlet
- 2) Housing
- 3) Screw rotors
- 4) Outlet

- **Material used in making different parts of the screw pump**

- Followings parts are made with the metals described below:

- Casing: Generally made of cast iron.

- Screw shafts: Made of high grade carbon steel.

- Bearings: High speed steels.

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- **Applications of Screw pump**

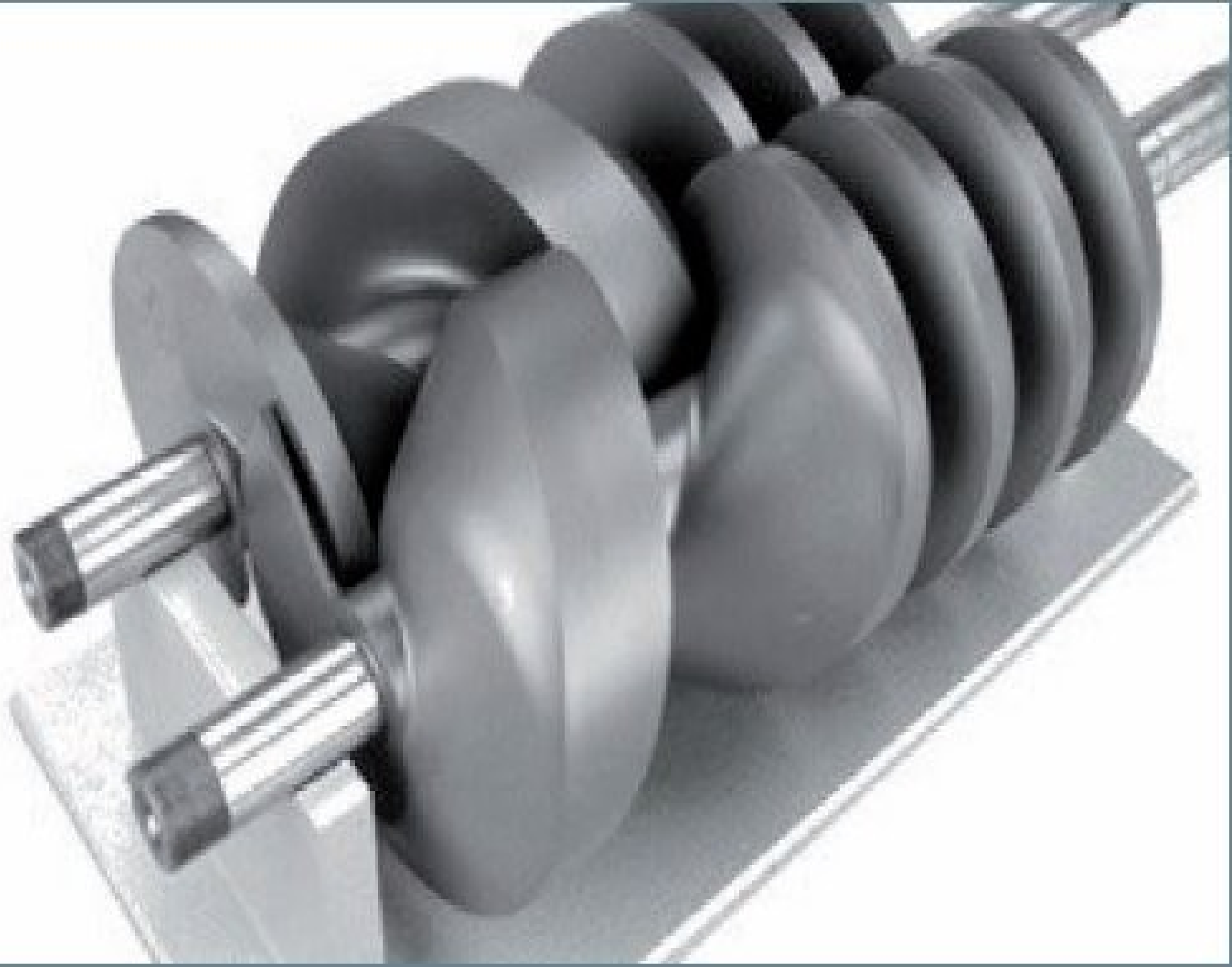
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- Normal the screw is used for pumping the high viscous fluids.

- They are also used for draining out the tanks having high vapor pressure liquids.

- They are used to take the water from the stern tube area, if there leakage there.

- So these are some of the uses of the screw pump.



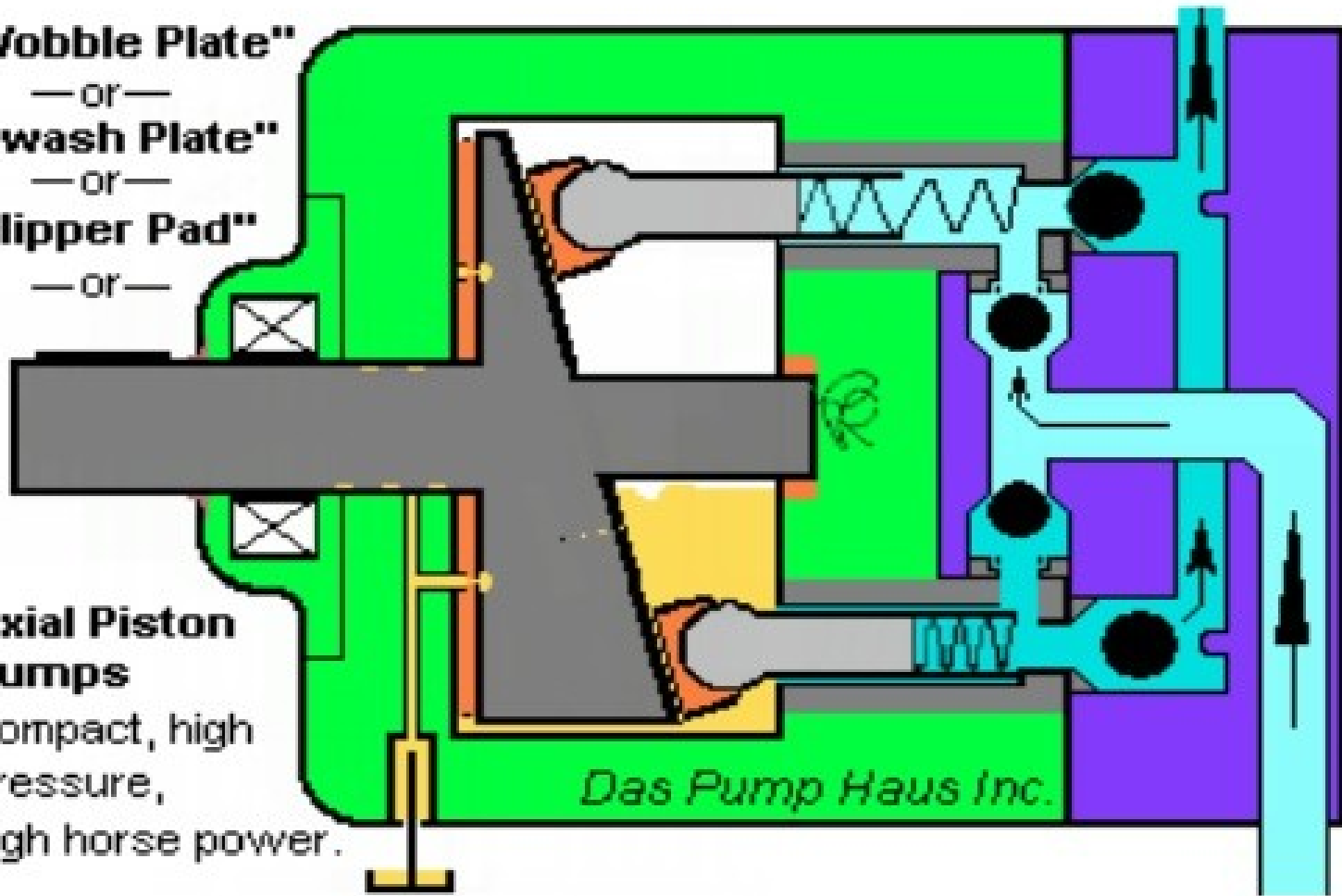
VIDEO 7

AXIAL PISTON PUMP

"Wobble Plate"
— or —

"Swash Plate"
— or —

"Slipper Pad"
— or —



**Axial Piston
Pumps**

Compact, high
pressure,
high horse power.

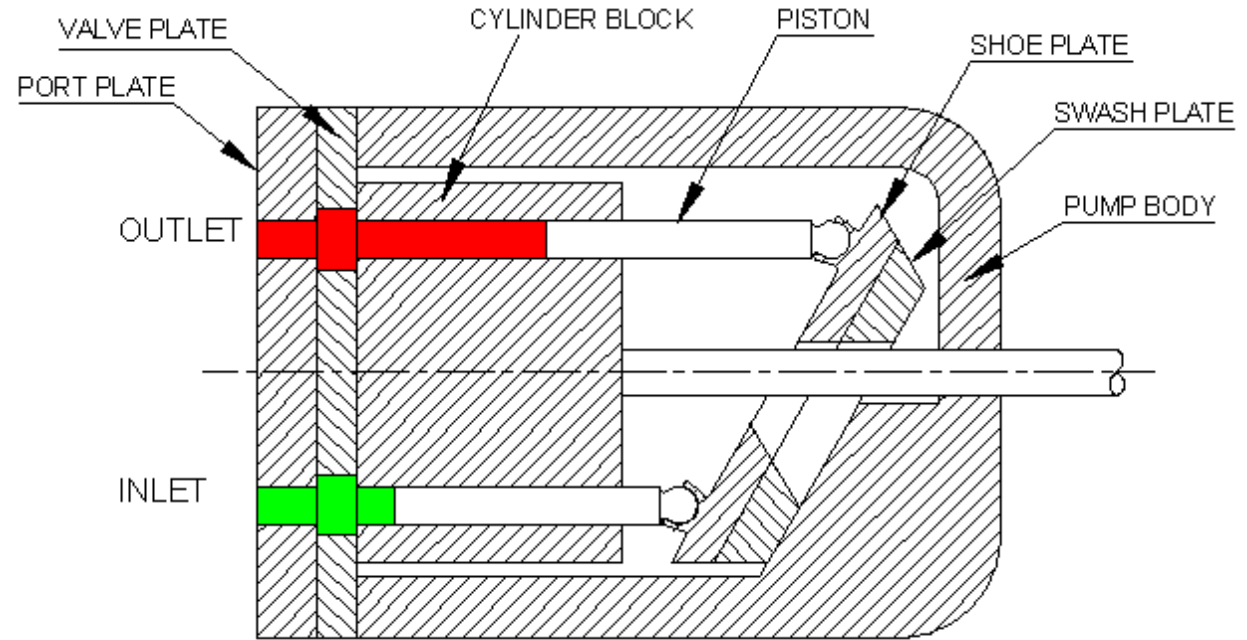


STRAIGHT AXIS PISTON PUMP:

In this pump, cylinder block is fitted to the drive shaft.

The shoe plate is mounted on a swash plate, which is fixed at an angle to the axis of rotation.

The angle of swash plate can be varied to change the discharge.



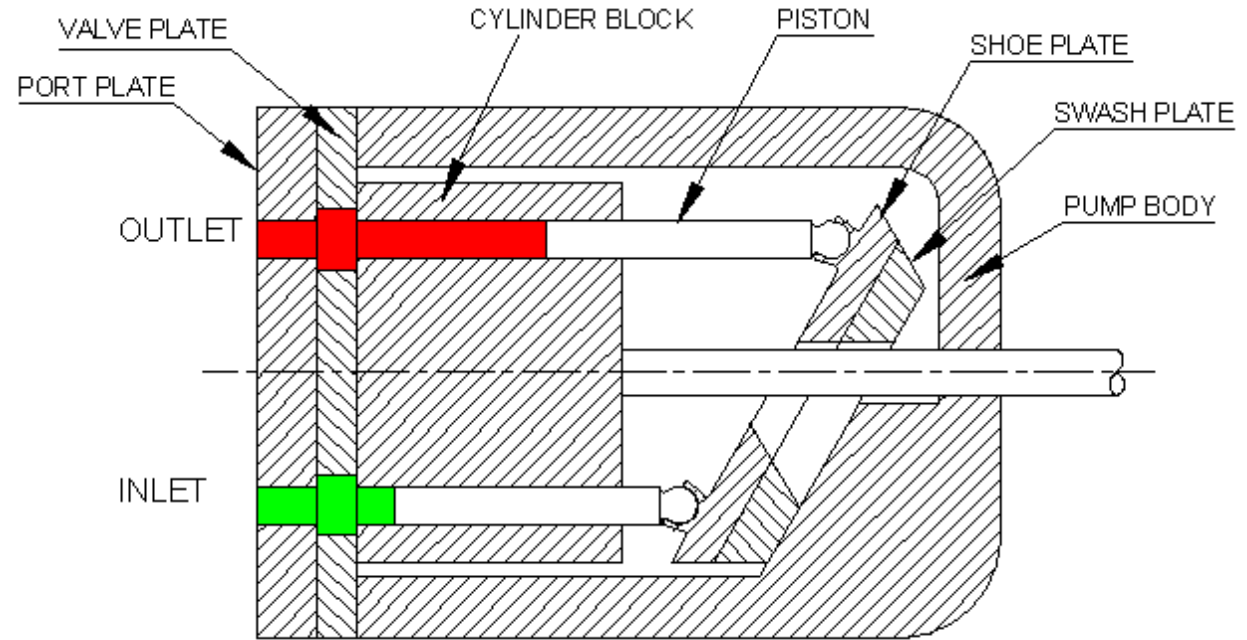
When the shaft is rotated, it causes the cylinder block rotates, the shoe plate will also rotate with it, causing the pistons in the bores to reciprocate.

Half rotation of a cylinder block causes suction of oil into a bore and the next half rotation causes discharge.

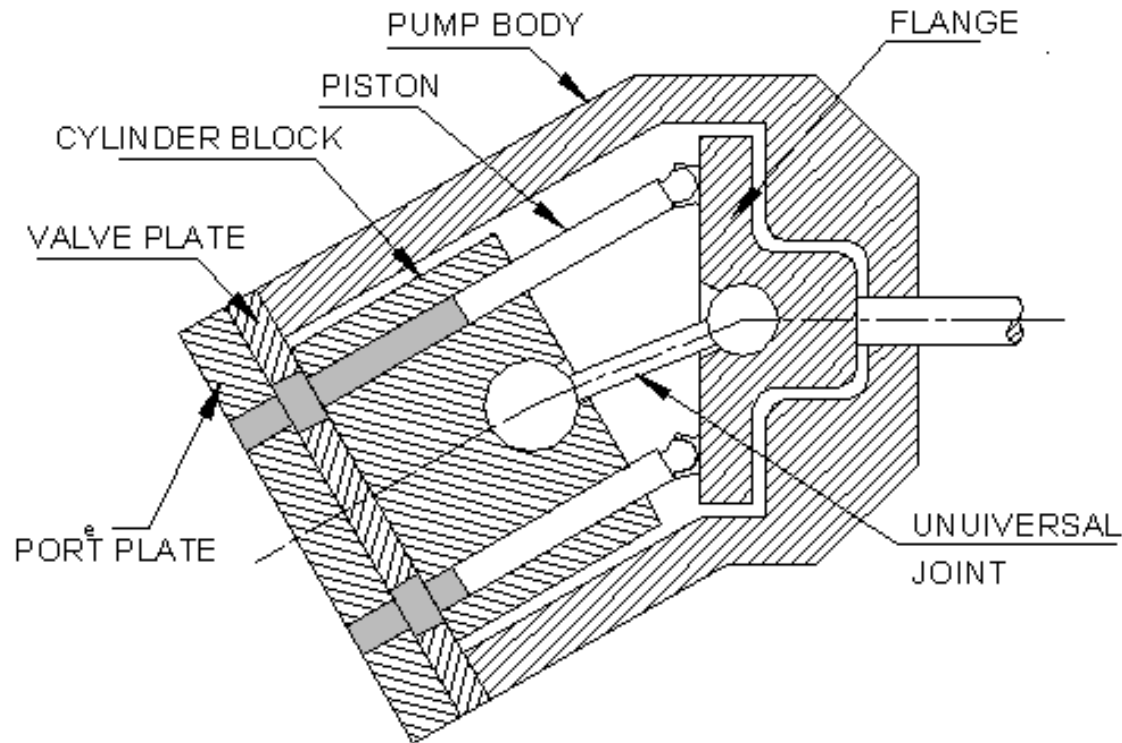
STRAIGHT AXIS PISTON PUMP:

There is 8 or 12 number of such bores, which are continuously performing suction and discharge in sequence; hence the pump discharge is smooth and continuous.

The discharge is determined by the size of bore, number of pistons, stroke length and speed of the shaft.



BENT AXIS PISTON PUMP:



In bent axis piston pump, the shoe plate is fixed to a flange; the flange is keyed to a drive shaft.

The axis of cylinder block and that of the flange are intersecting at an angle. A universal link couples the flange and the cylinder block.

Functioning of this pump is same as that of straight axis piston pump.

VIDEO 8

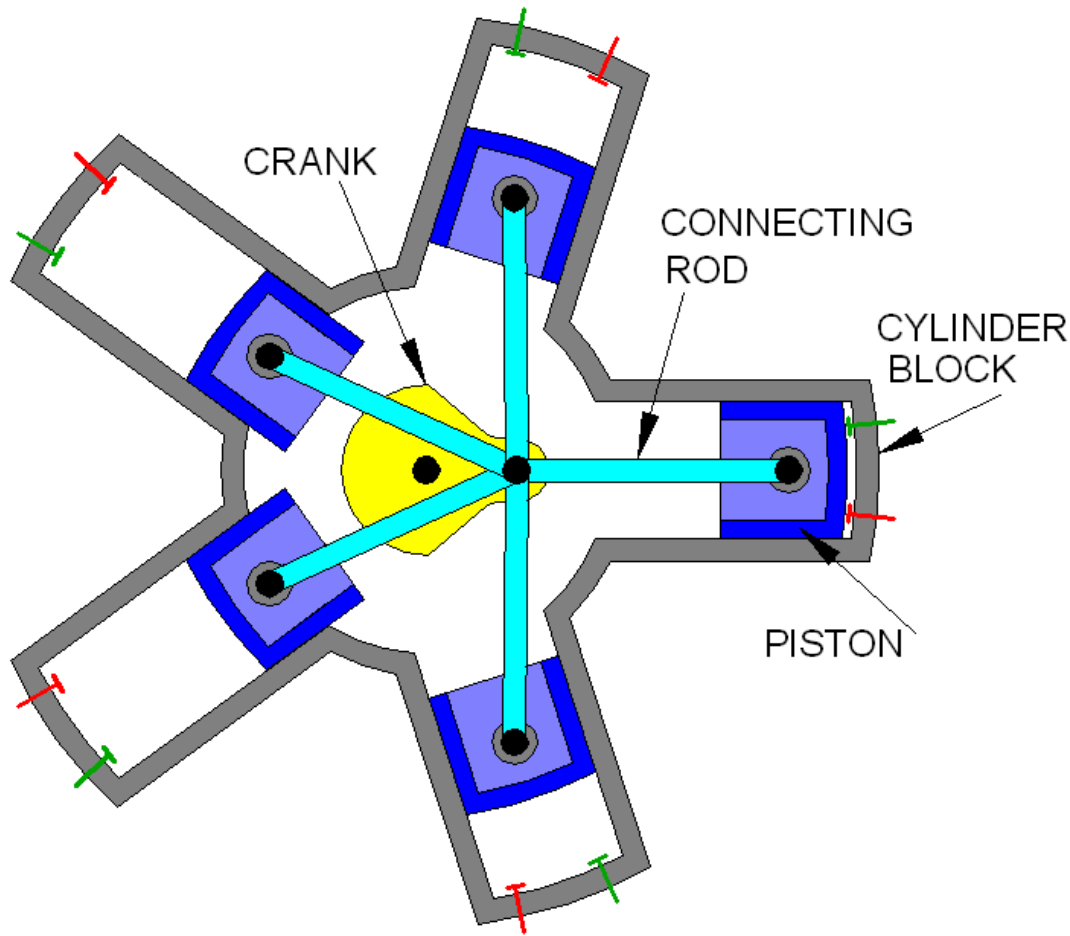
STATIONARY CYLINDER TYPE RADIAL PISTON PUMP:

Figure shows stationary cylinder type radial piston pump.

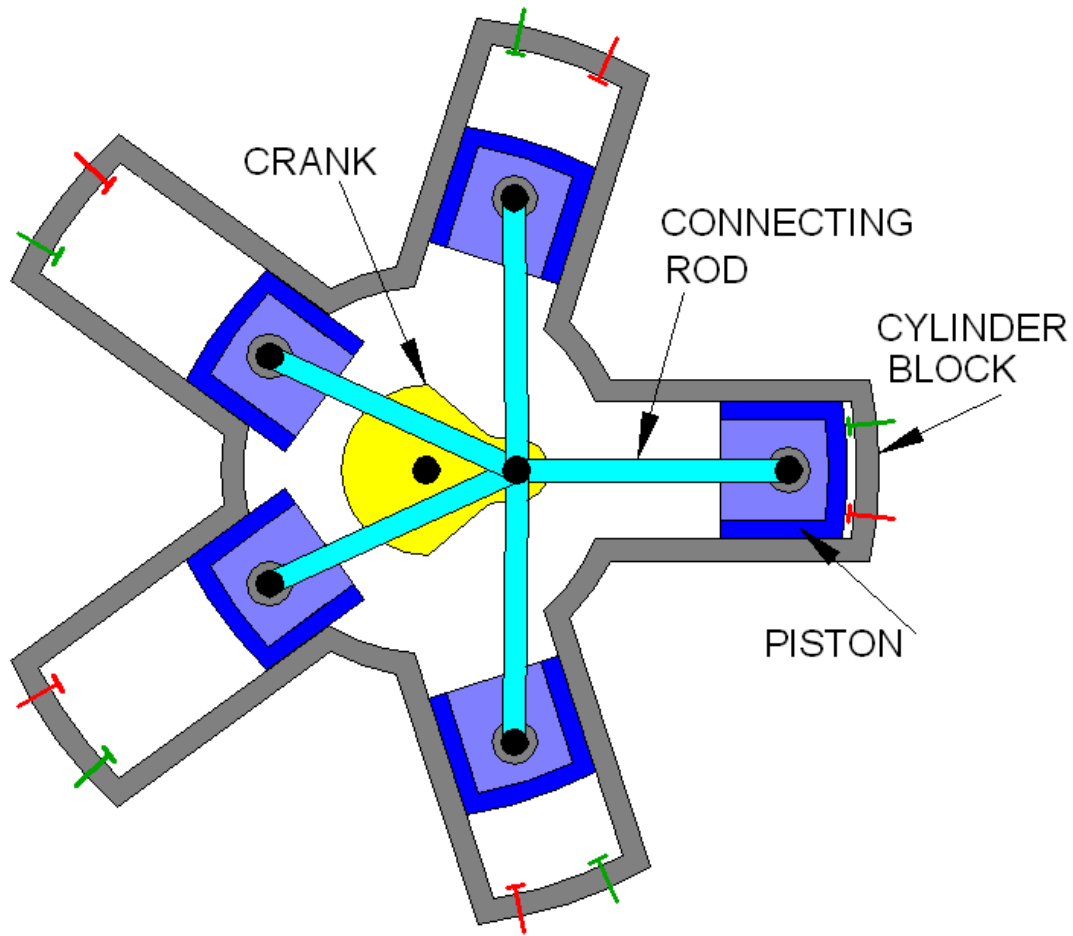
It consists of a stationary cylinder block, in which, five cylinders are arranged coplanar with equal angle between them.

Totally there are five pistons, one reciprocating inside each cylinder.

All pistons are connected to single crank by individual connecting rods as shown in figure.



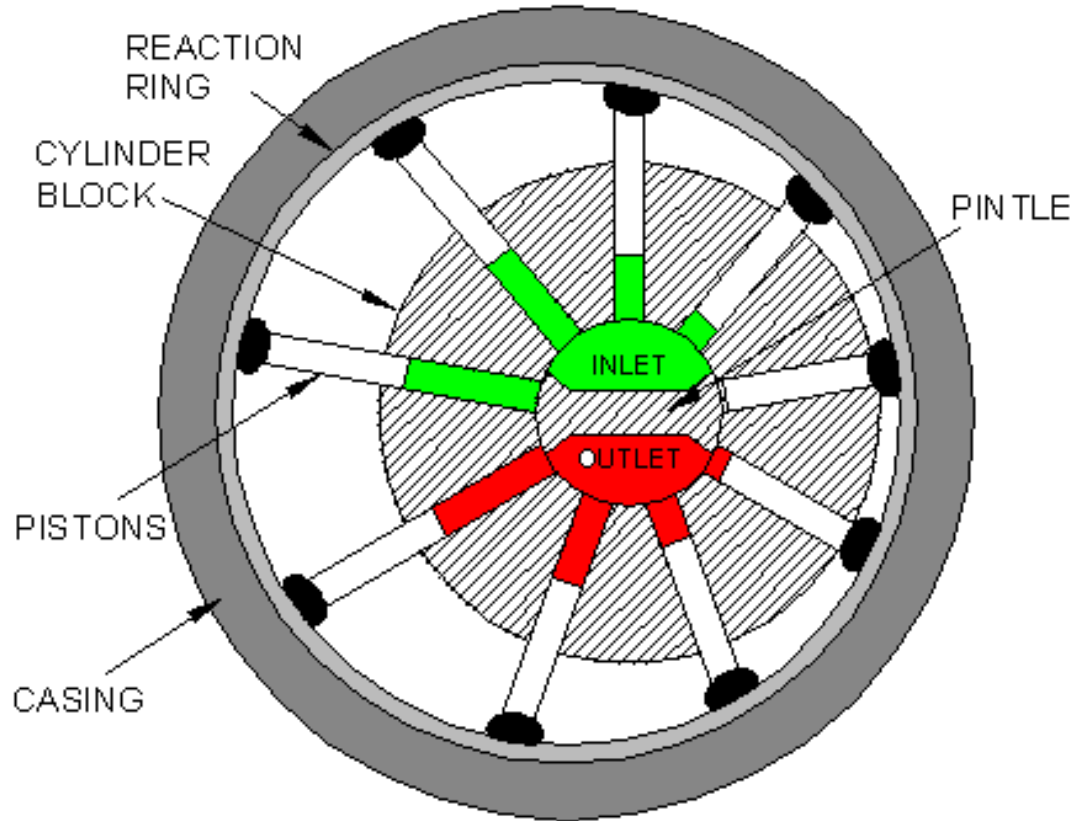
STATIONARY CYLINDER TYPE RADIAL PISTON PUMP:



All suction ports are connected to a single suction pipe and all delivery ports are connected to a single delivery pipe

When the shaft is rotated by means of any prime mover, the pistons reciprocate in cylinder and perform suction and delivery of liquid.

ROTATING CYLINDER TYPE RADIAL PISTON PUMP:

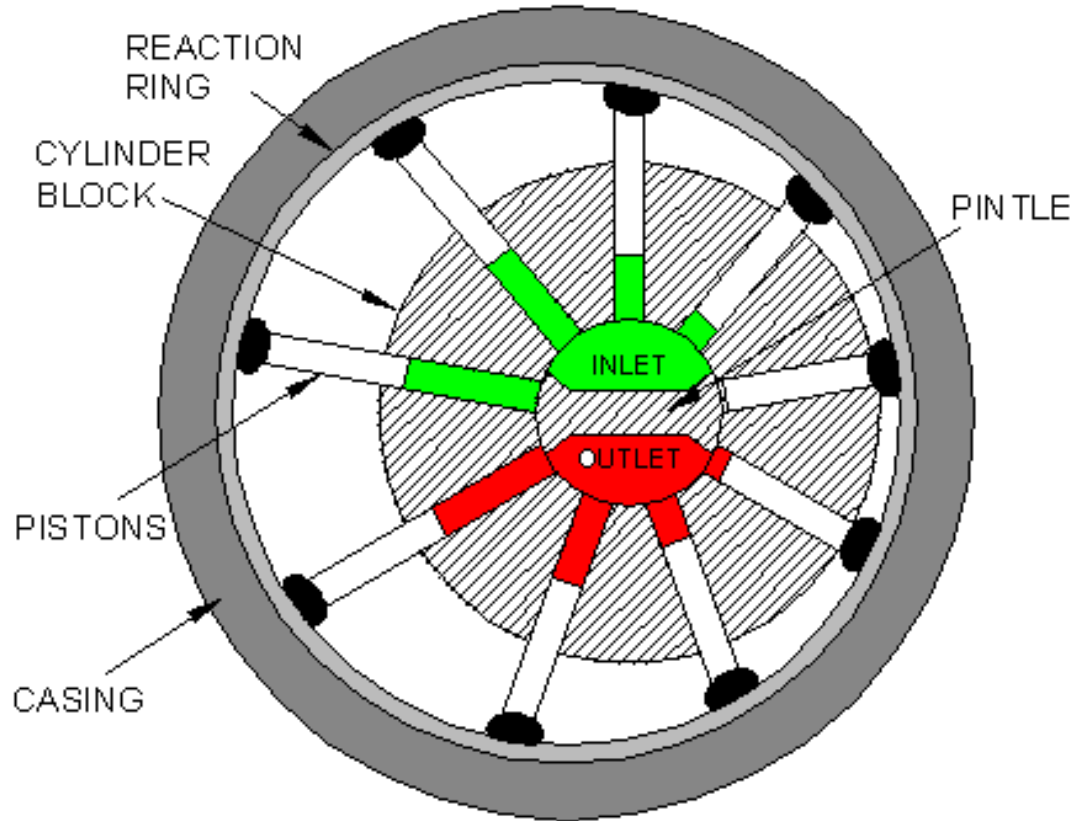


This pump consists of rotating cylinder block, which is mounted with an offset inside a casing.

The casing has a reaction ring with which, the pistons remains in contact while the cylinder block is rotating.

This is achieved by centrifugal force and pressure of liquid.

ROTATING CYLINDER TYPE RADIAL PISTON PUMP:



Pistons are assembled inside the radial bores of the cylinder block, inlet port and outlet port are located as shown in the fig.

Two ports are separated by pintle.

As the cylinder block rotates, pistons reciprocate in their bores.

This causes suction of oil during first half of rotation and discharge during the next half.

VIDEO 9

ADVANTAGES AND APPLICATIONS OF PISTON PUMP

- **Applications**

- These pumps are compact and can work with operating efficiencies.
- They are therefore commonly used in all high-pressure applications such as in presses.
- The variable delivery and pressure compensation features render their use for economic power utilization in different type of systems.
- Volumetric efficiency of piston pumps is about 98%.

- **Advantages**

- 1. High operating efficiency.
- 2. High operating pressure.
- 3. Wide range of speed.