UNIT-III Hydraulic Systems 08 Hours

- Introduction to Hydraulic Actuators and Fluid Power systems: Concept of Actuators
- Classification of Actuators: Pneumatic, Hydraulic and Electrical Actuators, Fluid Power systems
- Hydraulic Systems:
- Physical Components of a 111 Hydraulic systems
- Hydraulic Pumps (e.g. Gear Pumps, Vane Pumps, Piston Pumps and Axial Piston Pumps)
- Filters and Pressure Regulation,
- Relief Valve,
- Accumulator.
- Electronics circuits for hydraulic systems

Introduction to Hydraulic Actuators and Fluid Power systems: Concept of Actuators

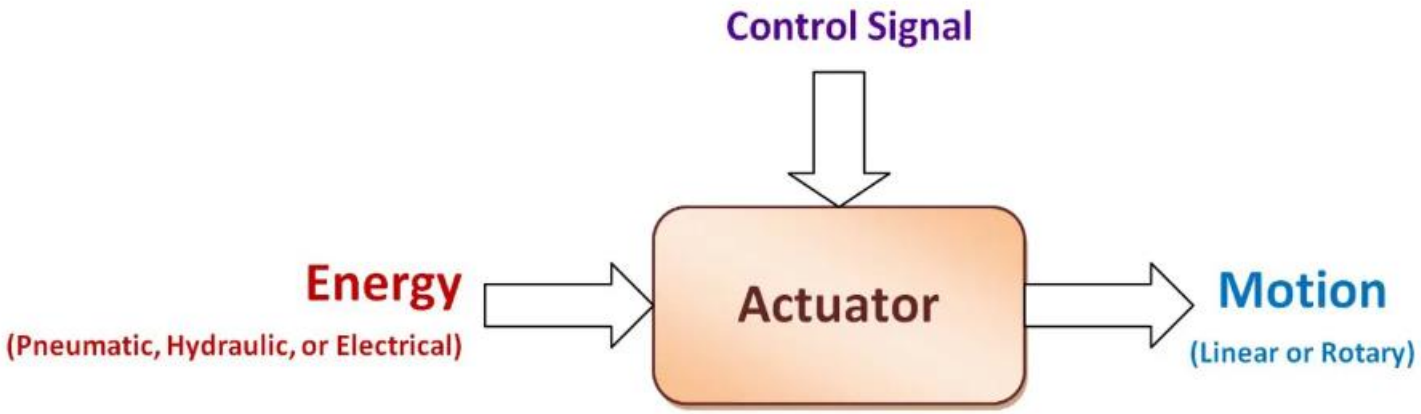
- Actuators are devices used **to produce action or motion.**
- It is operated by a source of energy (mainly electrical signal, air, fluid) and converts that energy into **motion.**
- Actuators is a mechanism by which a control systems acts upon environment.
- **Actuators output is usualy mechanical i.e. linear displacement or velocity.**
- Actuation can be from **few microns to few meters.**

- Basic actuators turn valves to either **fully opened or fully closed positions.**

- But modern actuators have much more advanced capabilities.

They provide intermediate position with high degree of accuracy.

Actuator functional diagram



Continue…..

- Magnetic Type
- Solenoid
- Piezoelectric type
- Screw jack
- Electro-active polymer
- Shape-memory alloy
- Thermal bimorph
- Comb drive
- Digital micro-mirror device, etc…

Examples of actuators

There are wide range of it used in industries and commercial.

Such as….

- Pneumatic actuator
- Electro-pneumatic type
- Hydraulic cylinder
- Electro-hydraulic type
- Mechanical type
- Spring actuator
- Electro-mechanical type
- Electric motor type
- Stepper motor
- Servomotor
- Thermal Type
- Shape-memory alloy

What is an Actuators ??

The hydraulic actuator uses a hydraulic fluid (e.g. oil) to energize the actuator and cause motion.

They have a hollow cylindrical tubing or fluid motor, which generates pressure to cause motion.

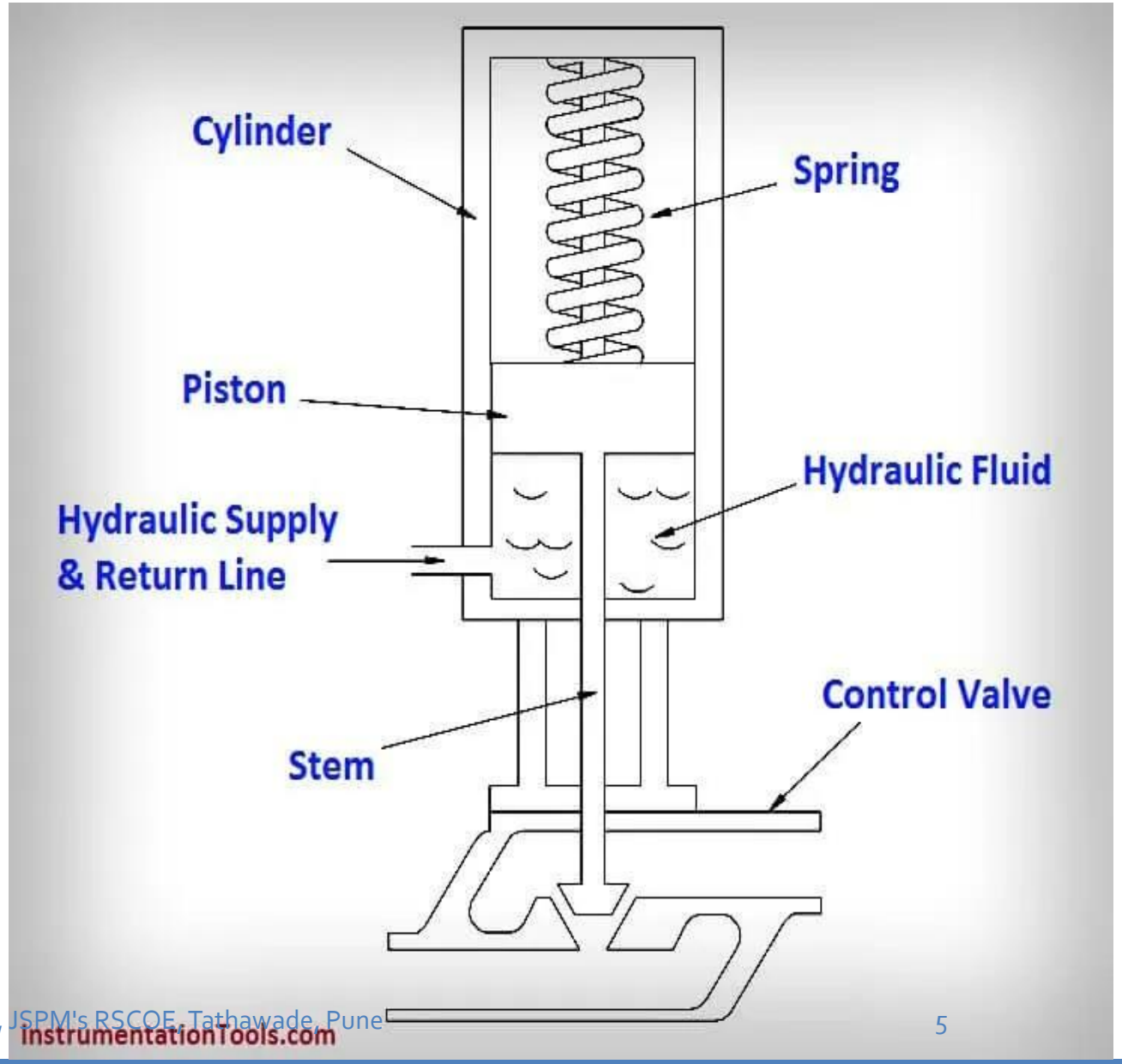
A piston is suspended at the center of the actuator.

Working:

When the fluid enters the bottom of the cylinder, a large pressure is formed by the fluid, which forces the piston to move and slide.

This piston then moves the device with which the actuator is connected.

The piston moves in the direction opposite to the spring connected at the other side (upper part of the cylinder) and the applied pressure moves the device.



Sr. No.	Sensor	Actuator
1	Sensor converts physical quantities and characteristics into electrical signals.	Actuator converts electrical signals into physical action such as force and motion.
2	It acts as an input device in any control system and placed in input port	It acts as an output device in a control system and placed in output port
3	Sensor takes input from environment and senses surroundings condition.	Actuator takes input from output signal conditioning unit of system.
4	Sensor gives output to input signal conditioning unit of system to convert into electrical form.	It gives output to environment and makes impact on load to control parameters.
5	It gives information to the system about environment condition to monitor and control.	It accepts command from system to deliver physical action.
6	Sensors are often used to measure process pressure, temperature, fluid levels, flow, vibration, speed etc.	Actuators are often used to operate control valves, dampers, guide vanes, and to move objects from one place to another, to move conveyor belts in robotic arms movement etc..
7	Sensor examples- Thermocouple, photo cell, RTD, LVDT, strain gauge, Load cell, hall sensors, differential flow meters, speed probes, PH meter etc	Actuator examples- motor actuator, servo motor, stepper motor, heaters, electro pneumatic actuator, electro-hydraulic actuator, magnetic actuator etc

Classification of Actuators

Actuators are divided into two categories based on the motion they produce and the power source they utilize.

1. Motion

Two forms of motion can be created by actuators: linear and rotary motion.

- Linear Actuator
- Rotary Actuator

Linear Actuator

Linear actuators are devices that move in a straight line. They are typically found in hydraulic and pneumatic equipment and can be mechanical or electrical. A linear actuator is found in almost every machine, piece of equipment, or device that requires straight motion.

Rotary actuator

Rotary actuators, in contrast to linear types of actuators, produce a round motion. Most machines, as the term “rotary” implies, use rotating elements to accomplish a turning movement. If a machine needs to move forward, backward, up, or down, they are frequently utilized in connection with a linear actuator.

Many rotary actuators are powered by electricity, but others are powered by hydraulic or pneumatic systems. Windshield wipers, electric fans, and manufacturing machinery that carry things from one location to another all use rotary actuators.

Classification of Actuators

2. Source of Energy

We may further distinguish between different types of actuators by sorting them according to the power source or system they utilize to move.

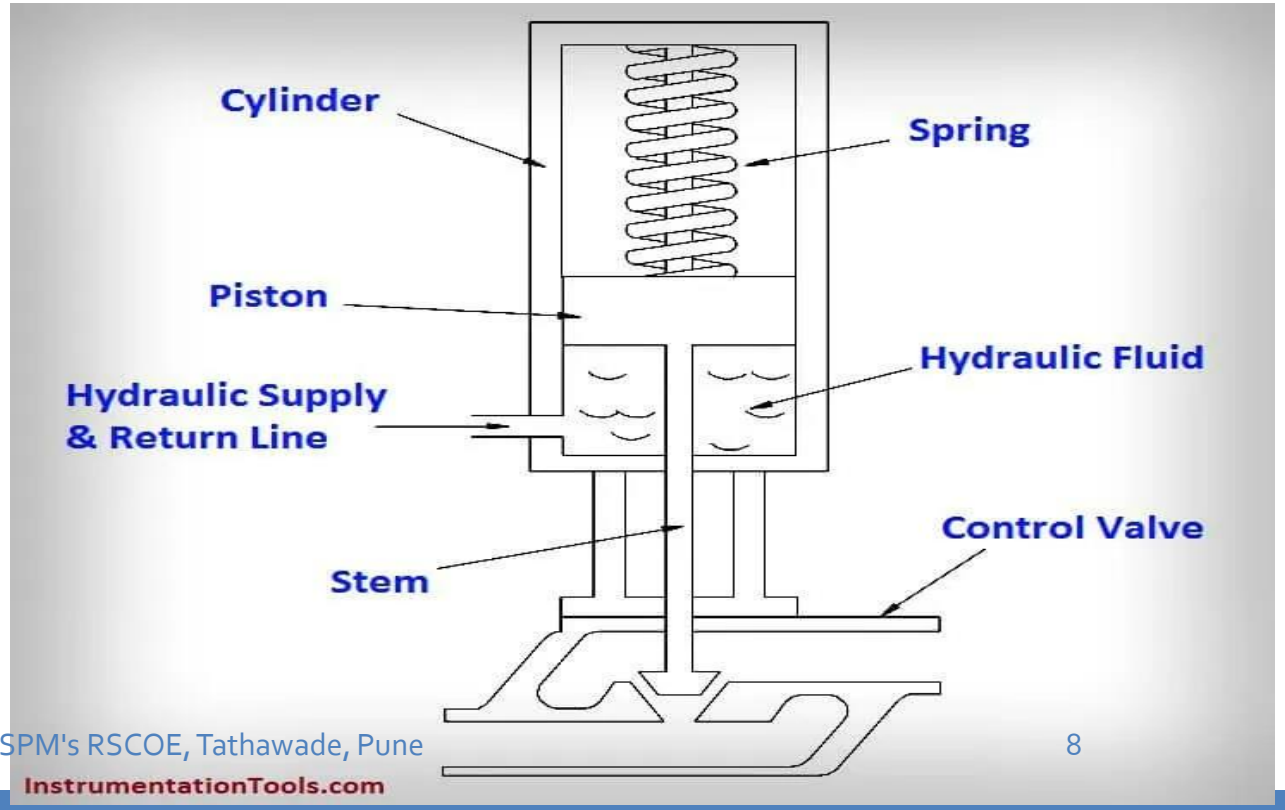
- Hydraulic
- Pneumatic
- Electrical

Hydraulic Actuators

The hydraulic actuator uses a hydraulic fluid (for example, oil) to energize the actuator and cause motion. They have a hollow cylindrical tubing or fluid motor, which generates pressure to cause motion.

A piston is suspended at the center of the actuator. When the fluid enters the bottom of the cylinder, a large pressure is formed by the fluid, which forces the piston to move and slide.

This piston then moves the device with which the actuator is connected. The piston moves in the direction opposite to the spring connected at the other side (upper part of the cylinder) and the applied pressure moves the device.



Advantages of Hydraulic Actuators

Hydraulic actuators are rugged and suited for high force applications.

They can produce forces 25 times greater than pneumatic cylinders of equal size.

They also operate in pressures of up to 4,000 psi.

A hydraulic actuator can hold force and torque constant without the pump supplying more fluid or pressure due to the incompressibility of fluids.

Hydraulic actuators can have their pumps and motors located a considerable distance away with minimal loss of power.

Disadvantages of Hydraulic Actuators

Hydraulics will leak fluid.

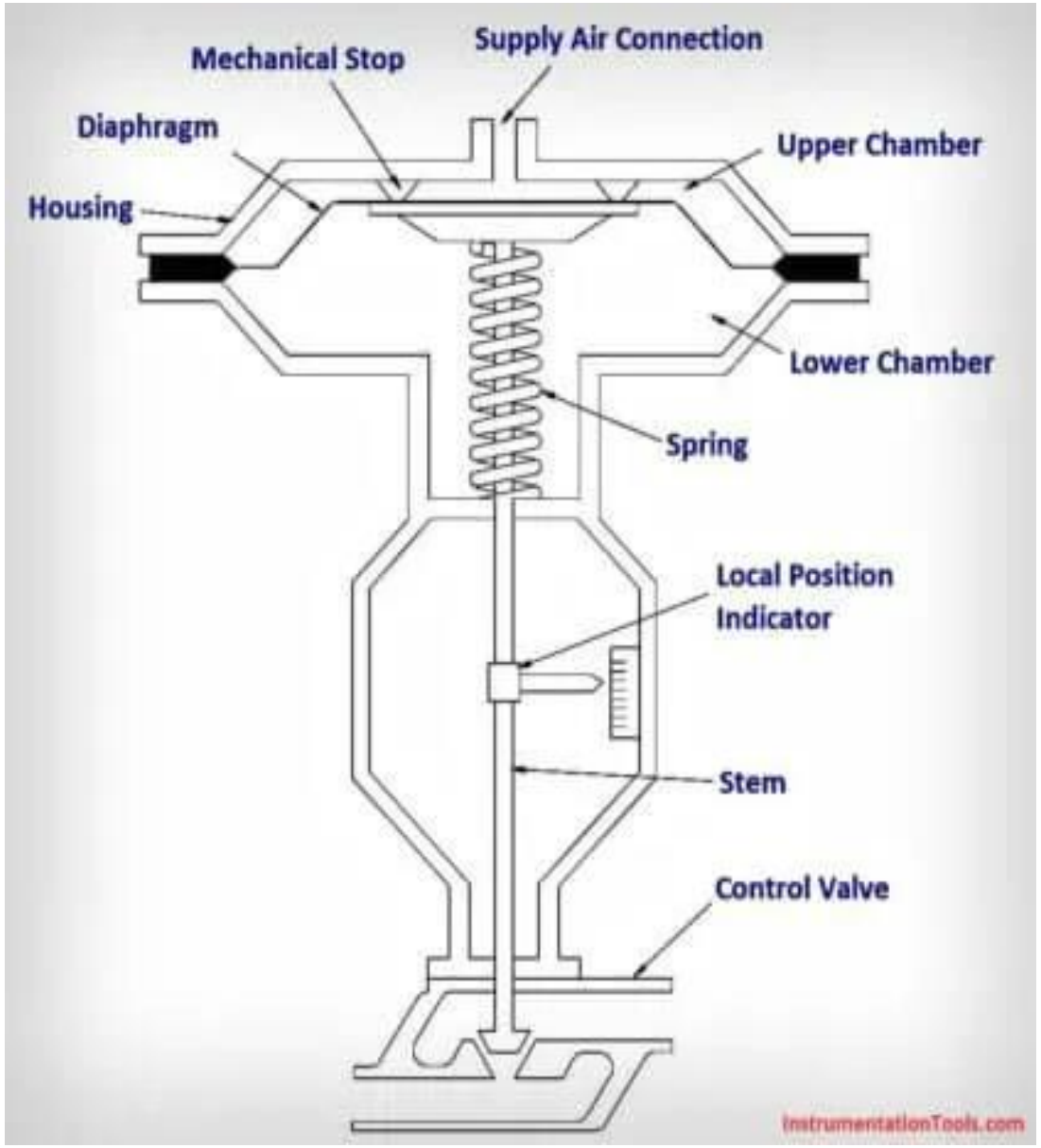
Like pneumatic actuators, loss of fluid leads to less efficiency and cleanliness problems resulting in potential damage to surrounding components and areas.

Hydraulic actuators require many complementary parts, including a fluid reservoir, motor, pump, release valves, and heat exchangers, along with noise reduction equipment.

Pneumatic Actuator

Pneumatic actuators are devices that convert the energy of compressed air or gas into a mechanical motion that regulates one or more final control elements.

They are used as a form of automation control to reduce mandatory human interaction with a system's internal mechanisms, which is particularly beneficial for automatic modulation and emergency shutdowns.

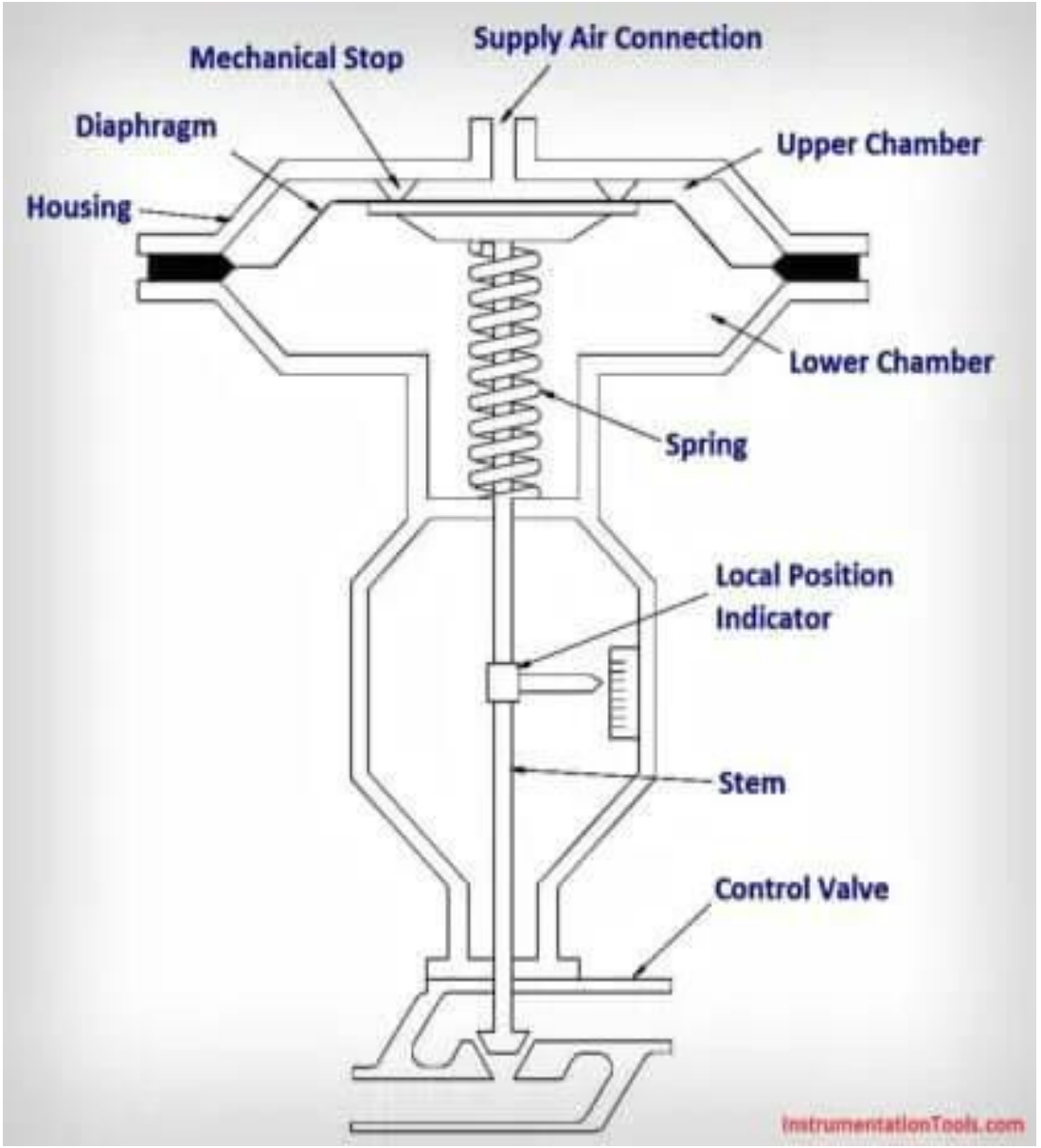


A simplified diagram of a pneumatic actuator is shown in Figure 1. It operates by a combination of force created by air and spring force. The actuator positions a control valve by transmitting its motion through the stem.

A rubber diaphragm separates the actuator housing into two air chambers. The upper chamber receives supply air through an opening in the top of the housing.

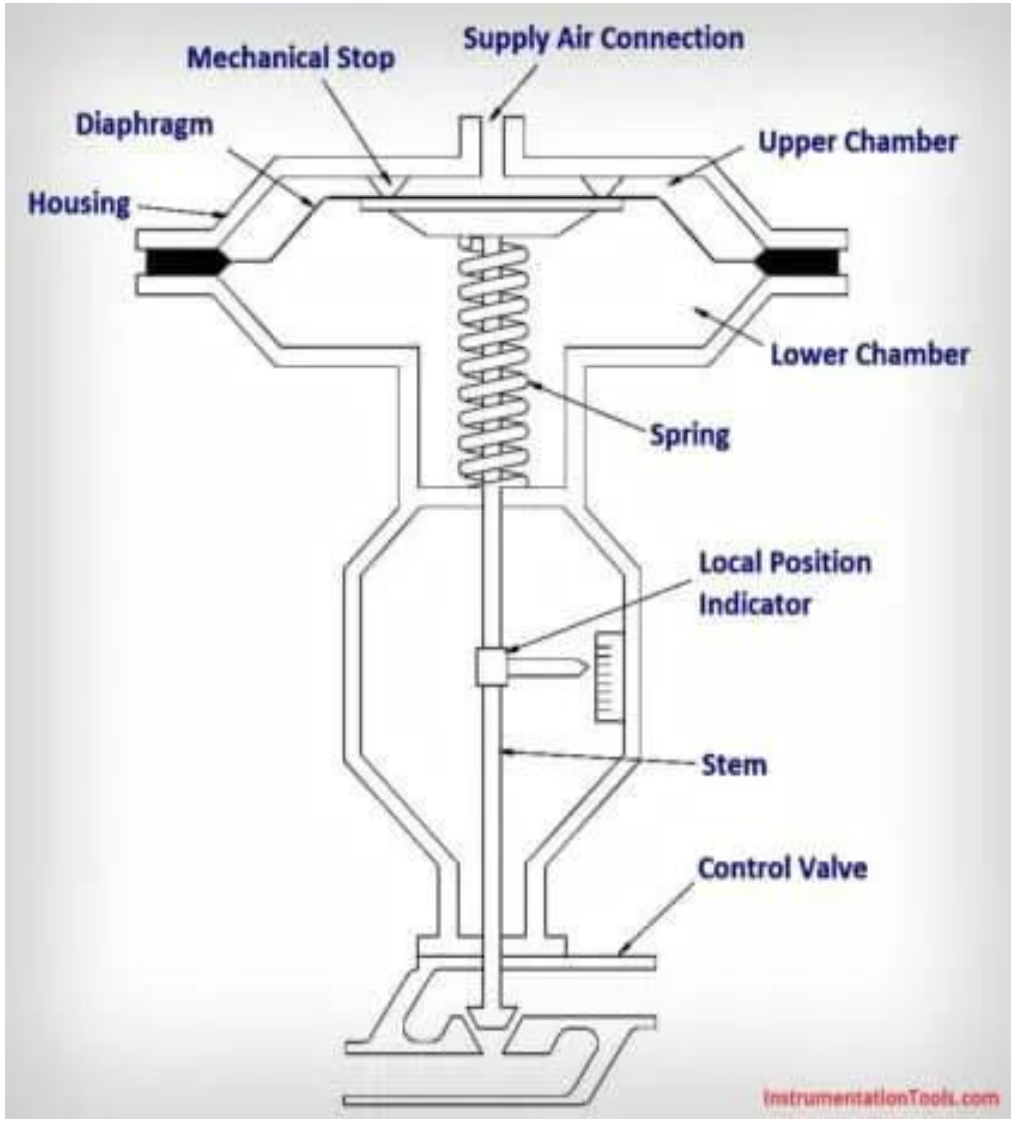
he bottom chamber contains a spring that forces the diaphragm against mechanical stops in the upper chamber. Finally, a local indicator is connected to the stem to indicate the position of the valve.

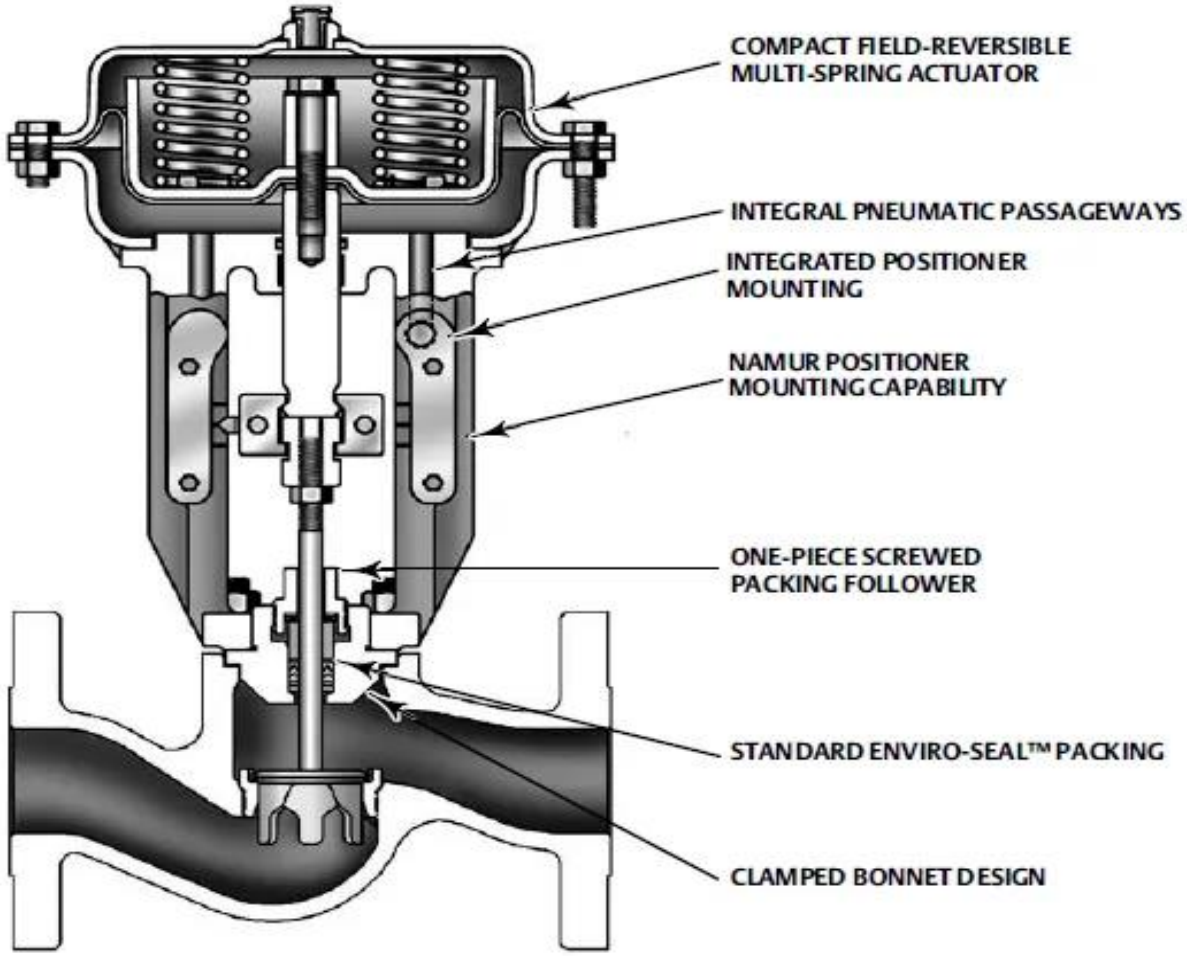
The position of the valve is controlled by varying supply air pressure in the upper chamber. This results in a varying force on the top of the diaphragm. Initially, with no supply air, the spring forces the diaphragm upward against the mechanical stops and holds the valve fully open.



As supply air pressure is increased from zero, its force on top of the diaphragm begins to overcome the opposing force of the spring. This causes the diaphragm to move downward and the control valve to close. With increasing supply air pressure, the diaphragm will continue to move downward and compress the spring until the control valve is fully closed.

Conversely, if supply air pressure is decreased, the spring will begin to force the diaphragm upward and open the control valve. Additionally, if supply pressure is held constant at some value between zero and maximum, the valve will position at an intermediate position. Therefore, the valve can be positioned anywhere between fully open and fully closed in response to changes in supply air pressure.




COMPACT FIELD-REVERSIBLE
MULTI-SPRING ACTUATOR
INTEGRAL PNEUMATIC PASSAGEWAYS
INTEGRATED POSITIONER
MOUNTING
NAMUR POSITIONER
MOUNTING CAPABILITY
ONE-PIECE SCREWED
PACKING FOLLOWER
STANDARD ENVIRO-SEAL™ PACKING
CLAMPED BONNET DESIGN

Advantages of Pneumatic Actuators

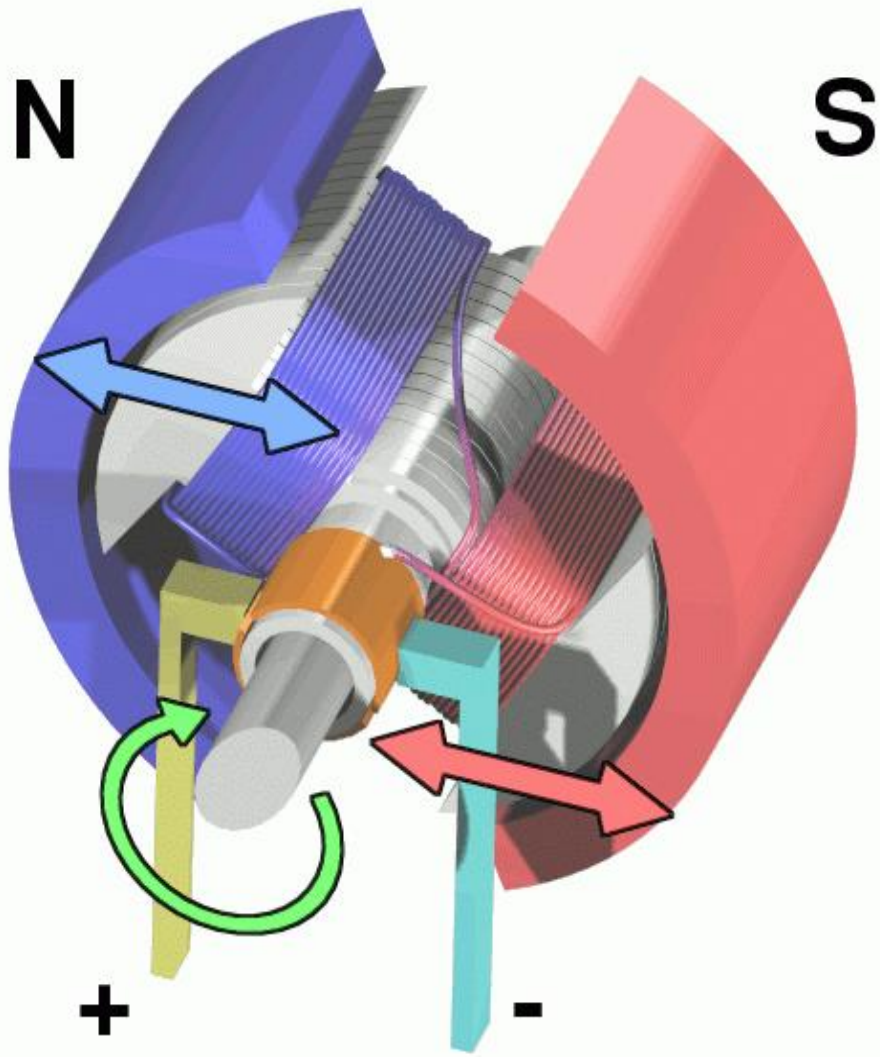
- The benefits of pneumatic actuators come from their simplicity.
- Pneumatic actuators' typical applications involve areas where the conditions involve extreme temperatures, a typical temperature range is -40°F to 250°F.
- In terms of safety and inspection, using air and pneumatic actuators avoids using hazardous materials. They also meet explosion protection and machine safety requirements because they create no magnetic interference due to the lack of motors.
- Pneumatic actuators are also lightweight, require minimal maintenance, and have durable components that make pneumatics a cost effective method of power

Disadvantages of Pneumatic Actuators

- Pressure losses and compressibility of air make pneumatics less efficient than other methods. Compressor and air delivery limitations mean that operations at lower pressures will have lower forces and slower speeds.
- To be truly efficient, pneumatic actuators must be sized for a specific job. Hence, they cannot be used for other applications.
- Even though air is readily available, it can be contaminated by oil or lubrication, leading to downtime and maintenance. Companies still have to pay for compressed air, making it a consumable, along with the compressor and line maintenance costs.

Electrical Actuators

- **An electric actuator is a device that can create movement of a load,**
- **O**r an action requiring a force such as clamping, using an electric motor to create the necessary force.
- **An electric motor will create rotary motion as the spindle, or rotor, rotates.**
- The motor rotates clockwise or anti-clockwise.



- In ROBOTICS …..
- There are AC and DC electric actuators
- The electric actuator is the most commonly used linear DC actuators in robotics.

- They **convert electric energy into linear motion**.
- The three major types of actuators are **hydraulic, pneumatic, and electric**, and picking the best one depends on what kind of robotic structure you are designing.

- Common examples of actuators include **electric motors, stepper motors, jackscrews, electric muscular stimulators** in robots, etc.

- Electric actuators provide **extremely accurate control and positioning**. Easily adapt machines to flexible processes and has a low operating cost.
- Are **energy efficient** and can provide you with **cost savings** in many cases.

A electric solenoid actuator

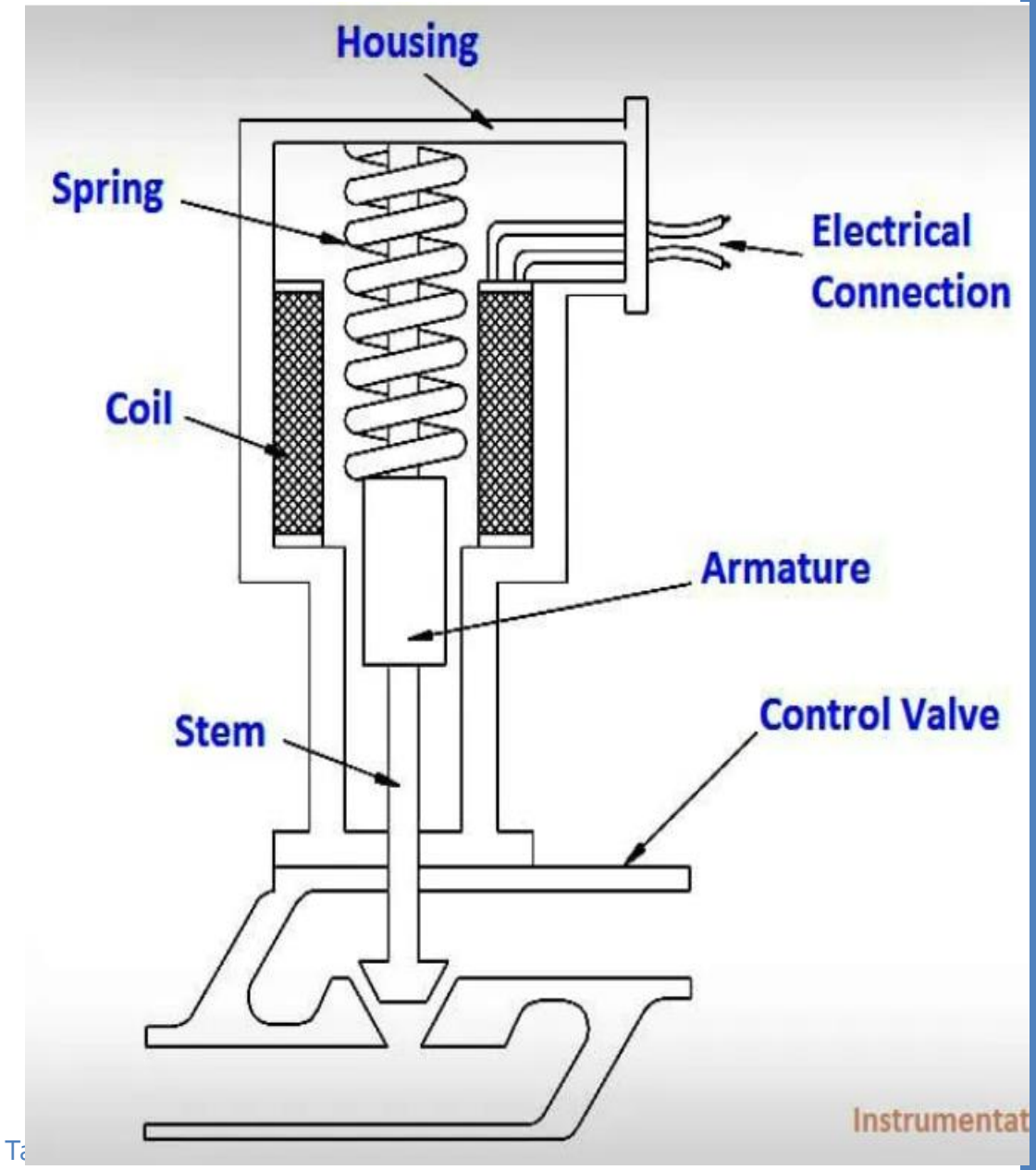
It consists of a coil, armature, spring, and stem.

Note : Electric Solenoid Actuator also called as ON/OFF valve or Solenoid Valve.

The coil is connected to an external current supply.

The spring rests on the armature to force it downward. The armature moves vertically inside the coil and transmits its motion through the stem to the valve.

ON: When current flows through the coil, a magnetic field forms around the coil. The magnetic field attracts the armature toward the center of the coil. As the armature moves upward, the spring collapses and the valve opens..



OFF: When the circuit is opened and current stops flowing to the coil, the magnetic field collapses. This allows the spring to expand and shut the valve

Advantage of solenoid actuators:

- Quick operation.
- Easier to install than pneumatic or hydraulic actuators.

Disadvantages.

They have only two positions: fully open and fully closed.

Second, they don’t produce much force, so they usually only operate relatively small valves.

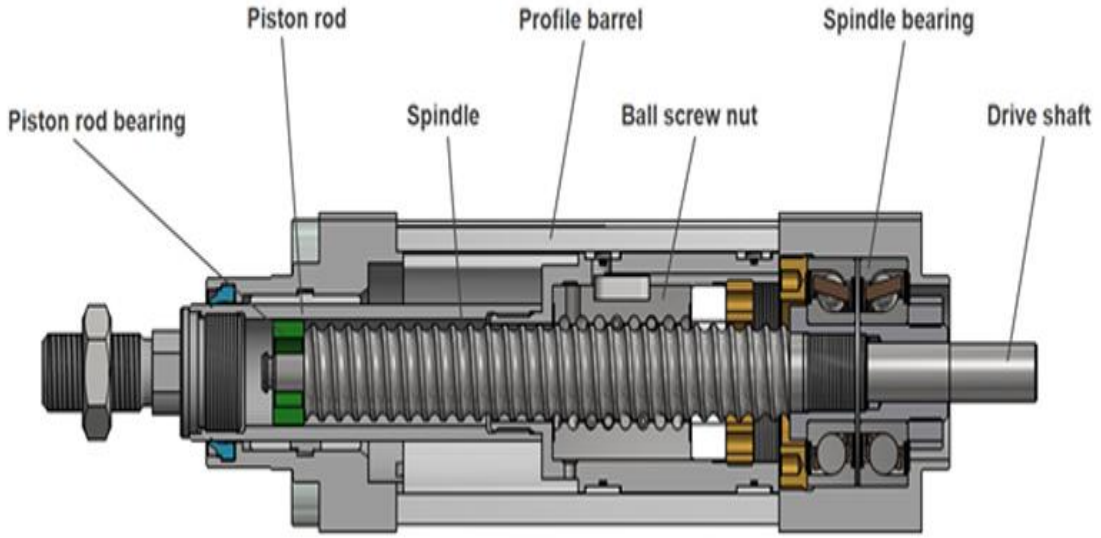
Electric actuator working

An electric actuator is a device that can create movement of a load, or an action requiring a force such as clamping, using an electric motor to create the necessary force.

Working: An electric motor will create rotary motion as the spindle, or rotor, rotates. The motor spindle is directly coupled to a helical screw, via the drive shaft, which in turn rotates in a ball screw nut.

As the spindle rotates the ball screw nut is driven forwards, or backwards, along the helical screw.

A hollow piston rod is attached to the ball screw nut and this creates the linear motion out of, or into the linear actuator as the motor rotates clockwise or anti-clockwise.
ator.



The motor is controlled by an electric drive, which allows the rotation speed to be varied and, hence, the linear speed of the actuator. A feedback mechanism gives positional information and the linear actuator can be programmed to move to a certain position, stop and then move on, or return to its rest position.

The power of the motor will determine the torque that can be generated and hence the force that can be put to useful motion through the actuator.

It can be programmed (such as PLC control), through the signal control (4-20mA, 1-5VDC, 0-10VDC) to make the valve opening more automatic, improve production efficiency and work efficiency.

Due to the increasing demand for automation and the development of technology, the demand for electric actuators has also improved a lot, such as safety performance. Electric actuators now have over loading protection, and when the voltage exceeds the required range, or an abnormal overheating occurs, the protection is immediately activated to prevent a failure that could cause the project to suspend and reduce productivity. When the motor is cooled, the switching power supply can be switched on again and the motor can work again.

Applications:

Electric actuators appear in a number of industries. Typically, they're used in industrial applications associated with manufacturing valves, pumps, and motors. They most commonly automate industrial valves, and many types of technical process plants use them, including:

· Upstream, midstream, and downstream oil and gas plants

· Wastewater treatment plants

· Power plants

· Food and beverage plants

· Farming and agricultural plants

· Pulp and paper plants

Hydraulic Systems

- A common example of a hydraulic actuator system:

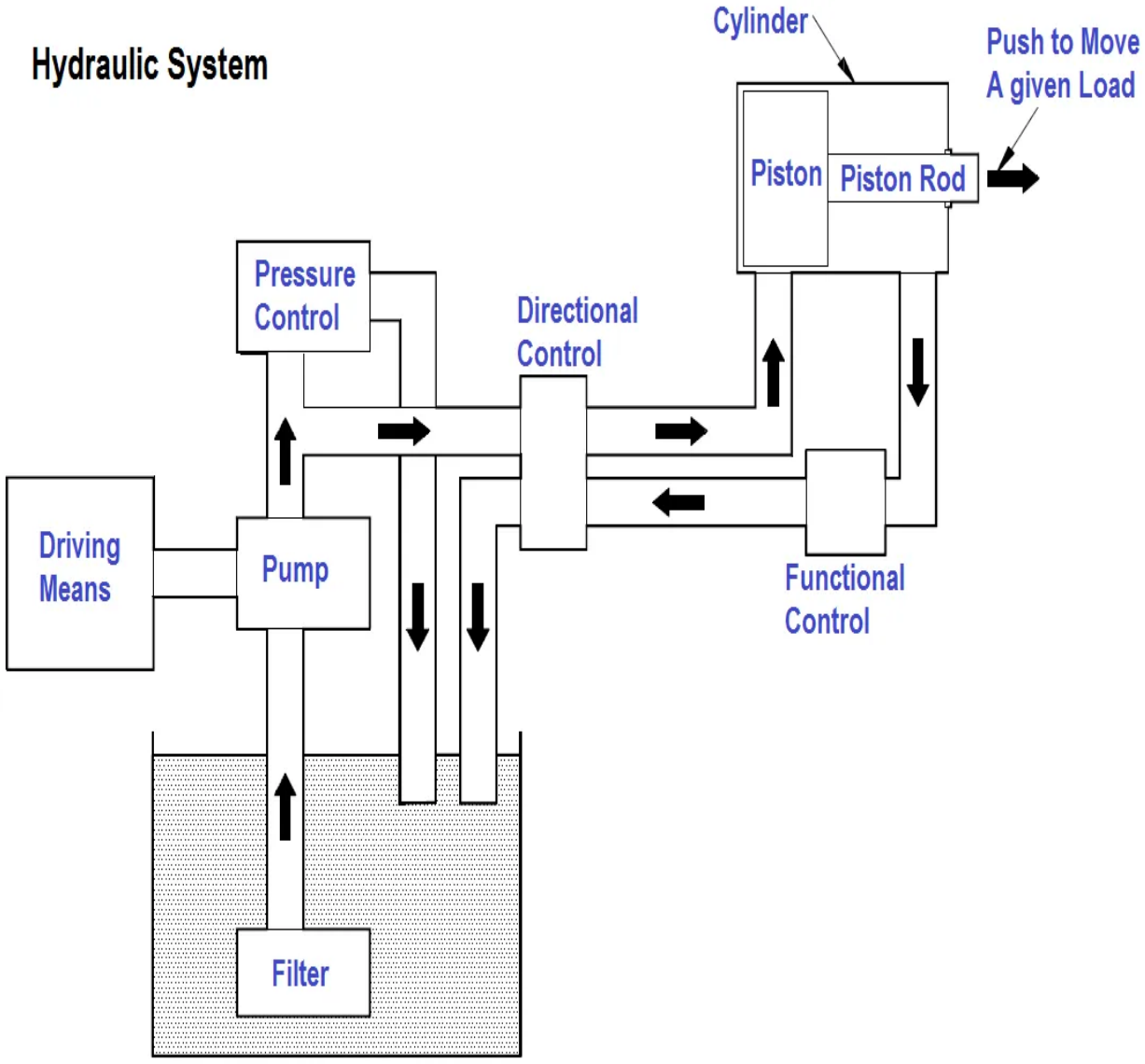
- JCB machine.
- In Robotics, an actuator is needed **to make the robots wheels turn**. Or **the joints of a robot arm to rotate**.
- **Brakes and steering** on cars;
- **Hydraulic lifts and jacks** for servicing cars;
- **Airplane wing flaps**,
- **Stabilizer controls, and landing gear**;
- **Mechanical arms on garbage trucks**;
- **Blades on bulldozers**

https://youtu.be/wE3fmFTtP9g

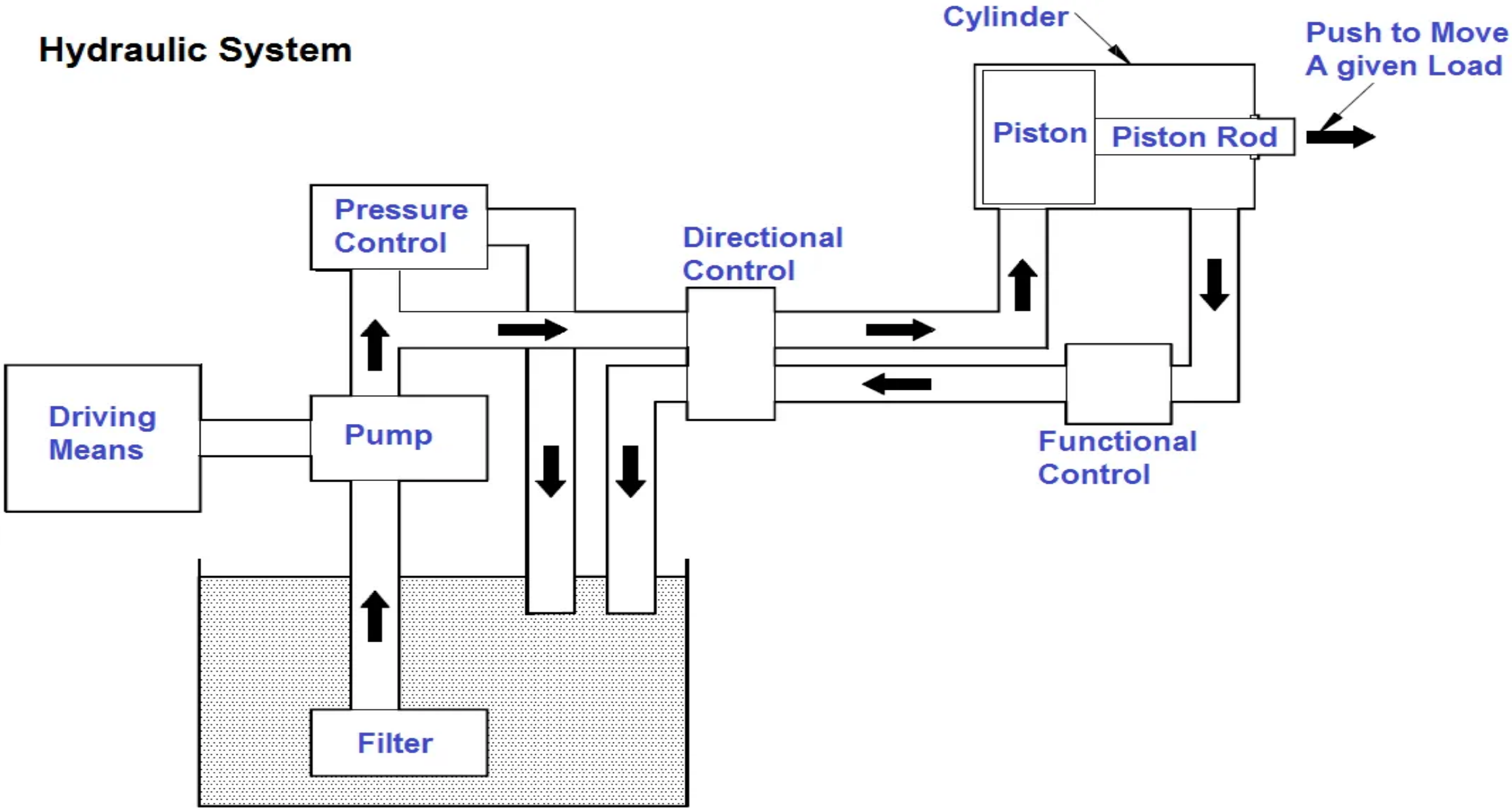
Hydraulic Systems

- A hydraulic system is a drive system whose movements are initiated by **pressurized fluids**.
- A system's hydraulic force can be used for various applications, such as **lifting, pushing, bending, pressing, and cutting**.
- **Their operations are based on Pascal's law, which states that pressure exerted anywhere on an enclosed liquid will be fully transmitted to the interior of the container.**
- **This allows these systems to generate large amounts of force with little effort**.

Block Diagram of a Hydraulic systems

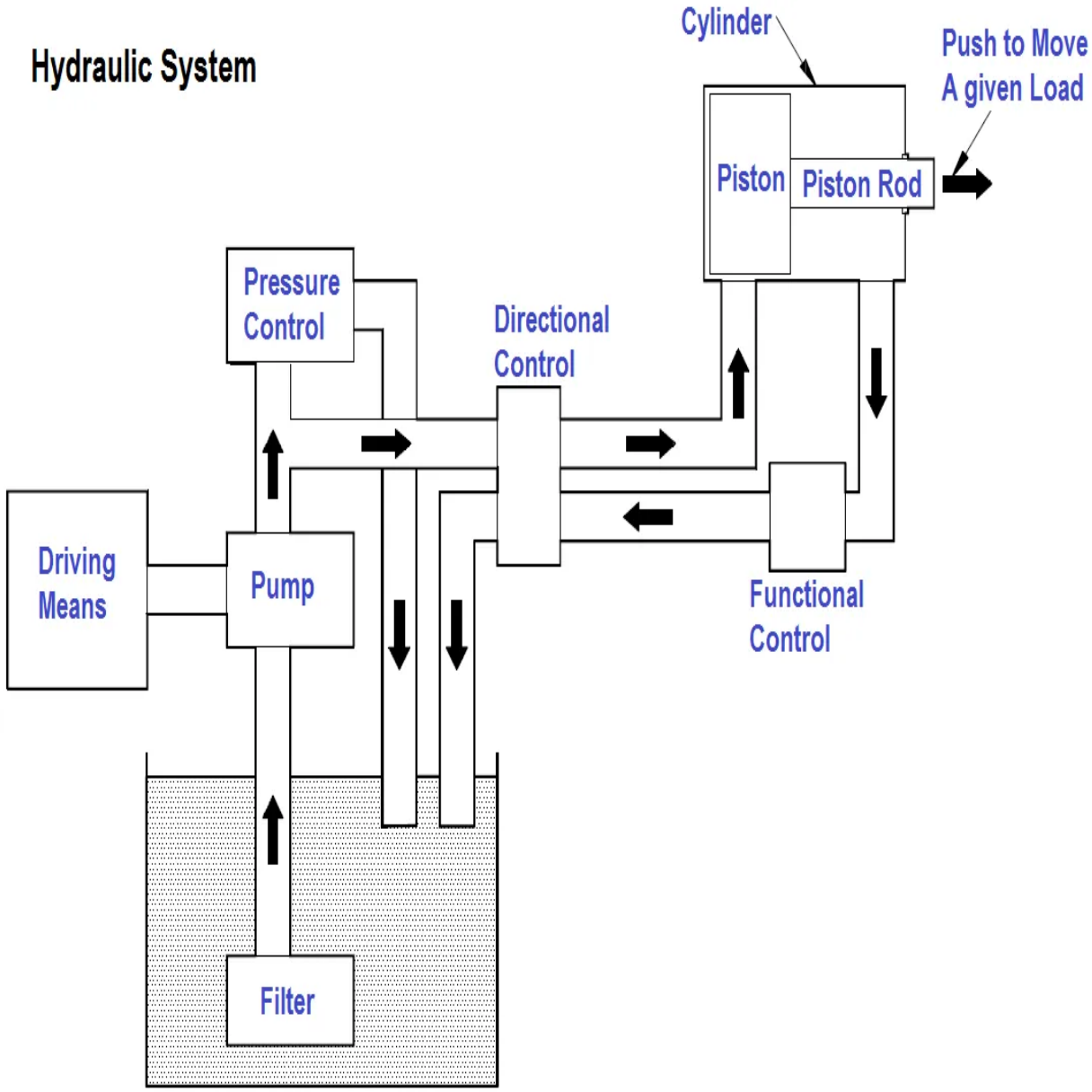


Hydraulic System



Hydraulic Operation

- Oil from a tank or reservoir flows through a pipe into a pump.
- Often **a filter** is provided on the pump suction **to remove impurities** from the oil.
- **The pump can be driven by an electric motor, air motor, gas or steam turbine, or an internal combustion engine**.
- **The pump increases the pressure of the oil**.
- Most hydraulic systems have some method of **preventing over-pressure**.
- One method of pressure control involves returning hydraulic oil to the oil reservoir.
- The **pressure control box is usually a relief valve** that provides a means of returning oil to the reservoir upon over-pressurization.

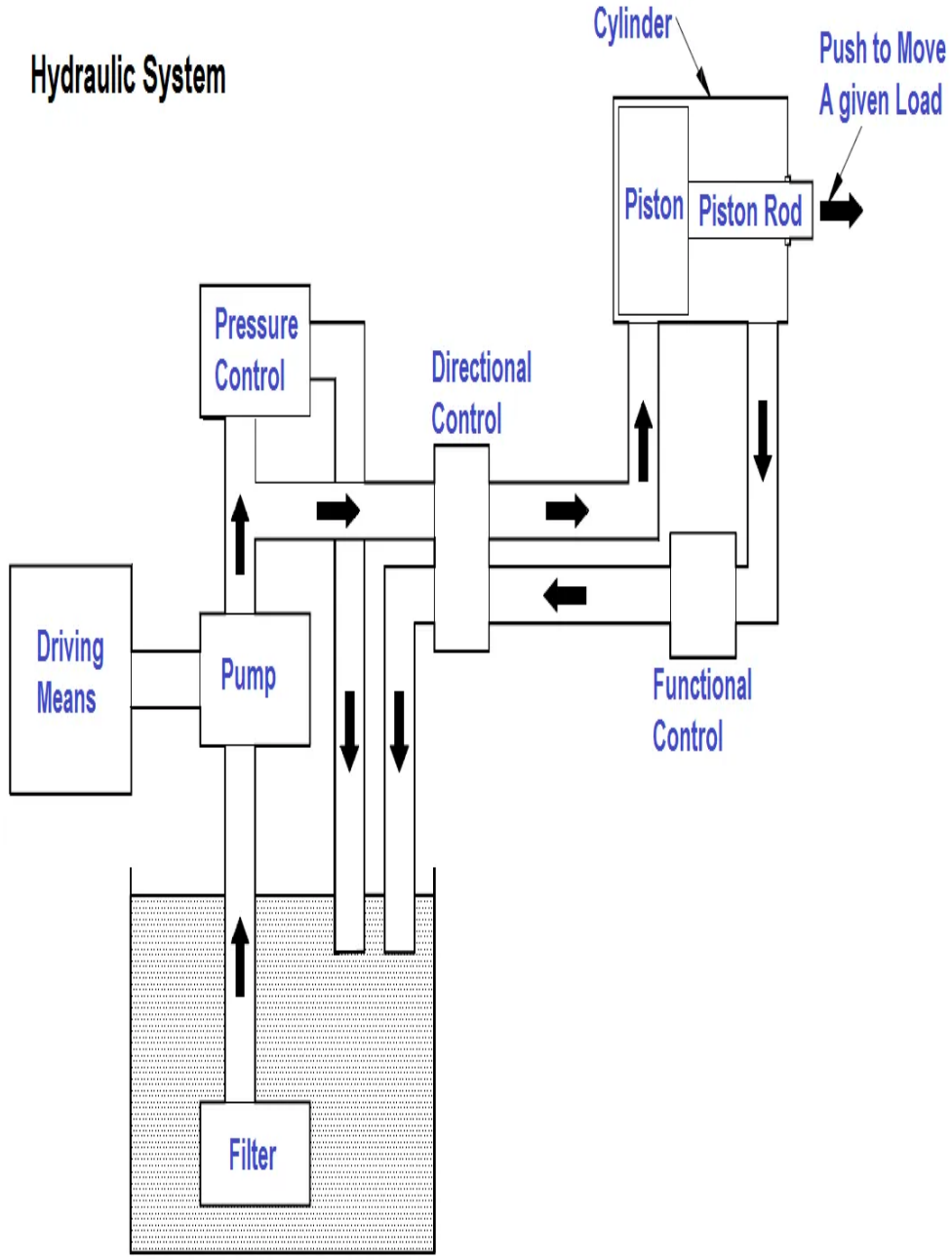


- **The high pressure oil flows through a control valve (directional control).**
- **This control valve changes the direction of oil flow, depending upon the desired direction of the load.**

- The oil that enters the cylinder applies pressure over the area of the piston, developing a force on the piston rod.

- **The force on the piston rod enables the movement of a load or device.**

- The oil from the other side of the piston returns to a reservoir or tank.



Applications for Hydraulic Systems

Hydraulic systems are used to accomplish different tasks in a wide variety of industries, such as:

- **Manufacturing**: Used for plastic processing, automated production lines, machine tools, loaders, crushers, and robotic systems

- **Construction:** Used in earthmoving equipment, tunnel boring machines, rail equipment, and drilling rigs

- **Automobile:** Used in brakes, shock absorbers, and steering systems

- **Aerospace**: Used for rudder control, landing gear, brakes, flight control, and rocket motor movement
- **Mining**
- **Agriculture**
- **Robotics**.

Components of Hydraulic system

1. The hydraulic actuator

It is a device **used to convert fluid power into mechanical power** to do useful work (i.e. motion).

TYPES OF ACTUATORS:

1. **Linear Actuators** (Hydraulic cylinders)
2. **Rotary Actuators** (Hydraulic motors)

a. **Continuous rotary actuators**

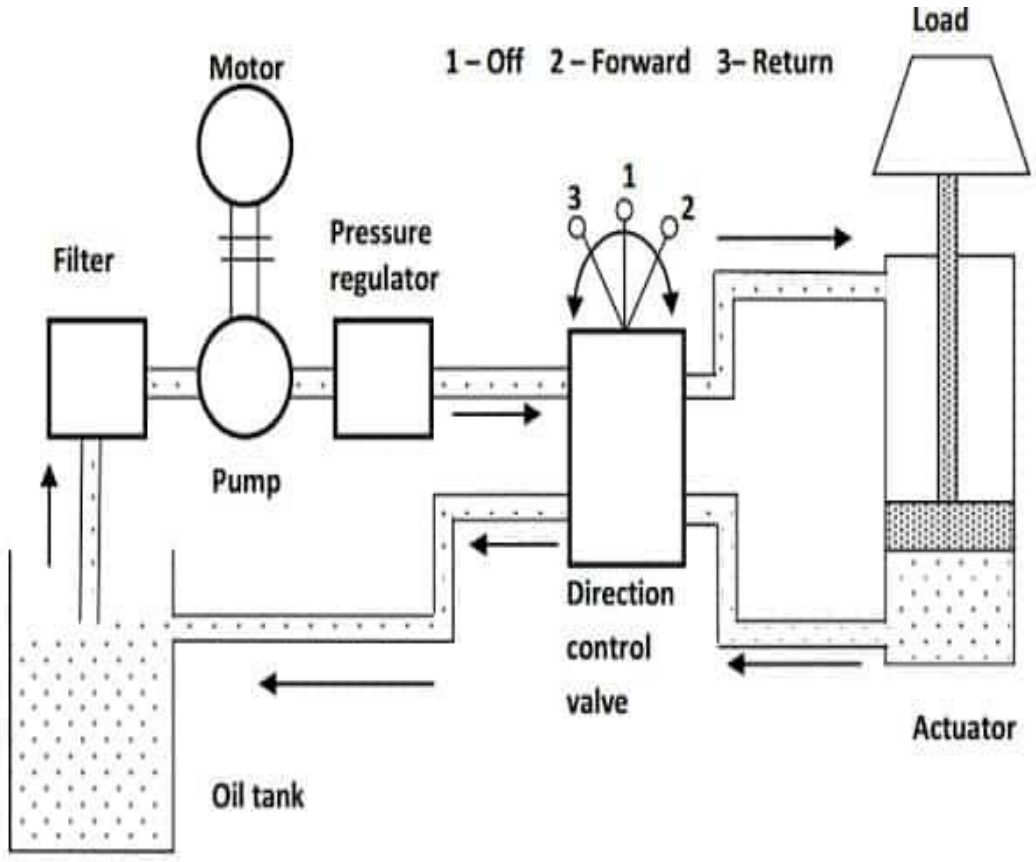
b. **Semi rotary actuators**

The difference between a rotary actuator and a Motor: the rotary actuator rotates around a limited arc,

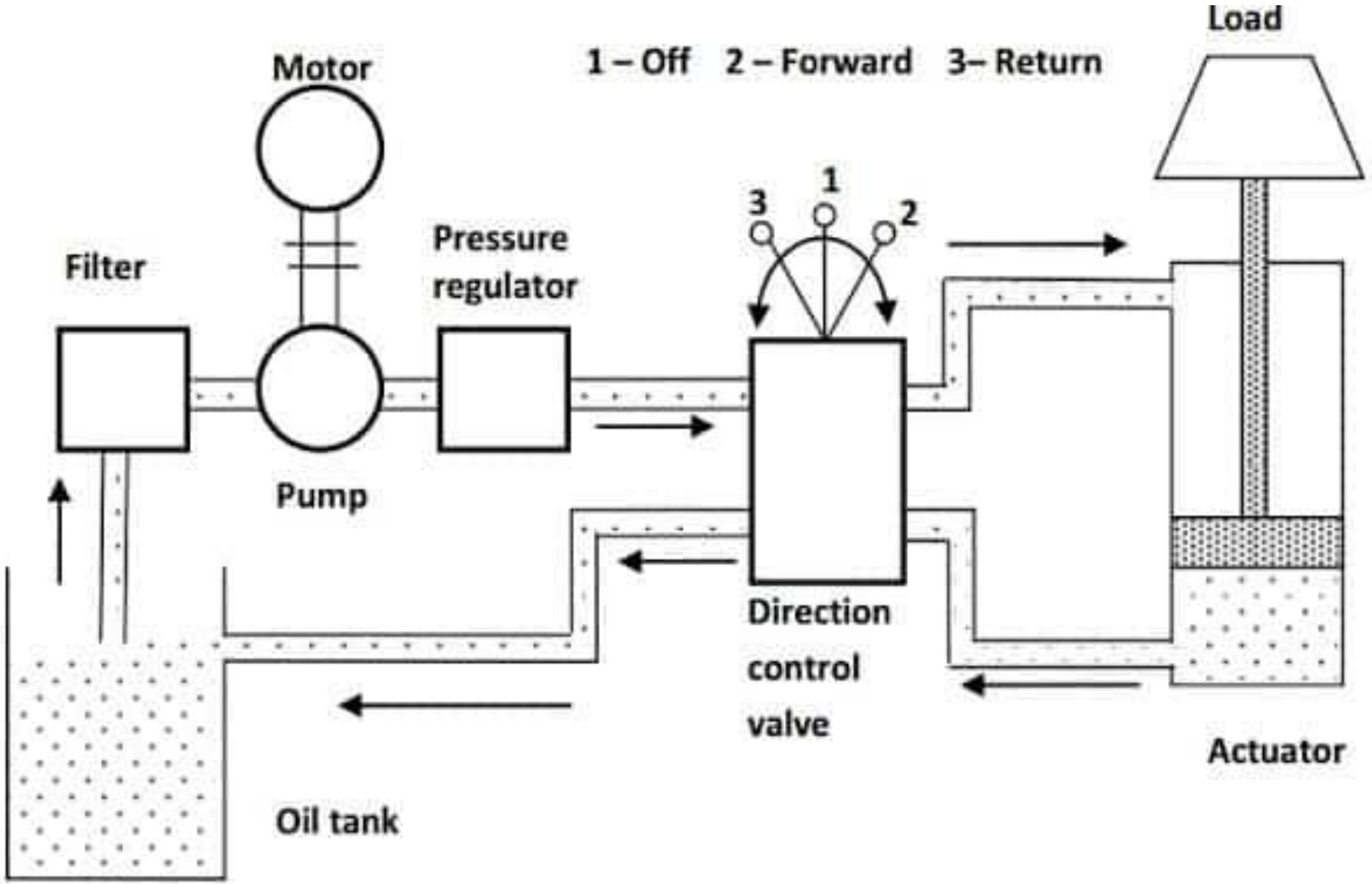
while a motor may rotate infinitely

Functions Of Actuators :

1) To produce motion in one line
2) To produce continuous rotary motion
3) To produce rotary/oscillatory motion less than 360°
4) To apply a force and clamp the job.



Components of a hydraulic system



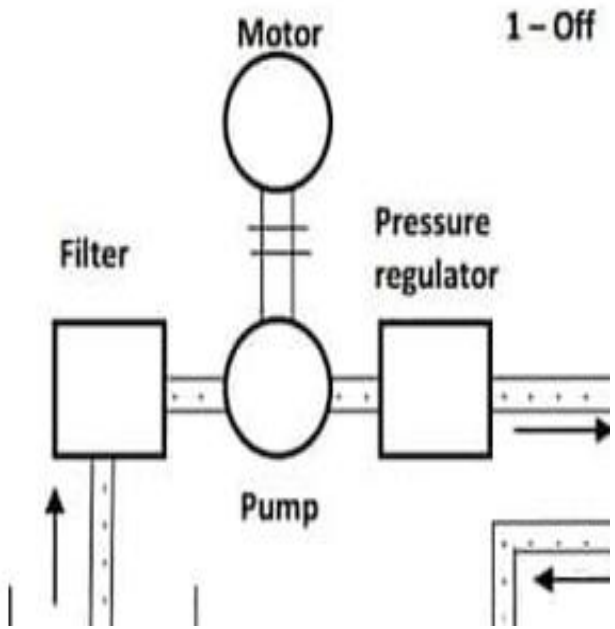
Components of a hydraulic system

2. Hydraulic pump (heart of a hydraulic system)

- It is used to force the fluid from the reservoir to the hydraulic circuit.
- It converts mechanical energy into hydraulic energy.
- The mechanical energy is delivered to the pump via prime mover such as the electric motor.
- Due to the mechanical action the pump creates a 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.

Importance of Pump :

1. They convert mechanical energy into hydraulic energy.
2. Pumps used to generate high pressure in the hydraulic system
3. The **Volumetric efficiency of the pump is relatively high**
4. They have **high-performance characteristics under varying speed and pressure requirements**



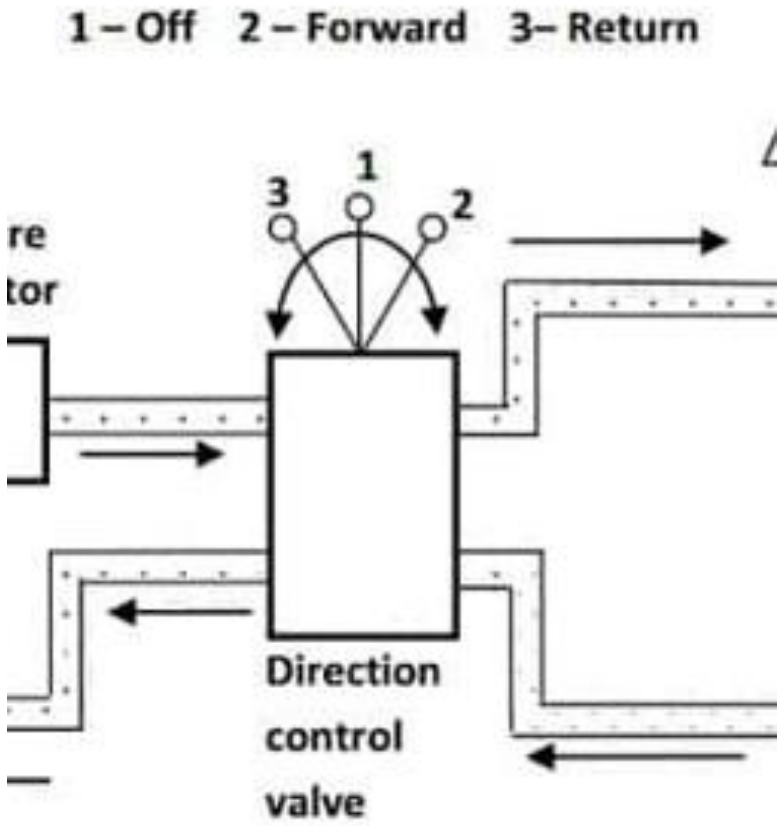
3. Valves

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

Positions 1 – Off 2 – Forward 3– Return

This unit is devoted to each of the following categories of control valves.

1. **Directional control valves (DCV)**
2. **Pressure control valves (PCV)**
3. **Flow control valves (FCV)**



- DCVs control **the direction of flow in a circuit.**
- PCVs control the **pressure level**, which controls the output
- force of a cylinder or the output torque of a motor.
- FCVs control **the flow rate of the fluid which controls the speed of the actuator**

Different types of valves and their functions :

Pressure relief valves – Relief valve **opens and bypasses fluid when pressure exceeds** its setting. These are used mostly in all circuits.

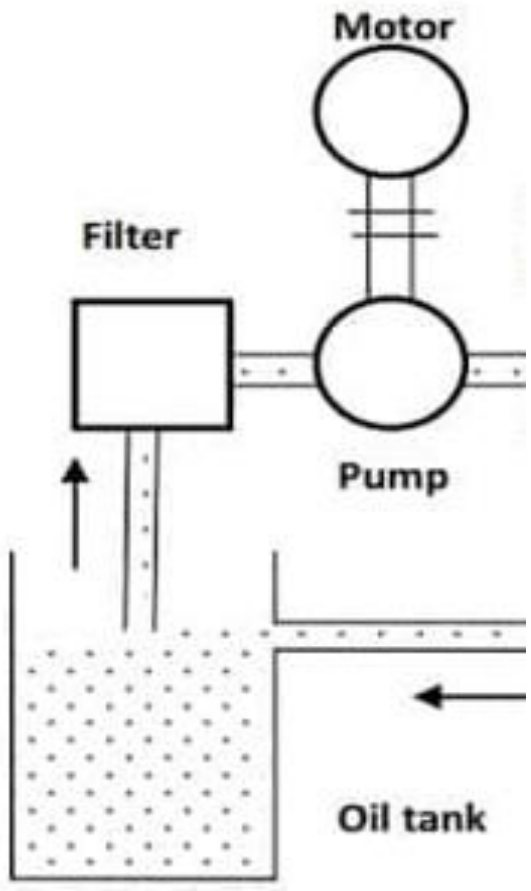
Pressure-Reducing Valve – This type of valve (which is normally open) is used to maintain reduced pressures in specified locations of hydraulic systems.

Unloading Valves – The high-low pump circuits where two pumps move an actuator at a high speed and low pressure, punching press.

Counterbalance valves – They are used to prevent a load from accelerating uncontrollably.
This situation can occur in vertical cylinders in which the load is a weight.
This can damage the load or even the cylinder itself when the load is stopped quickly at the end of the travel.

5. Oil Tank or Reservoir:

This is an oil storage tank in which hydraulic oil is stored.
The oil passes through various pipelines and after doing useful work in actuator; the oil returns to the oil tank.
In the regions of low temperature, oil heaters are attached to air tanks.
Reservoir is used to hold the hydraulic liquid



6.Pipelines : (Fluid Conducting elements):

It is the functional connection for oil flow in the hydraulic system.
The efficiency of oil flow is greatly influenced by the physical characteristics of piping systems.

There are two pipes:

a) The pipe which carries pressurized oil is called **pressure pipelines**

b) Pipes that carry low pressurized oil or used oil (are called as **return pipelines**).

7. Filters

It is 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 (to remove contaminants)**.

Filters are classified as

i. Reservoir filters

ii. Line filters

iii. Off-line filters

iv. Other cleaning equipment

Functions of Filter:

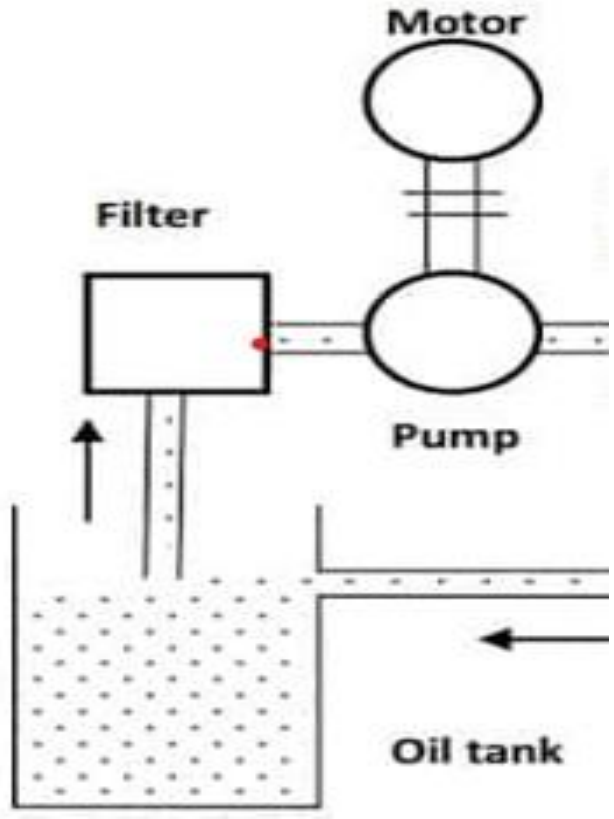
1) Take care of the **cleanliness** of the components.

2) **Reduce the maintenance**.

3) **Remove silting (polution).**

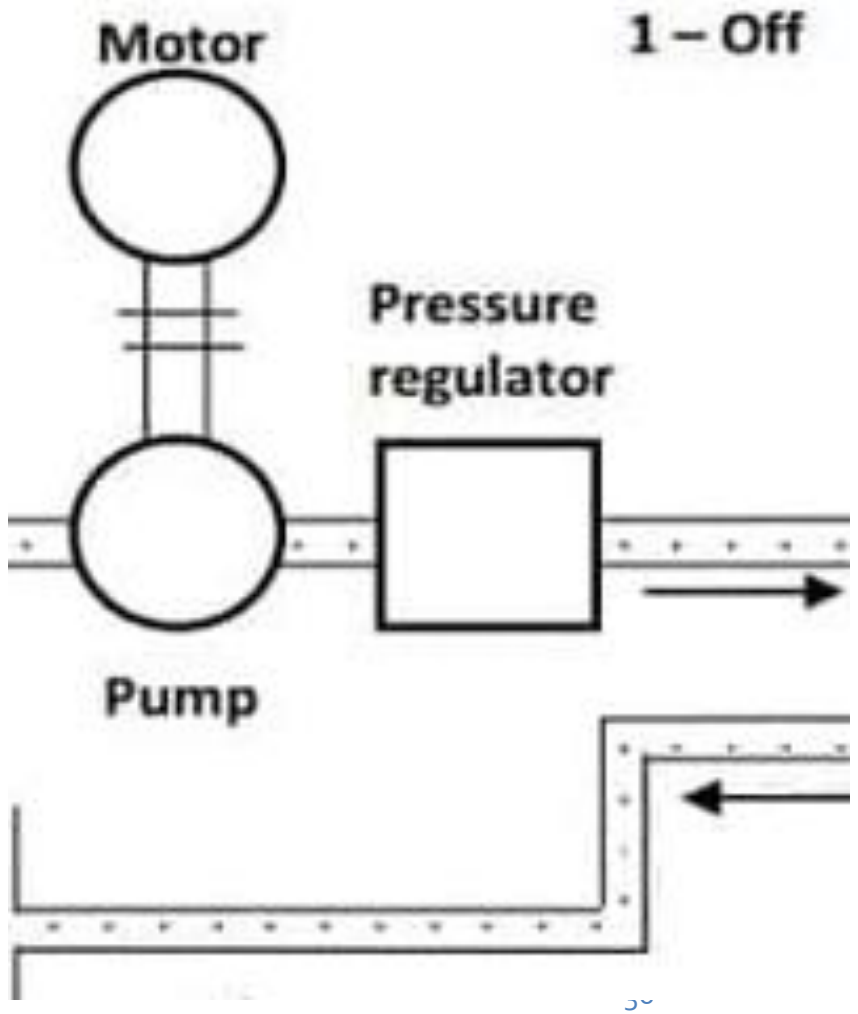
4) To **increase the system reliability**.

5) To prevent the entrance of solid contaminants to the system



8.Pressure regulator

- Pressure regulator maintains the required level of pressure in the hydraulic fluid.
- The piping is shown in Fig. is of **closed-loop type** with fluid transferred from the storage tank to one side of the piston and returned from the other side of the piston to the tank.
- Fluid is drawn from the tank by a pump that produces fluid flow at the required level of pressure.
- If the fluid pressure exceeds the required level, then the excess fluid returns back to the reservoir and remains there until the pressure acquires the required level.



9. Accumulators

Accumulators are devices that store hydraulic fluid under pressure.

Storing hydraulic fluid under pressure is a way of **storing energy for later use**.

Perhaps the most common application for an accumulator is supplementing the pump flow in a hydraulic system in which a high flow rate is required for a brief period of time.

Types of Accumulators ;

1. Weight loaded accumulator
2. Spring-loaded accumulator
3. Gas-charged accumulator
4. Piston type
5. Bladder type
6. Diaphragm type

10. Hydraulic Power Pac

10.Hydraulic Power Pack :

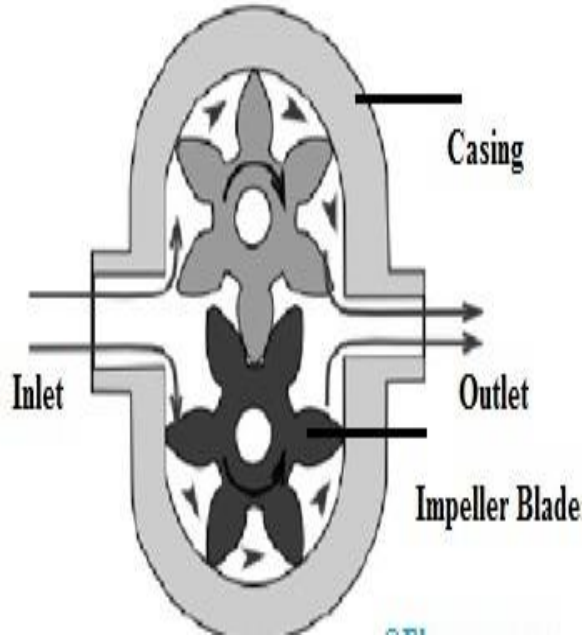
The hydraulic power unit (power supply unit) provides the energy required for the hydraulic installation.

The main components of power packs are – The reservoir (tank), Drive (electric motor), Hydraulic pump, Pressure relief valve, filter, and cooler.

Principle: Hydraulic Pump

A hydraulic pump is a mechanical source of power that converts mechanical power into hydraulic energy (hydrostatic energy i.e. flow, pressure).

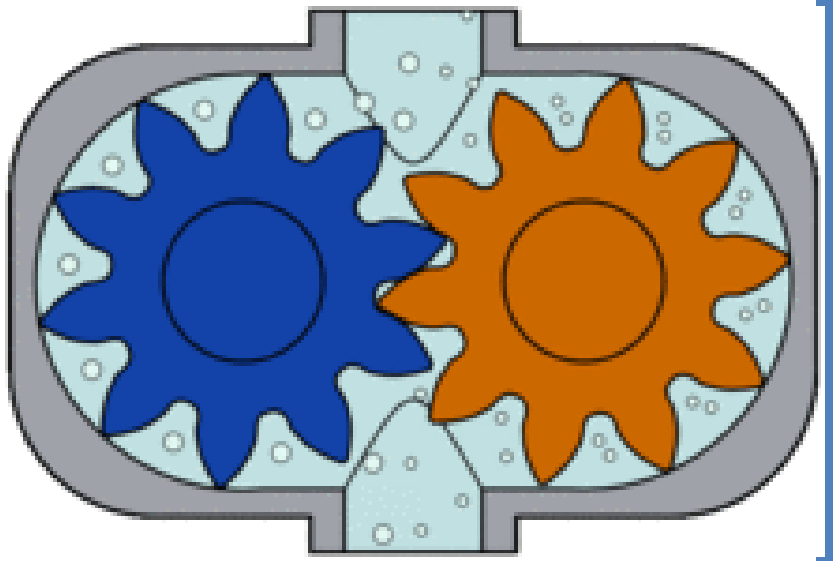
https://youtu.be/cMmwb3JmLoo



Working:

When a hydraulic pump operates, it performs two functions.

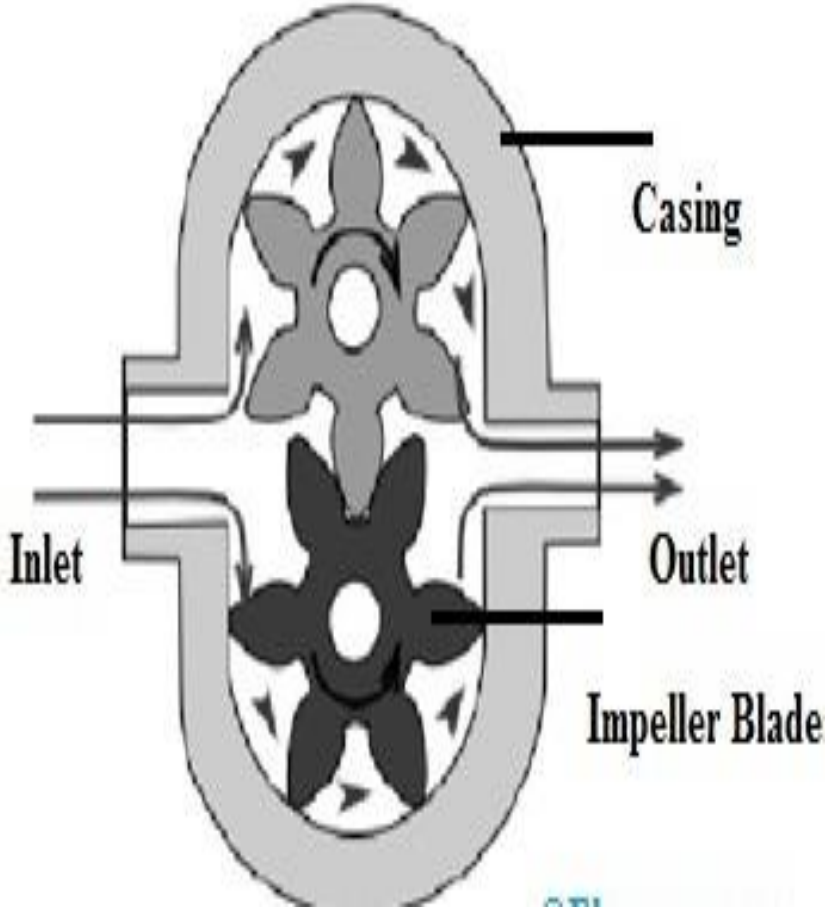
- **1. Its mechanical action creates a vacuum (low pressure) at the pump inlet which allows atmospheric pressure to force liquid from the reservoir into the inlet line to the pump.**
- 2. Its mechanical action delivers this liquid to the pump outlet and forces it into the hydraulic system.



- A pump produces liquid movement or flow:
  it does not generate pressure.

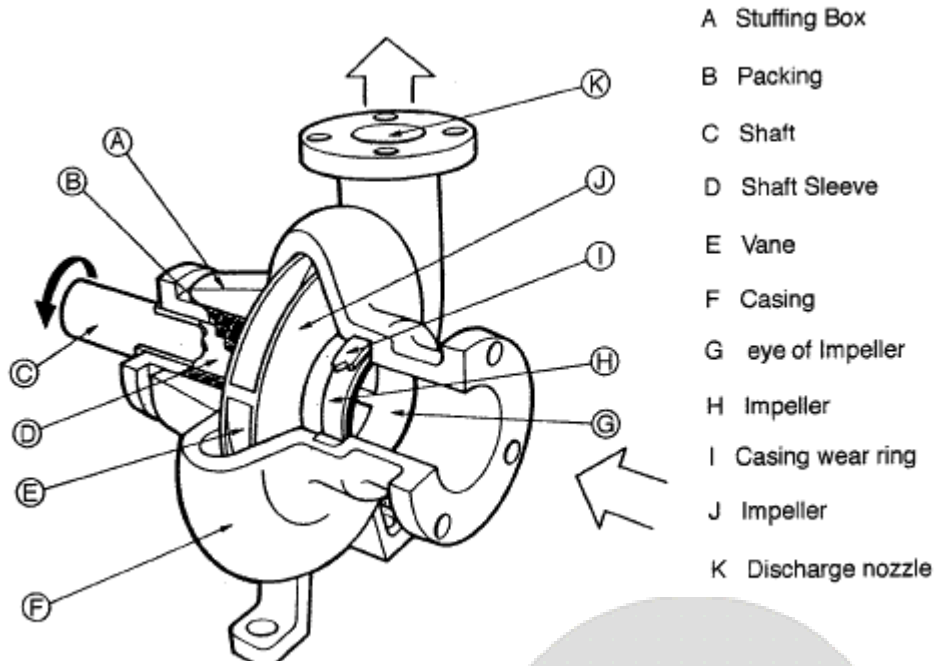
- It produces the flow necessary for the development of pressure which reduces **resistance to fluid flow** in the system.

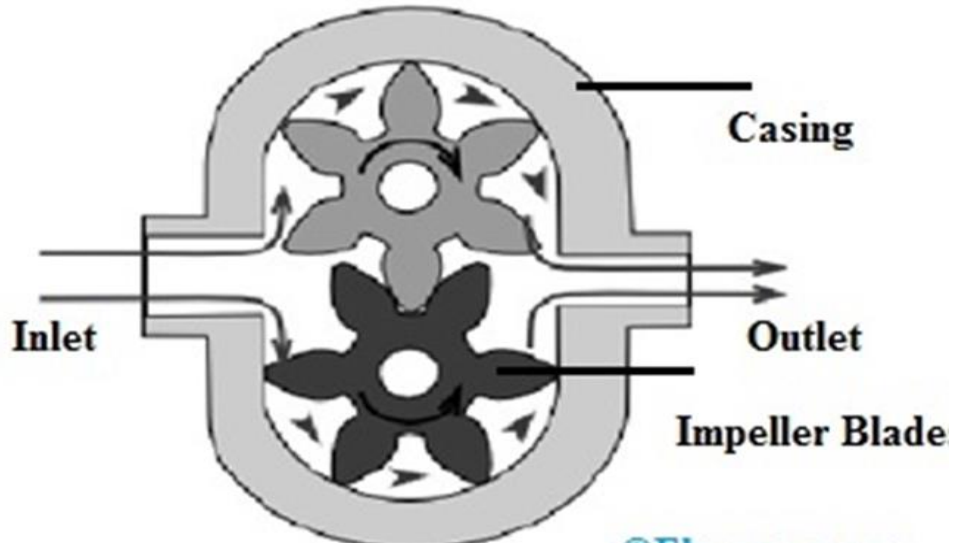
- **e.g., If a pump is not connected to a system, the pressure of the fluid at the pump outlet is zero.**
- Further, for a pump connected to a system, the pressure will rise only to the level necessary to overcome the resistance of the load.

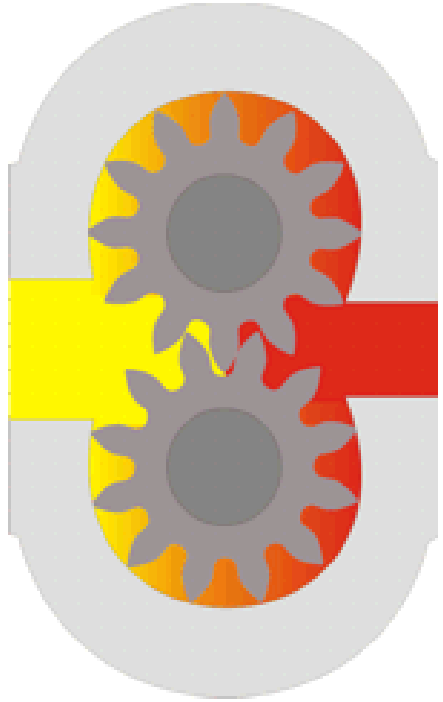


Hydraulic pumps components

- Casing
- Runner Vanes
- Shaft
- Bearings
- Sealing
- Oil Storage Tank
- Pipeline
- Electric Motor
- Hydraulic Actuator
- Relief Valve







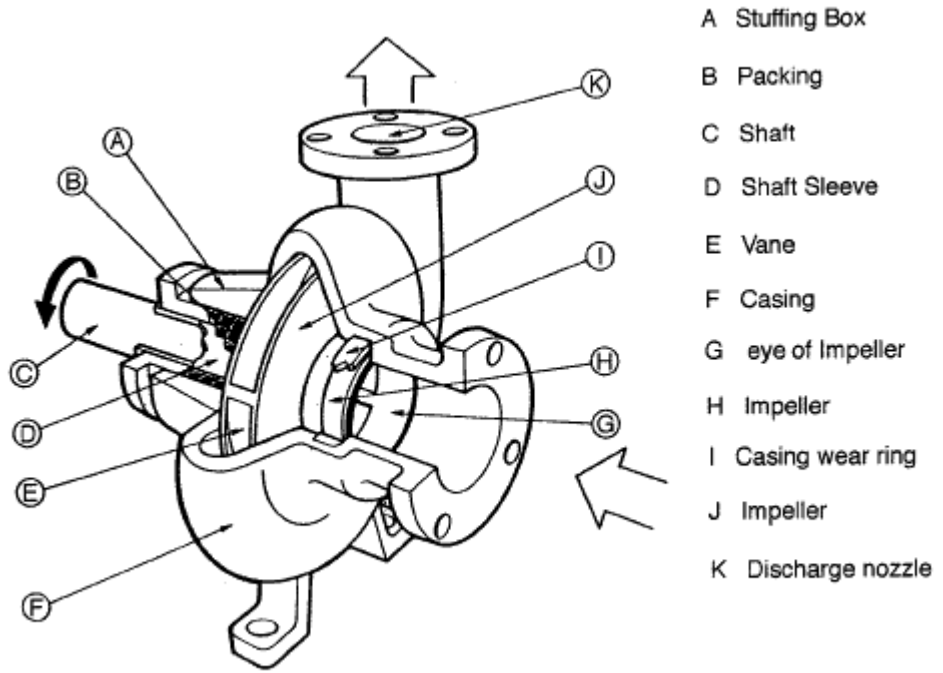
1. Casing

The casing is the hydraulic pump's external part designed **to ensure safety** for the internal parts.

e. g. aluminum casings, cast iron castings.

It prevent fluid from **splashing outside the pump**.

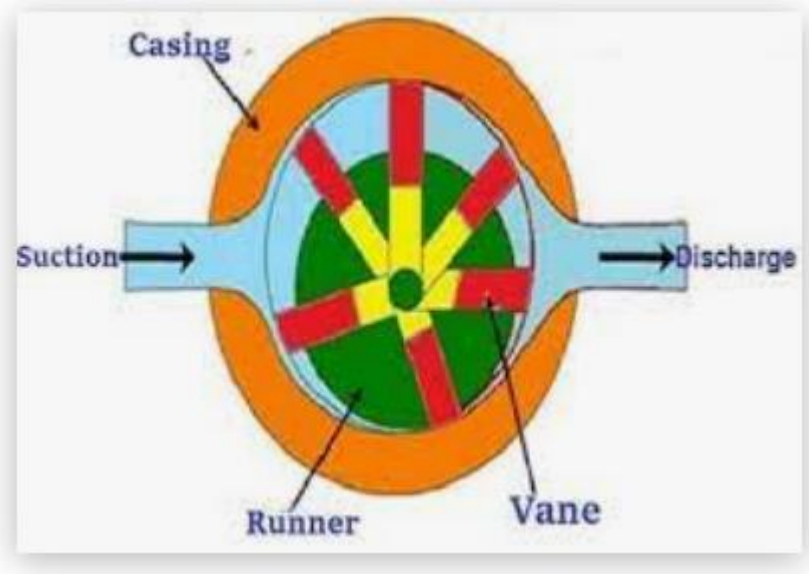
The component also **prevents** the hydraulic system from getting damaged **if a heavy weight falls on the system**.



2. Runner Vanes/ Blades

There is a rotary part of the hydraulic pump known as a runner that rotates inside the pump casing.

A number of vanes rotate along with the rotation of the runner. The fluid inside the pump also rotates with the rotation of the runner vanes. The result is an increase in fluid pressure. In addition, these vanes are also essential for cooling the system and lubricating it.



https://youtu.be/civimwb3jmL?si=

3. Shaft

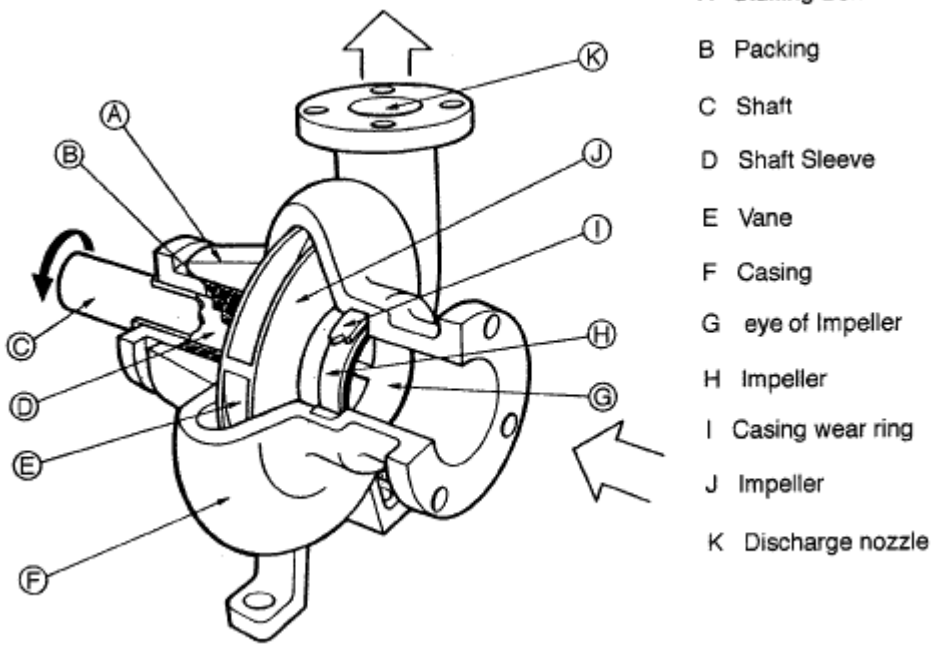
A shaft is used to assemble the runner. A steel or stainless steel shaft is used for the assembly. The shaft size can be adjusted based on the runner.

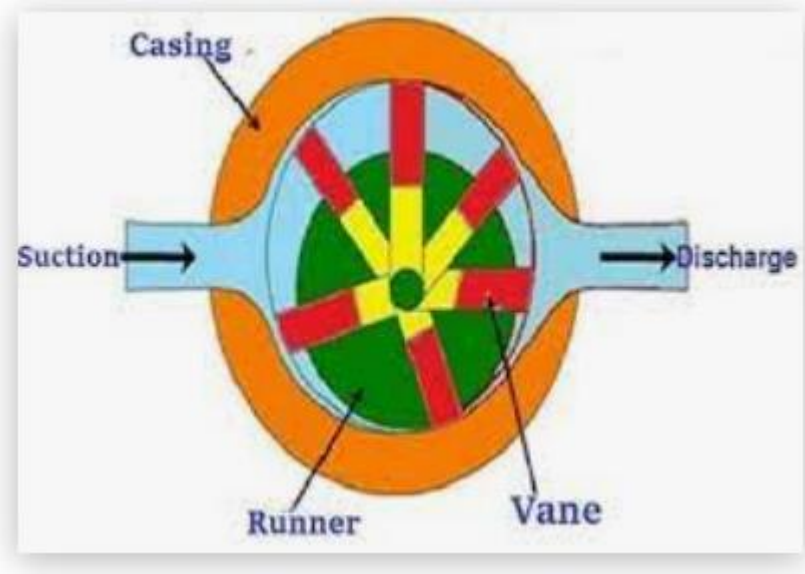
4. Bearings

For the runner to rotate, bearings are needed.

5. Sealing

Fluid leaks from the pump can be prevented by the seal. Pumps usually fail because bearing components are damaged. Bearing components can be protected from contaminants and coolants by means of a seal.





6. Oil Storage Tank

It contains non-compressible fluids (including hydraulic oil). The tank also **protects the hydraulic oil from contamination**.

7. Pipeline

A pipeline transports hydraulic fluid between different parts of the system.

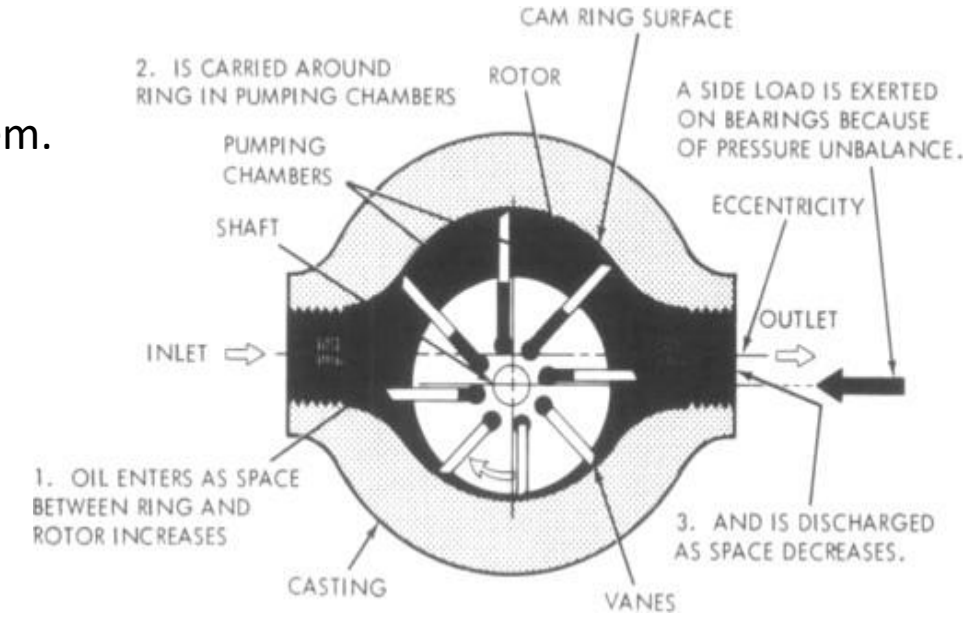
8. Electric Motor

The pump can be driven by an electric motor.

Motors are used to drive the driving shaft inside the system.

From there, the driver gear is driven.

An electric motor is thus used to power the pump.



9. Hydraulic Actuator

A hydraulic actuator transforms hydraulic energy into mechanical power in order to accomplish the desired effect.

10. Relief Valve

The relief valve controls the pressure within the hydraulic system.

By means of a pressure relief valve, excess fluid pressure is returned to the inlet.

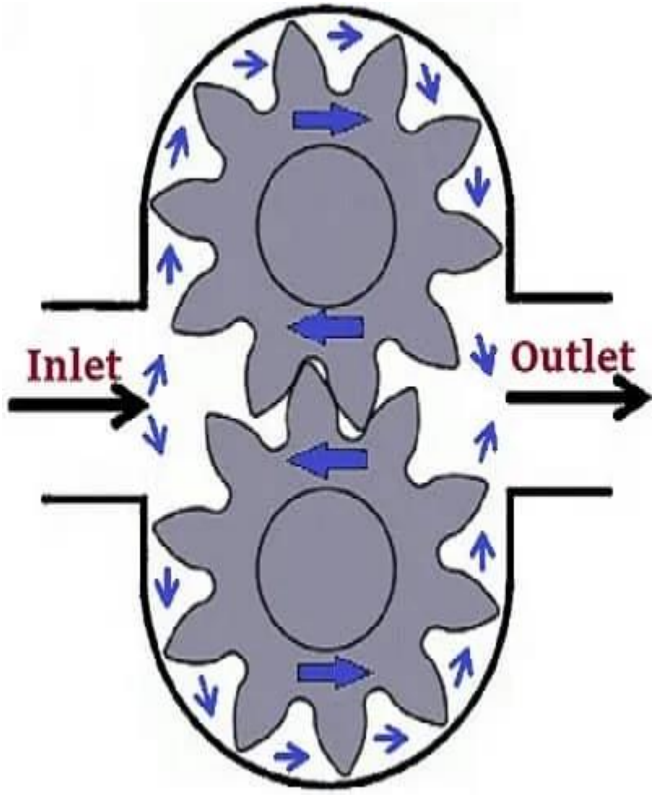
In short….

- A hydraulic pump carries any fluid from the tank or reservoir to other system parts.

- The **inlet & outlet of this pump includes check valves** which are arranged at the **inlet of the pump to push the fluid from the reservoir or tank into the pump & the outlet will force fluid to supply to the remaining parts of the system**.

- Here, **the fluid at the inlet is pushed through the vacuum created**.
- A gas engine or **electric motor is used as the prime mover for rotating the shaft**.

- The impeller blades are arranged on the shaft & the nearby fluids will turn with the shaft's movement.



Gear Pumps:

USES:

The gear pump is commonly used in machines such as forklifts for hydraulic fluid power.

ADVANTAGES:

- They’re an easy-to-use, easy-to-maintain solution with a simple design. These pumps range in internal and external designs.

- Probably the simplest and most commonly used types of hydraulic pumps today and they are easily maintained and economic.

- This design is characterized as having fewer moving parts, being easy to service, more tolerant of contamination than other designs, and relatively inexpensive.

- Gear pumps are fixed displacement, also called positive displacement, pumps.
- This means the same volume of flow is produced with each rotation of the pump’s shaft.

https://youtu.be/W_W1ll31cww

Different hydraulic pump types

- Reciprocating pumps
- Rotary pumps
  - Gear pumps
    - External gear pumps
    - Lobe pumps
  - Internal gear pumps
    - Gerotor pumps
- Screw pumps
- piston pumps
  - Axial piston pumps
  - Radial piston pumps
- Vane pumps

https://youtu.be/W_W1ll31cww

Performance of Gear pumps are measured in terms of the **pump's maximum pressure rating, cubic inch displacement, and maximum input speed limitation.**

Different types of gear pumps:

- Internal gear pumps
- External gear pumps
- Gerotor pumps
- Lobe pumps

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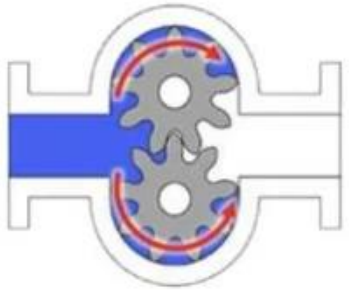
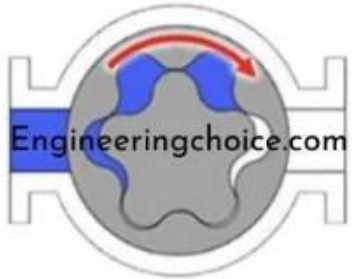
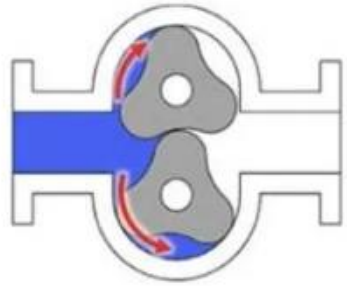
External Gear Pump



Gerotor Pump

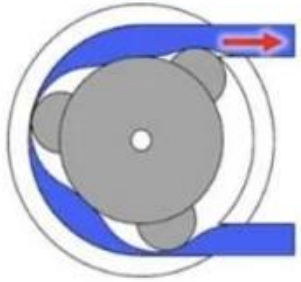


Lobe Pump



Internal Gear Pump

Peristaltic Pump



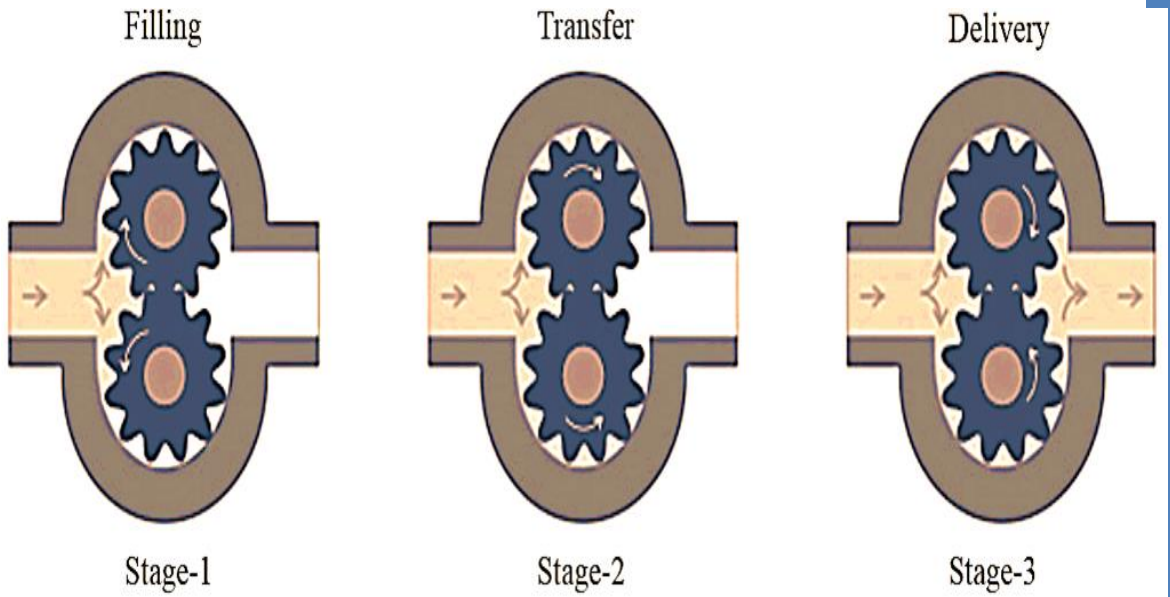
Vane Pump

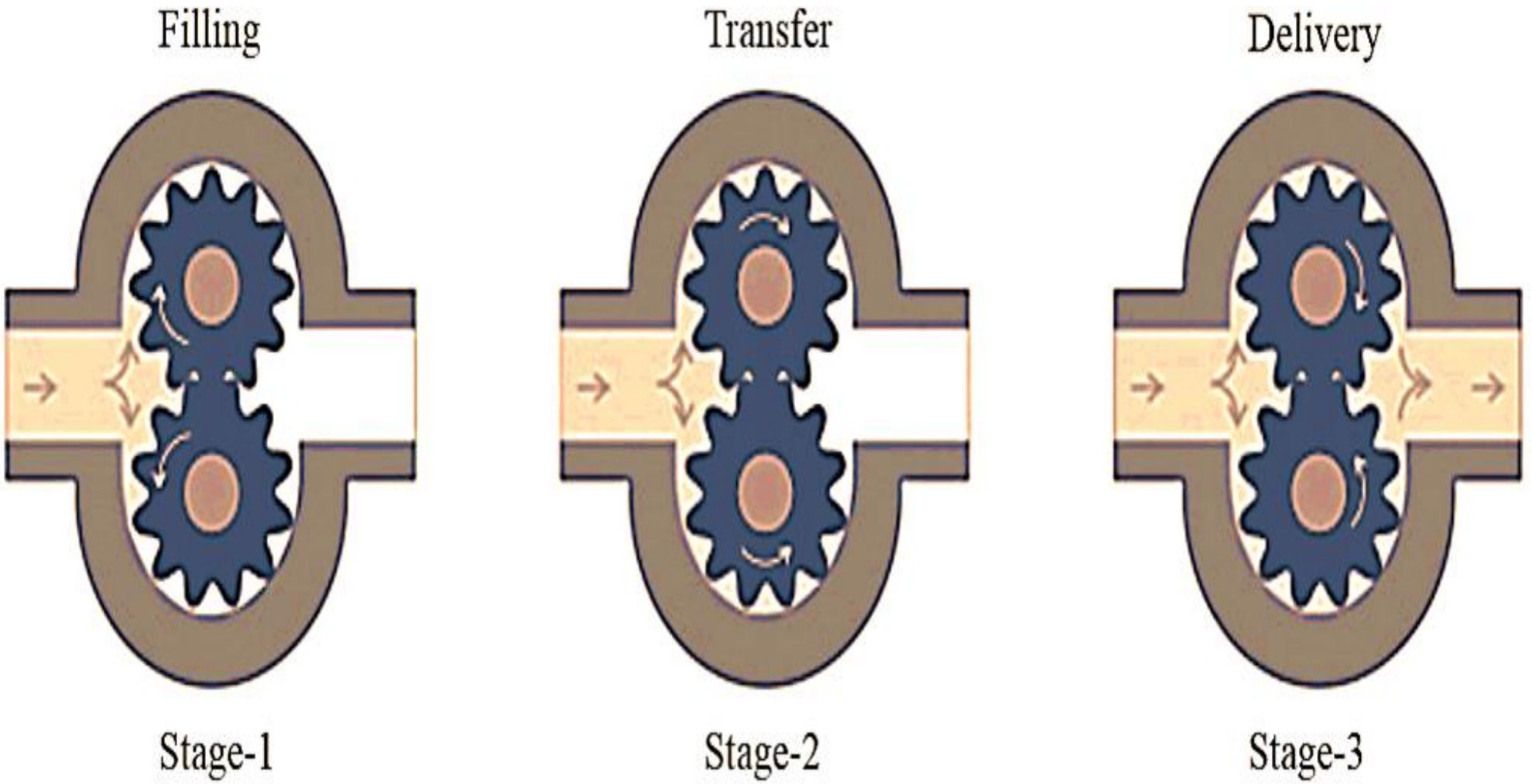
External Gear Pumps

External Gear pumps rely on the counter-rotating motion of meshed external spur gears to impart motion to a fluid.

They are generally **fixed-displacement designs, very simple and robust.** They are commonly found as **close-coupled designs** (where the motor and pump share a common shaft and mounting).

Oil travels around the periphery of the pump housing between the teeth of the gears.
On the outlet side, the meshing action of the teeth decreases the volume to discharge the oil.



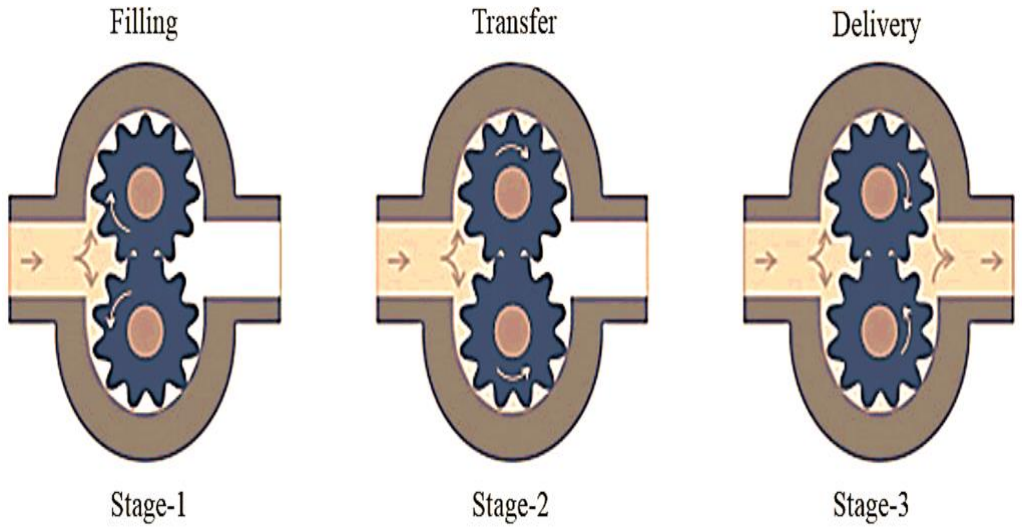

Filling
Transfer
Delivery
Stage-1
Stage-2
Stage-3

- The small amount of oil that is trapped between the re-meshing gears discharges through the Elkins and back to the pump's suction side.

- External gear pumps are **very popular in fixed-displacement hydraulic applications as they are capable of providing very high pressures**.

Advantages:

•It is the **most famous type of** hydraulic pump
•Gear pump has a **very low number of moving components**
•These pumps have an **easy maintenance**
•These have **relatively low cost**
•Gear pumps can **tolerate contaminations**
•These are **very efficient.**

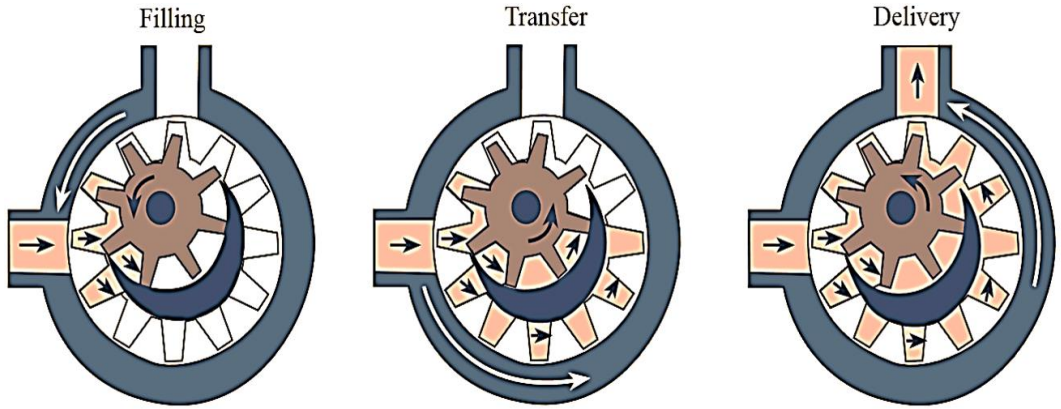


Internal Gear Pumps:

The internal gear pump uses the meshing action of an internal and external gear combined with a crescent-shaped sector element to create fluid flow.

The axis of the external gear is **offset** from that of the internal gear.

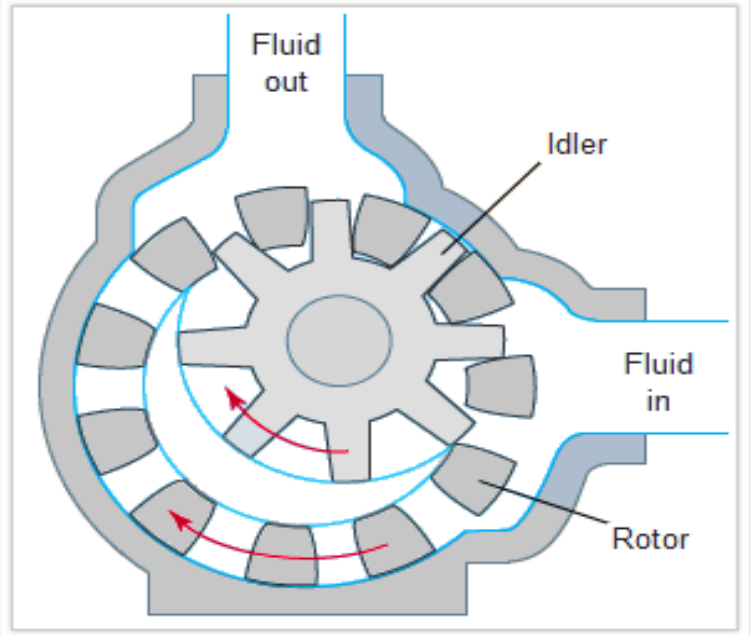
As the two gears rotate, their coming out of mesh and going again into mesh creates **suction and discharge zones.**



The sector serves as a barrier between suction and discharge.

The internal gear pump has one or two more external gear teeth than the internal gear so that these designs have a lower relative speed between the internal and external gears.

E.g., if the inner and outer gears have 8 and 9 teethes, respectively, the inner gear will rotate 9 times, and the outer gear will rotate 8 times.

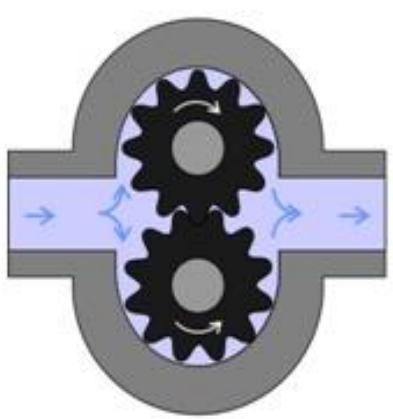


This low relative speed means a low rate of wear.
https://www.youtube.com/watch?v=y7_AtJoUY6g

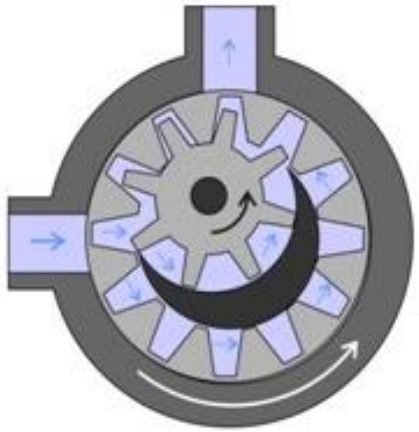
Advantages:

- It has one stuffing box
- The internal gear pump has only two moving components
- It is perfect for high viscosity fluids
- It has flexible design

INTERNAL	EXTERNAL
BULKY	COMPACT
EASY TO CLEAN AND REASSEMBLE	LARGER OUTLET SIZES
SMALLER OUTLET SIZES	GEAR DESIGNS INCLUDE SPUR, HELICAL, OR HERRINGBONE
ALL GEAR DESIGNS ARE SPUR	LESS EXPENSIVE
BETTER SUCTION CAPABILITIES	HIGHER SPEEDS
SUITED TO SHEAR-SENSITIVE FLUIDS AND HIGHER TEMPERATURES	SUITED TO HIGHER PRESSURES
MORE EXPENSIVE	
LIMITED TO SMALL CAPACITIES AND MODERATE PRESSURES	



External Gear Pump



Internal Gear Pump

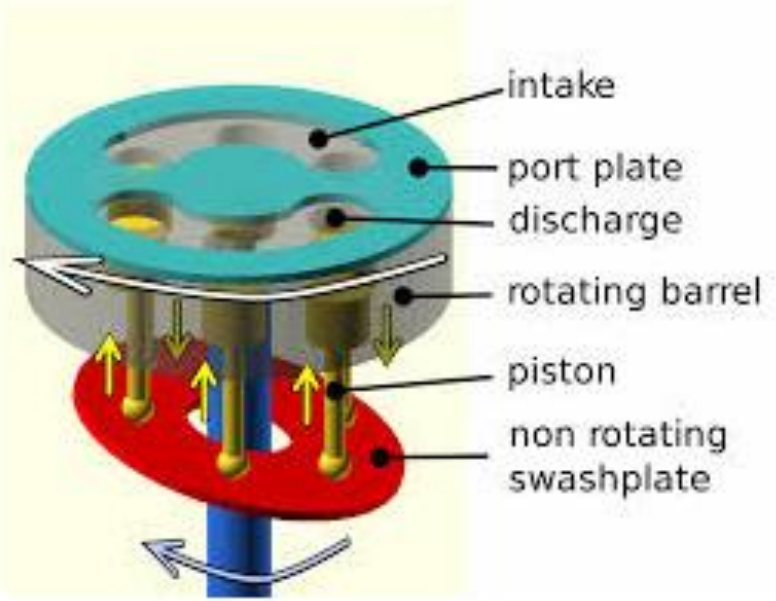
Piston Pumps

Working principle:

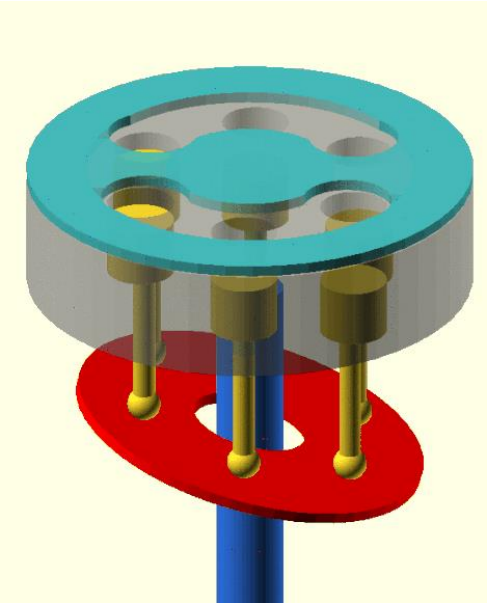
Pistons work by **transferring the force output of an expanding gas / fluid in the cylinder to a crankshaft, which provides rotational momentum to a flywheel**.
Such a system is known as a reciprocating engine.

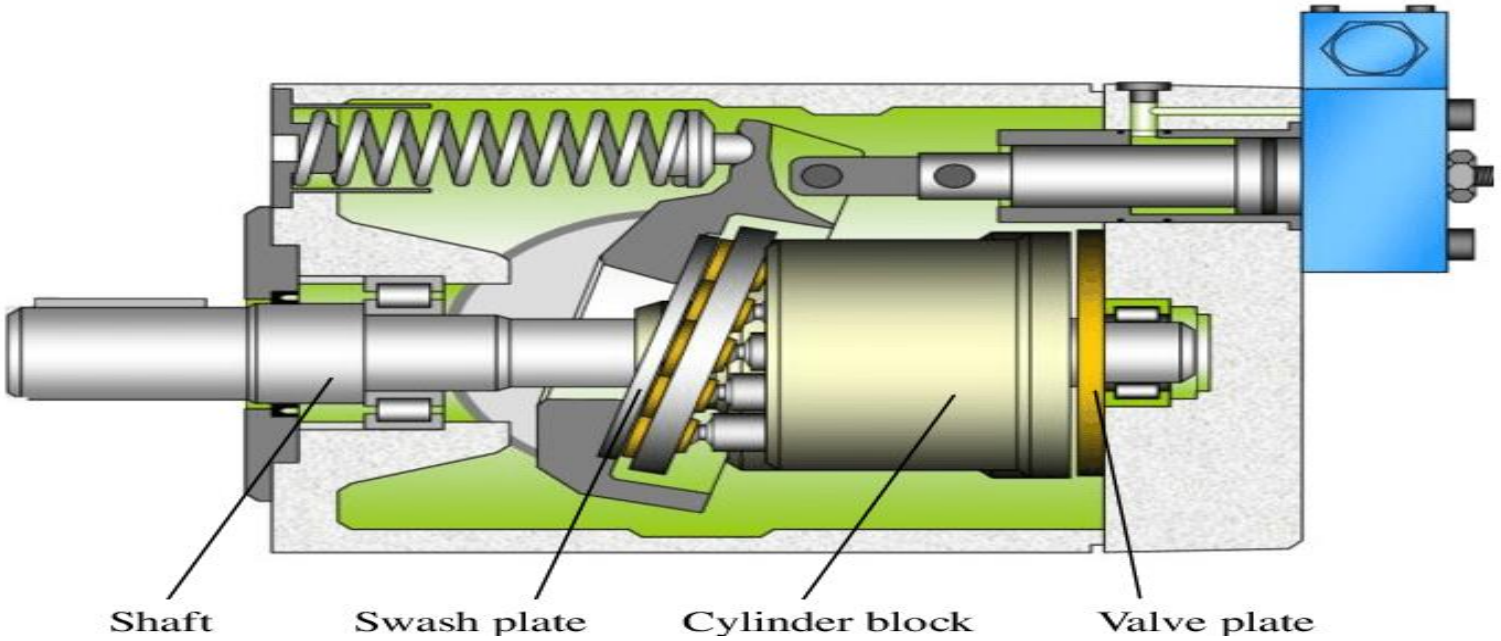
A piston pump is **a type of positive displacement pump where the high-pressure seal reciprocates with the piston**.

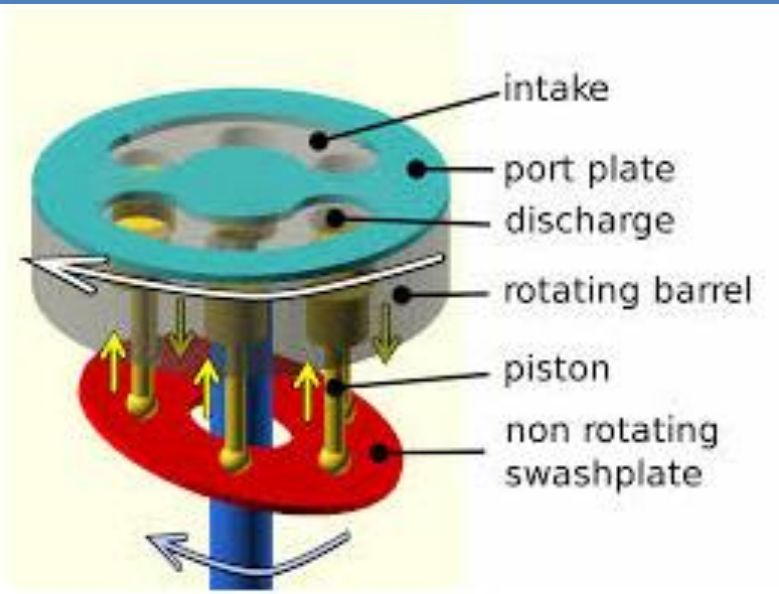
Piston pumps can be **used to move liquids or compress gases**.



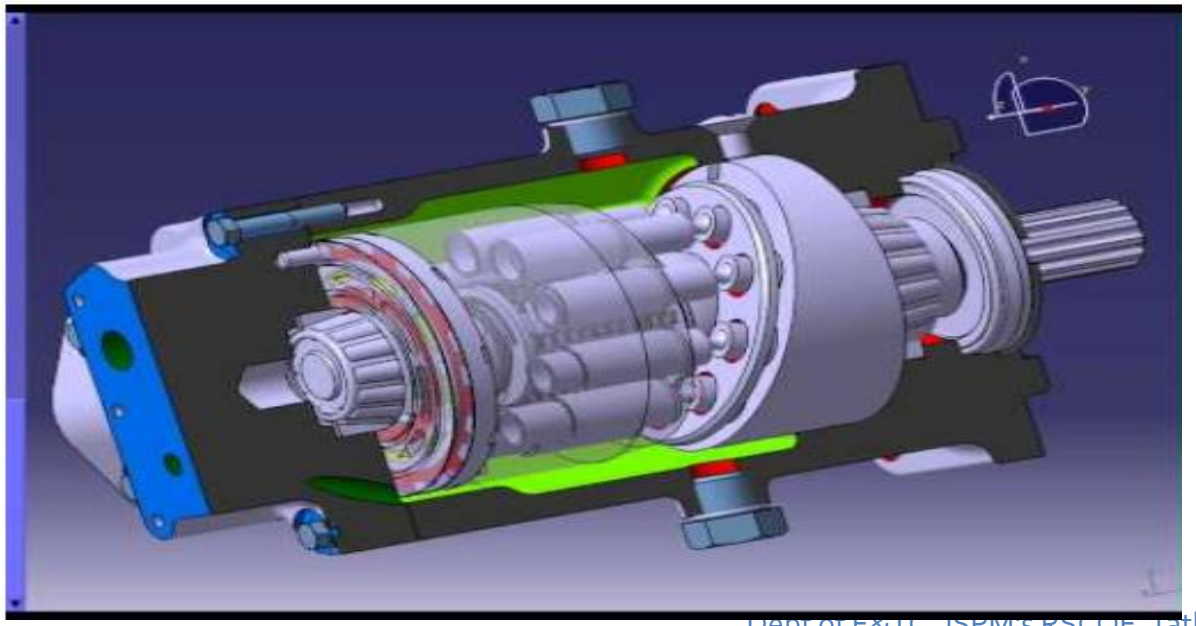
Piston Pump

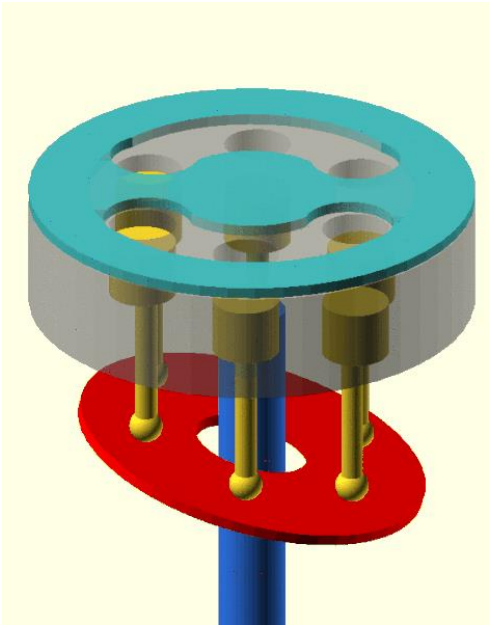



Shaft
Swash plate
Cylinder block
Valve plate


intake
port plate
discharge
rotating barrel
piston
non rotating
swashplate

Piston Pump





Advantage of a piston pump:

- High pressure operation can be achieved without adversely affecting flow rate.
- Efficiency, Very useful
- They can **operate over a wide range of pressures**.
- Can move fluids through a machine, regardless of viscosity.
- A long performance life.

Disadvantages:

Higher initial cost associated with piston pumps a lower resistance to contamination and increased complexity.

There are two types of piston pumps:1. Axial Piston Pumps and 2. Radial Piston Pumps

1. Axial Piston Pumps:

- An **axial piston pump** is a positive displacement pump that has a number of pistons in a circular array within a cylinder block.
-

https://www.youtube.com/watch?v=2UYktuZuhr4

- **Axial piston pumps use axially mounted pistons** that reciprocate within internal cylinders **to create alternating suction and discharge flow.**

- They can be designed as variable-rate devices making them useful for **controlling the speeds of hydraulic motors and cylinders**.

- In this design, **a swashplate is used to vary the depth** to which each piston extends into its cylinder as the pump rotates, affecting the volume of discharge.

- A pressure compensator piston is used in some designs to maintain a constant discharge pressure under varying loads.

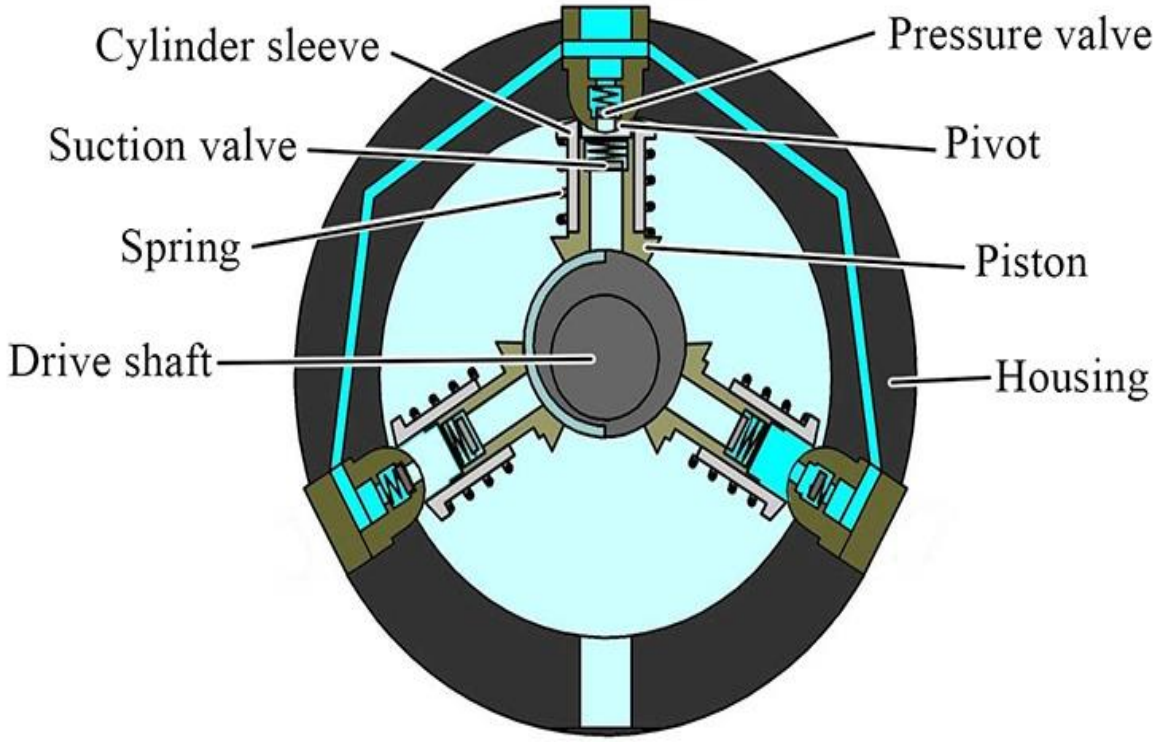
2. Radial Piston Pumps:

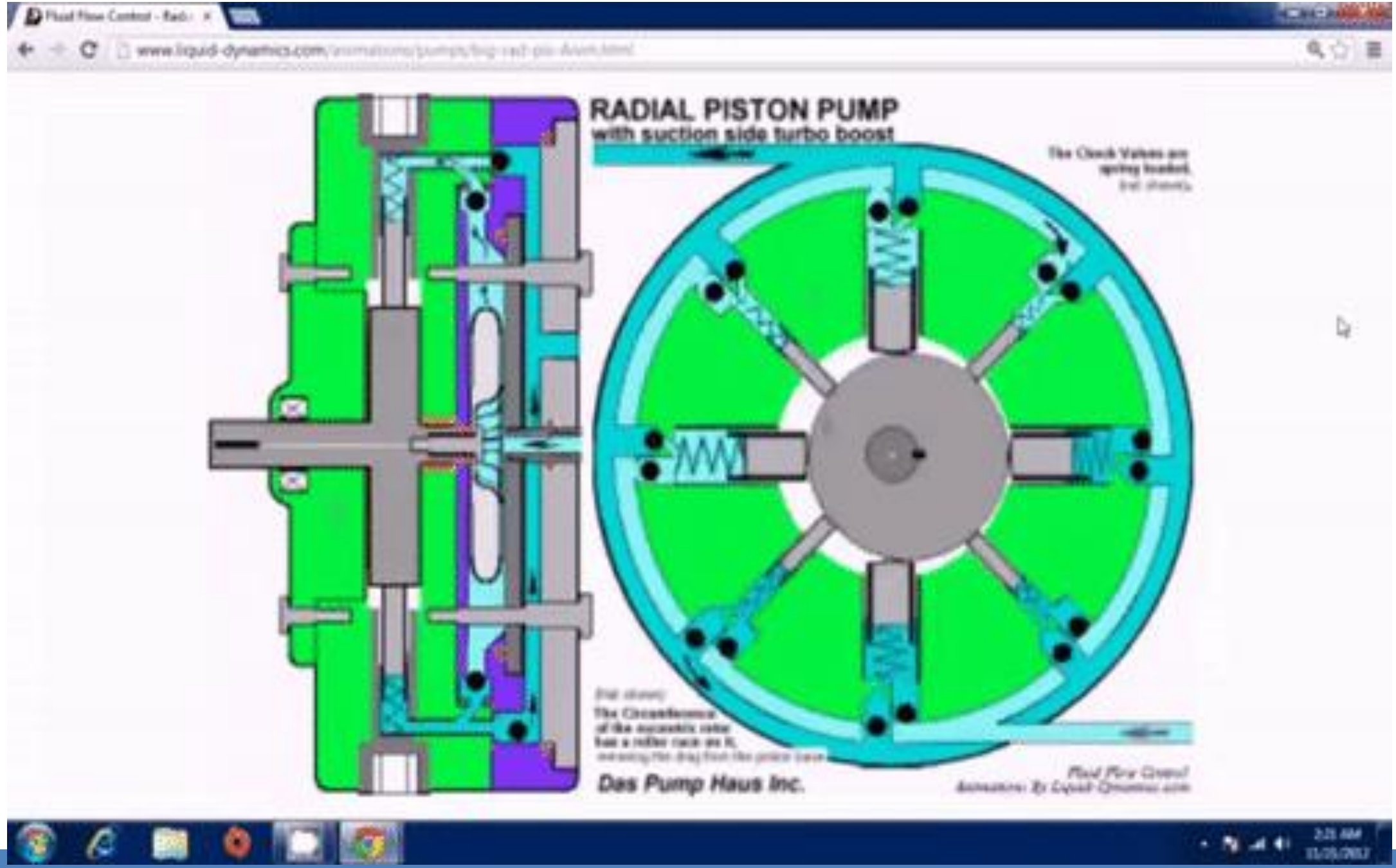
These are fixed displacement type, but many come as a variable displacement option.

An odd number of radial piston arranged around a rotating shaft.

This is encased within an eccentric ring.

As the shaft rotates the distance betw the eccentric ring and shaft cent varies, hence the pistons move thro suction and Pressure cycle.




RADIAL PISTON PUMP
with suction side turbo boost
Das Pump Haus Inc.

The driven shaft is often hollow and allows fluid to enter and exit the pump.

The displacement changes varying the amount of eccentricity; this is done either manually via adjustment screws or hydraulically with a piston.

ADVANTAGE:

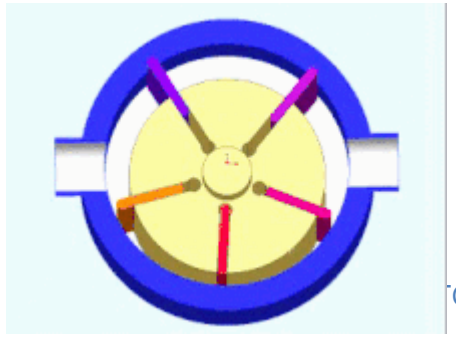
These are excellent for high pressure and are strong and reliable

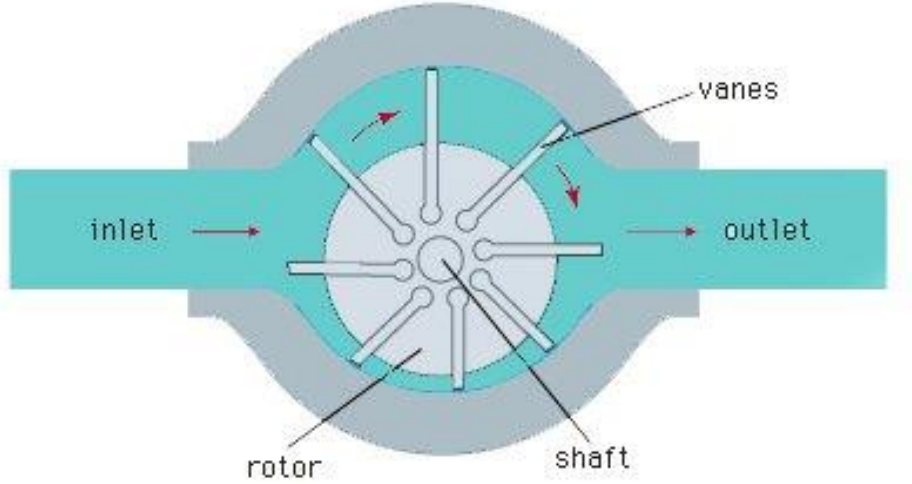
Vane Pumps:

These types of hydraulic pumps use a series of rigid vanes, mounted in an eccentric rotor, which sweep along the inside wall of a housing cavity to create smaller volumes, which forces the fluid out through the discharge port.

In some designs, the volume of the fluid leaving the pump can be adjusted by changing the rotational axis of the rotor for the pump housing.

Zero flow occurs when the rotor and housing axes coincide.

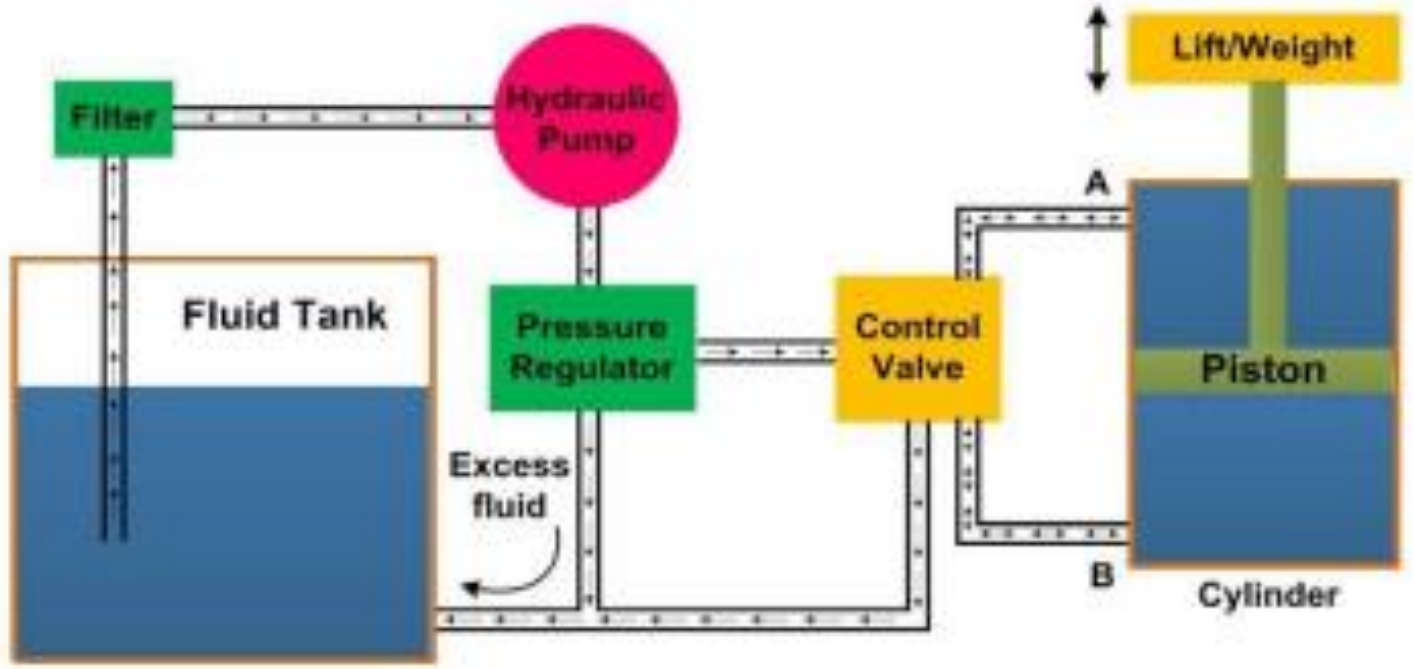




Filters and Pressure Regulation

A filter regulator is a combination of a filter and pressure regulator in a single unit. Both of these are also available as separate units.

The benefit is that the single unit takes less space, reduces the chance of leaks due to less air connections and, in some cases, can improve the performance.



What is the difference between a filter and a regulator?

A regulator is used to control the speed and precision of the flow of liquids and air,

Whereas the filter cleans the air that travels from the compressor.

What is the difference between a filter and a regulator?

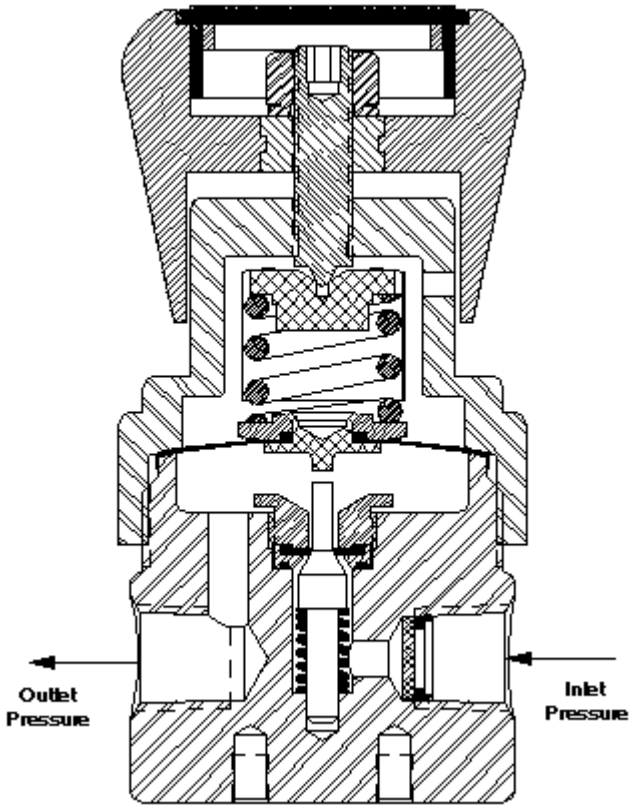
A regulator is used to control the speed and precision of the flow of liquids and air, whereas the filter cleans the air that travels from the compressor.

Single stage pressure reducing regulator

When the media flows into the unit via the inlet port, it is held bubble-tight underneath the poppet in the seat area, as shown by the red area in the animation.

The user can then wind down on the hand knob, which pushes the diaphragm down onto the poppet (manually actuating the diaphragm), to achieve the controlled release of outlet pressure, as shown by the blue area in the animation.

(Note :- A poppet is a mushroom-shaped valve often used **as an exhaust or inlet valve in an internal-combustion engine**. Poppets are sometimes called mushroom valves, because of their shape. Poppet valves are used in most piston engines to open and close the exhaust ports in the cylinder heads.)



Relief Valve

A relief valve, also known as a pressure relief valve, is a device that lowers the pressure to prevent damage to the system.

Their function is **to protect pressure sensitive equipment from damage caused by overpressure**.

They are critical in a pressure system to **ensure that system failures are avoided**.

- They are designed **to release excessive pressure that builds up in equipment and piping systems.**

- To prevent major damage to equipment, and more importantly, injury to workers, relief valves can release elevated pressures before they become extreme.

The purpose of a relief valve is to keep the pressure in a system within set limits to prevent overpressure.

Relief valves are designed to prevent damage due to overpressure conditions.

Safety valves have a fail-safe purpose. Their main purpose is to protect property, the environment, and foremost people.

Accumulator

In hydraulics, an accumulator is **an energy storage device**.
It is similar to a rechargeable electrical battery in electrical systems.

A hydraulic accumulator stores and discharges energy in the form of a pressurized fluid.

Accumulator is a pressure vessel for **storing hydraulic pressure in it utilizing compressible and de-compressible nature of nitrogen gas**.

Accumulators are used extensively **to hold pressure in a circuit, especially where actuators are used**.

The accumulator makes up for any leakage and maintains system pressure when all valving is closed.

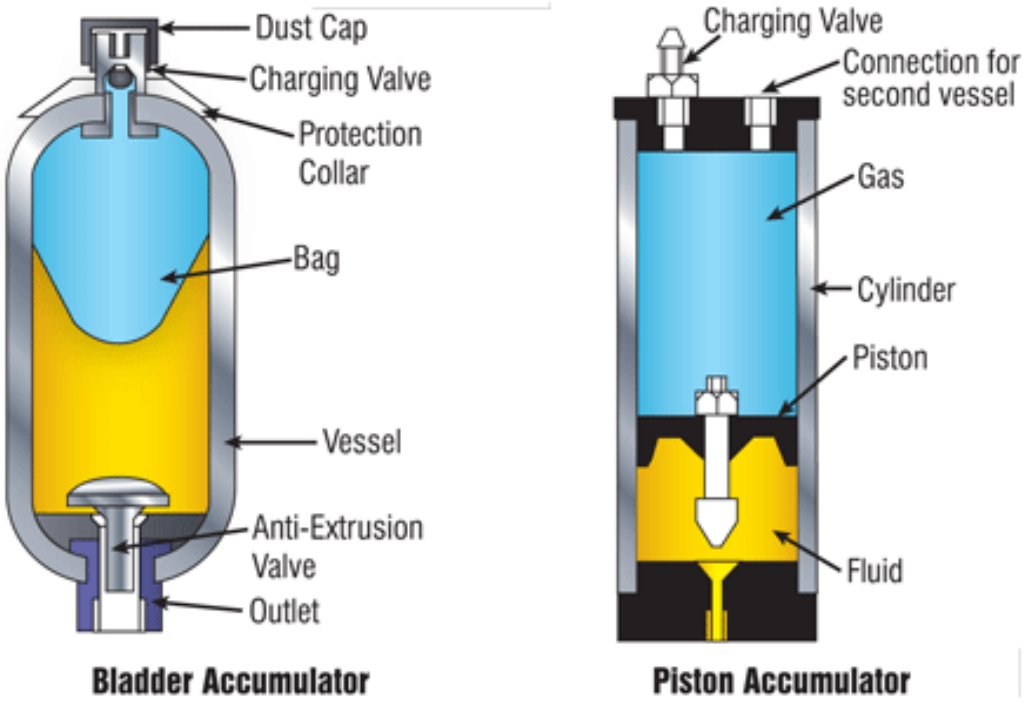
What are the four functions of an accumulator?

Hydraulic accumulators are able to provide a handful of functions: **Energy storage, leakage compensation, and vibration and shock reduction**.

These functions can be used for various applications and purposes, although energy storage is by far the most common.

How do accumulators improve system performance?

Energy storage.
Ability to store energy.
Emergency backup.
Vibration and shock reduction.
Leakage compensation.
Temperature compensation.
Faster response.


Dust Cap
Charging Valve
Protection Collar
Bag
Vessel
Anti-Extrusion Valve
Outlet
Bladder Accumulator
Charging Valve
Connection for second vessel
Gas
Cylinder
Piston
Fluid
Piston Accumulator

Electronics circuits for hydraulic systems